



FINANCING CLEAN ENERGY IN DEVELOPING ASIA

VOLUME 2

Edited by Bambang Susantono, Yongping Zhai,
Ram M. Shrestha, and Lingshui Mo

SEPTEMBER 2022

**FINANCING
CLEAN ENERGY IN
DEVELOPING ASIA**
VOLUME 2

Book Endorsements

Fatih Birol

Executive Director of the International Energy Agency

IEA analysis clearly shows that there is a major shortfall in global clean energy investment compared to what is needed to achieve net zero emissions by mid-century and that the underspend is perhaps most stark in developing Asia. The ADB has a critical role to play in addressing this problem, and this report makes an important contribution by identifying real-world solutions to the region's most pressing clean energy investment challenges.

Francesco La Camera

Director-General of the International Renewable Energy Agency

Asia is the world's powerhouse for renewables—accounting for almost 50% of total installed capacity globally. But the pace of energy transition and the deployment of clean energy sources must accelerate significantly to keep net zero aspirations alive and achieve international commitments under the Paris Agreement and the UN Development Agenda 2030. The Asia-Pacific region plays a major role.

Indeed, Asia's long-term interests are best served by decisions that address energy-related carbon emissions and promote the transition. Without a strong regional commitment to a renewables-based future, global efforts to create a more resilient, prosperous and climate safe future are considerably weakened. Central to decision making must be the fact that the transition brings significant, long-term economic and social benefits. While the finance gap is high, IRENA's World Energy Transitions Outlook shows that investing in the energy sector would pay off with employment set to reach 122 million people by 2050—more than double today's total energy jobs, with the renewable energy sector employing some 40 million people. Six million of them in Southeast Asia alone.

This book by the Asian Development Bank is a valuable reference providing information and lessons on financing mechanisms, policies, and business models for renewable energy from one of the fast-growing regions globally. It may serve as a useful resource on finance and investments for IRENA Members in Asia-Pacific and beyond as they embark on accelerating energy transitions towards net zero.

FINANCING CLEAN ENERGY IN DEVELOPING ASIA

VOLUME 2

Edited by Bambang Susantono, Yongping Zhai,
Ram M. Shrestha, and Lingshui Mo

SEPTEMBER 2022



Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO)

© 2022 Asian Development Bank
6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

Some rights reserved. Published in 2022.

ISBN 978-92-9269-722-8 (print); 978-92-9269-723-5 (electronic); 978-92-9269-724-2 (ebook)
Publication Stock No. TCS220368-2
DOI: <http://dx.doi.org/10.22617/TCS220368-2>

The views expressed in this publication are those of the authors and do not necessarily reflect the views and policies of the Asian Development Bank (ADB) or its Board of Governors or the governments they represent.

ADB does not guarantee the accuracy of the data included in this publication and accepts no responsibility for any consequence of their use. The mention of specific companies or products of manufacturers does not imply that they are endorsed or recommended by ADB in preference to others of a similar nature that are not mentioned.

By making any designation of or reference to a particular territory or geographic area, or by using the term “country” in this document, ADB does not intend to make any judgments as to the legal or other status of any territory or area.

This work is available under the Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO) <https://creativecommons.org/licenses/by/3.0/igo/>. By using the content of this publication, you agree to be bound by the terms of this license. For attribution, translations, adaptations, and permissions, please read the provisions and terms of use at <https://www.adb.org/terms-use#openaccess>.

This CC license does not apply to non-ADB copyright materials in this publication. If the material is attributed to another source, please contact the copyright owner or publisher of that source for permission to reproduce it. ADB cannot be held liable for any claims that arise as a result of your use of the material.

Please contact pubsmarketing@adb.org if you have questions or comments with respect to content, or if you wish to obtain copyright permission for your intended use that does not fall within these terms, or for permission to use the ADB logo.

Corrigenda to ADB publications may be found at <http://www.adb.org/publications/corrigenda>.

Notes:

In this publication, “\$” refers to United States dollars.

ADB recognizes “Laos” as the Lao People’s Democratic Republic,

“China” as the People’s Republic of China, “Korea” as the Republic of Korea,

“Ceylon” as Sri Lanka, “Siam” as Thailand, and “Vietnam” as Viet Nam.

ADB placed on hold its assistance in Afghanistan effective 15 August 2021. This report was prepared based on information available for Afghanistan as of 31 July 2021.

All photos are by ADB.

Cover design by Francis Manio.

Contents

VOLUME II

Tables, Figures, and Boxes	iv
Abbreviations	viii
Weights and Measures	xii
About the Editors	xiii
Authors	xv
Introduction	1
Part 5 Financing Clean Energy: Approaches and Practices	8
12 Clean Energy Financing: Sources, Instruments, Risks, and Mitigation Options	9
13 Financing Hydropower for Low-Carbon Development: Approaches, Opportunities, and Challenges	52
14 Unlocking Financing for Scaling up Demand-Side Energy Efficiency	96
Part 6 Clean Energy in South Asia: Policies and Strategies	150
15 Scaling Up Clean Energy in India: Solar Parks and Demand-Side Management Strategies	151
16 Solar Power Financing for Energy Security and Promoting Green Growth in Bangladesh	185
17 Lessons from Sri Lanka's Policies, Strategies, and Financing for Clean Power	216

Tables, Figures, and Boxes

Part 5 Financing Clean Energy: Approaches and Practices

12 Clean Energy Financing: Sources, Instruments, Risks, and Mitigation Options

Tables

1	Flow of Clean Energy-Related Climate Finance in Selected Countries, February 2019	16
2	Renewable Energy Investment in Asia, 2019	26
3	Other Financing Models for Energy Efficiency Projects in Thailand	41

Figures

1	Summary of Energy-Related Multilateral Development Bank Climate Finance Committed to Asia, 2019	13
2	Climate Finance Architecture	14
3	Share of Selected Funds Set Aside for the Private Sector	17
4	Infrastructure Project Investment Commitments, 2017	18
5	Top Mobilizers of Public and Private Investments in Asia, 2017	19
6	Investment Trends, 2008–2018	27
7	Mix of Instruments Used for International Public Climate Finance, 2015–2016	30
8	Comparison of Financing Structure of Public and Private Infrastructure Projects Globally, 2017	31
9	Viability Gap	33
10	Bangladesh Solar Home Systems Financing Model	38
11	Donor Funding Flow to the Energy Sector in Selected Small Island Developing States	42
12	Renewable Energy Share in Energy Sector Donor Finance in Small Island Developing States	43

13 Financing Hydropower for Low-Carbon Development: Approaches, Opportunities, and Challenges

Tables

1	Hydropower Projects Funded by Selected Multilateral Climate Funds	78
---	---	----

2	Estimated Total Hydropower Capacity (GW) by 2030 and 2040 under the International Energy Agency Scenarios	83
---	---	----

Figures

1	Financing Scheme of A/B Loans	65
2	Financing Structure of Nam Ngiep 1 Hydropower Project, Lao People's Democratic Republic	65

Boxes

1	Nam Theun 2 Hydropower Project, Lao People's Democratic Republic	61
2	Two Examples of Hydropower Projects Financed by Regional Banks	63
3	Nam Ngiep 1 Hydropower Project, Lao People's Democratic Republic	66
4	Upper Tamakoshi Hydropower Project, Nepal	68
5	Hydropower Financing in Bhutan Solely with Loan and Grants from India	70
6	Intergovernmental Joint Venture for Financing Hydropower Projects in Bhutan	71
7	Arun 3 Hydropower Project, Nepal	72
8	Upper Trishuli 3A Hydroelectric Project, Nepal	73
9	Upper Trishuli-1 Hydropower Project, Nepal	75
10	Karot Hydropower Project, Pakistan	76
11	Tina River Hydropower Project, Solomon Islands	78

14 Unlocking Financing for Scaling up Demand-Side Energy Efficiency

Figures

1	The Complexities of Nudging Markets Toward Greater Energy Efficiency	102
2	Alignment of Financing Mechanisms	105
3	Energy Efficiency Revolving Fund—Debt Financing	107
4	Energy Efficiency Revolving Fund—Energy Services Agreement	108
5	On-Bill Financing	110
6	Standard Offer Programs	111
7	Shared Savings Model	113
8	Guaranteed Savings Model	114
9	Shared Savings Model	120
10	RISE Energy Efficiency Indicators Results for Asian Countries, 2019	123

11	Financing Scheme of the India Partial Risk-Sharing Facility for Energy Efficiency Projects	126
12	Thailand's Energy Efficiency Revolving Fund and Energy Services Companies' Fund Financing Scheme	129
13	Capital Mobilized and Leveraged by the Republic of Korea's Energy Use Rationalization Fund	131
14	Financing Structure of the Republic of Korea's Energy Use Rationalization Fund	132
15	Republic of Korea: Types of Energy Services Company Contracts	132
16	Client's Cash Flows under the Energy Service Agreements	134
17	Flow of Funds and Contractual Arrangements	138
18	Energy Efficiency and Jobs	143
19	Energy Efficiency Market Transformation Requires Multipronged Efforts	145

Boxes

1	Strategies for Scaling up Energy Efficiency	112
2	Examples of Energy Service Company Delivery Models in Developing Energy Efficiency Markets	115
3	Super Energy Service Companies in India and Saudi Arabia	117
4	Energy Efficiency Readiness Factors	122
5	The Evolution of Bulgaria's Residential Retrofit Program	136
6	Energy Efficiency Financing Programs: Key Lessons Learned	142

Part 6 Clean Energy in South Asia: Policies and Strategies

15 Scaling Up Clean Energy in India: Solar Parks and Demand-Side Management Strategies

Table

1	Clean Technology Fund Contribution to Solar Projects in India	158
---	---	-----

Figures

1	Incremental Installed Power Generation Capacities by Type of Energy, 2014–2020	153
2	Solar Tariff Trend Since Bhadla Phase I Bidding	165
3	Energy Savings due to Energy Efficiency, 2000–2017	170

Box

	Charanka and Bhadla Solar Park	161
--	--------------------------------	-----

16 Solar Power Financing for Energy Security and Promoting Green Growth in Bangladesh

Figures

1	On-Grid Power Plant Capacity and Electricity Generation, June 2020	187
2	Sustainability of Electricity Distribution, 1996–2019	188
3	Natural Gas Prices in Selected Cities/Countries, March 2015	189
4	Share of Different Technologies in Renewable Energy Generation in 2020	190
5	Share of Different Solar Energy Generation Projects in 2020	191
6	Market Share of Financial Institutions in the Renewable Energy Market, 2015	200
7	Generation Capacity of Power Plants with Expensive Purchasing Costs, July 2019–June 2020	208

Boxes

1	Draft Solar Energy Road Map 2041	197
2	IDCOL Solar Home System Program	201
3	Draft Road Map to Scale-up Solar Irrigation Pumps in Bangladesh	204

17 Lessons from Sri Lanka's Policies, Strategies, and Financing for Clean Power

Figures

1	Progress in Countrywide Electrification, 1970–2018	218
2	Off-Grid Nonconventional Power Generation	222
3	Power Generation Mix in 2000 and 2017	223
4	Development of Nonconventional Renewable Energy Sources, 2000–2017	229

Box

	Mannar Wind Power Generation Project	235
--	--------------------------------------	-----

Abbreviations

ADB	–	Asian Development Bank
AIIB	–	Asian Infrastructure Investment Bank
ASEAN	–	Association of Southeast Asian Nations
BDB	–	bilateral development bank
BEE	–	Bureau of Energy Efficiency (India)
BERC	–	Bangladesh Energy Regulatory Commission
BOOT	–	build–own–operate–transfer
BPDB	–	Bangladesh Power Development Board
CBSB	–	Climate Bonds Standard Board
CDAP	–	Community Development Action Plan (India)
CDM	–	Clean Development Mechanism
CEB	–	Ceylon Electricity Board (Sri Lanka)
CER	–	certified emissions reduction
CIF	–	Climate Investment Funds
CO ₂	–	carbon dioxide
CPF	–	Carbon Partnership Facility
COVID-19	–	coronavirus disease
CPI	–	Climate Policy Initiative
CTF	–	Clean Technology Fund
DSM	–	demand-side management
ECA	–	export credit agency
EE	–	energy efficiency
EESL	–	Energy Efficiency Services Limited (India)
EIB	–	European Investment Bank
ESA	–	energy service agreement

ESCO	–	energy service company
ESMAP	–	Energy Sector Management Assistance Program
EV	–	electric vehicle
FIT	–	feed-in tariff
GCF	–	Green Climate Fund
GEF	–	Global Environment Facility
GHG	–	greenhouse gas
GNI	–	gross national income
HPP	–	hydropower project
IDCOL	–	Infrastructure Development Company Limited (Bangladesh)
IDA	–	International Development Association
IEA	–	International Energy Agency
IFI	–	international financial institution
IPCC	–	Intergovernmental Panel on Climate Change
IPP	–	independent power producer
IRENA	–	International Renewable Energy Agency
ITDG	–	Intermediate Technology Development Group (Sri Lanka)
JBIC	–	Japan Bank for International Cooperation
JICA	–	Japan International Cooperation Agency
KfW	–	German Development Bank
LED	–	light-emitting diode
LoR	–	lender of record
M&V	–	measurement and verification
MDB	–	multilateral development bank
MNRE	–	Ministry of New and Renewable Energy (India)
MPEMR	–	Ministry of Power, Energy and Mineral Resources (Bangladesh)
MSMEs	–	micro, small, and medium-sized enterprises
NAPCC	–	National Action Plan on Climate Change (India)

NCRE	–	nonconventional renewable energy
NDC	–	nationally determined contribution
Norad	–	Norwegian Agency for Development Cooperation
NSM	–	National Solar Mission (India)
NTPC	–	National Thermal Power Corporation (India)
ODA	–	official development assistance
OECD	–	Organisation for Economic Co-operation and Development
PPA	–	power purchase agreement
PPCR	–	Pilot Program for Climate Resilience
PPP	–	public–private partnership
PRSF	–	Partial Risk-Sharing Facility (India)
PUCSL	–	Public Utilities Commission of Sri Lanka
PV	–	photovoltaic
RPO	–	renewable purchase obligation
RPS	–	renewable portfolio standard
SDG	–	Sustainable Development Goal
SDS	–	Sustainable Development Scenario
SE4ALL	–	Sustainable Energy for All
SECI	–	Solar Energy Corporation of India
SHS	–	solar home system
SIDS	–	small island developing states
SLSEA	–	Sri Lanka Sustainable Energy Authority
SMEs	–	small and medium-sized enterprises
SPC	–	special purpose company
SPPA	–	standard power purchase agreement
SPPD	–	solar park project developer
SPV	–	special purpose vehicle
SREDA	–	Sustainable and Renewable Energy Development Authority (Bangladesh)

SREP	–	Scaling-up Renewable Energy Program (Bangladesh)
STEPS	–	Stated Policies Scenario
UNCTAD	–	United Nations Conference on Trade and Development
UNFCCC	–	United Nations Framework Convention on Climate Change
UJALA	–	Unnat Jyoti by Affordable LEDs for All (India)
VAT	–	value-added tax
VGF	–	variable gap fund



Weights and Measures

GW	–	gigawatt
GWh	–	gigawatt-hour
kwh	–	kilowatt-hour
kWp	–	kilowatt-peak
MW	–	megawatt
TWh	–	terawatt-hour

About the Editors



Bambang Susantono is the former Vice-President for Knowledge Management and Sustainable Development of the Asian Development Bank (ADB). Distinguished in providing global thought leadership on sustainable development, he is a published author and active researcher. He was responsible for managing knowledge in ADB and coordinating research and studies on wide-ranging topics including in economy, infrastructure, digital

technology, health, education, social, urban, water, energy; and cross-cutting nexus themes such as climate change, environment, gender equality, and regional cooperation.

He holds a doctor of philosophy (PhD) in Infrastructure Planning, as well as master's degrees in Transportation Engineering, and City and Regional Planning from University of California, Berkeley and a bachelor's degree in Engineering from the Bandung Institute of Technology.



Yongping Zhai has been working on energy development in Asia and Africa for more than 30 years. He was Chief of the Energy Sector Group of ADB, in charge of overall energy policy coordination and technical support to ADB energy sector operations. He was also in charge of developing energy sector knowledge work for ADB and interacted with worldwide energy sector partners.

Prior to being Chief of Energy Sector Group, Yongping Zhai was Director of the South Asia Energy Division (2010–2015), ADB, covering energy sector operations in Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. He also served as ADB's Lead Energy Specialist (2008–2010), in charge of the energy sector in Southeast Asia including Indonesia, the Philippines, and the Greater Mekong Subregion.

He graduated from the Thermal Energy Engineering Department, Tsinghua University, Beijing, People's Republic of China (1983) and received a PhD in Energy Economics from Institute of Energy Economics and Policy, affiliated with the University of Pierre-Mendès France in Grenoble, France (1989).



Ram M. Shrestha is an Emeritus Professor at the School of Environment, Resources and Development, Asian Institute of Technology (AIT), Bangkok, Thailand and a former Chairman of the Academic Senate of AIT. He has served as the Editor-in-Chief of International Energy Journal; as an Associate Editor of Energy Economics, Energy – The International Journal and Journal of Energy Engineering of American Society of Civil Engineers; and as a Guest

Editor of Energy Policy. He has also been a member of the International Advisory Board of Carbon Management.

He holds a PhD in resource economics and a master's degree in industrial engineering and management from AIT. He graduated with a bachelor's degree in electrical engineering from M.S. University of Baroda, India. He also holds a Bachelor of Law from Tribhuvan University, Nepal.



Lingshui Mo is a consultant of ADB on low-carbon and green development (climate and clean energy policy, mitigation projects). She is also a visiting researcher at Chongyang Institute for Finance Study, Renmin University of the People's Republic of China. She provides technical support to ADB on green finance/climate finance, carbon markets, low-carbon technology financing and transfer, low-carbon city development, and clean energy policy. She led a team

to develop mitigation projects for carbon finance in the UK consulting company, Camco Carbon Credit Limited. Prior to ADB, she participated in the formulation of economic and social development plans, industrial policies, regional plans, and urban infrastructure investment plans, and was also in charge of the assessment and approval of urban infrastructure projects of the Government of the People's Republic of China. She holds master's degrees in economics and international finance.



Authors

Jiwan Acharya

Principal Energy Specialist, South Asia Department
Asian Development Bank

Subhes Bhattacharyya

Professor of Net Zero Energy Systems, University of Surrey

María Rodríguez de la Rubia Gassol

Senior Consultant, Energy Global Practice, World Bank

Len George

Principal Energy Specialist, Pacific Department, Asian Development Bank

Anthony Jude

Senior Energy Consultant, Asian Development Bank

Keshan Samarasinghe

Clean Energy Technology Consultant, Asian Development Bank

Ashok Sarkar

Senior Energy Specialist and Program Leader - Infrastructure,
Energy and Extractives Global Practice, World Bank

Ram Shrestha

Emeritus Professor, School of Environment, Resources and Development,
Asian Institute of Technology, Thailand

Maria Fritzie Vergel

Consultant, Sustainable Development and Climate Change Department,
Asian Development Bank

Priyantha Wijayatunga

Chief of Energy Sector Group, Asian Development Bank

Ranishka Wimalasena

Energy Specialist, Pacific Department, Asian Development Bank

Hongwei Zhang

Principal Portfolio Management Specialist, South Asia Department,
Asian Development Bank

Siddique Zobair

Environment, Climate Change and Energy Efficiency Consultant,
Asian Development Bank

Introduction

The Asia and Pacific region is expected to play a crucial role in tackling climate change. It is responsible for about half of current global carbon emissions. Many countries have already announced contributions toward implementing greenhouse gas mitigation under the Paris Climate Agreement. Major economies like Japan, the People's Republic of China (PRC), and the Republic of Korea have recently announced that they aim to achieve net zero emissions by around the middle of this century. Several other countries in the region are considering similar targets.

Reducing emissions means transitioning to clean energy, a move that is also crucial for energy security and sustainable development. Fossil fuels meet 85% of energy needs in the region, with several countries heavily dependent on imports, rendering them economically vulnerable. One-tenth of the region's population meanwhile still lacks access to electricity, with many more people depending on traditional biomass for cooking and heating. Many urban areas endure serious air pollution.

Huge additional investments and the mobilization of private finance are required to fund the required rapid shift to clean energy. The global and regional landscape for energy financing has evolved in recent years. Emerging new sources of finance include climate finance and carbon markets, alongside new instruments, like green bonds, and new innovative risk mitigation measures. These offer opportunities for energy entrepreneurs, project developers, investors, and financing institutions. However, investment in clean energy, such as solar, wind, bioenergy, hydropower, and geothermal, along with energy efficiency projects, requires an adequate understanding of the risks, uncertainties, and challenges involved in financing both on the supply and demand sides.

These projects are different from conventional energy projects. Risks and challenges can vary not only by type of project but also by country. It therefore becomes crucial to select the appropriate combination of financing instruments, risk mitigation measures, funding sources, and business models for the effective financing of each clean energy project. In many cases, innovative financing approaches may be required to address project-specific barriers and risks.

While countries in Asia and the Pacific are at varying levels of maturity in terms of clean energy development and financing, several examples of successful clean energy financing can be found in the developing countries of the region. Multilateral development institutions like the Asian Development Bank (ADB) have also been actively engaged in clean energy development, and lessons learned can be valuable in helping to identify appropriate financing mechanisms and business models for new project developments. No publication currently provides such information in the context of the developing countries in Asia and the Pacific.

This book aims to provide an up-to-date account of the financing approaches, policies, and business models available for the development of clean energy resources. These are complemented by appropriate examples of clean energy projects and programs from developing countries in the region. A variety of clean energy projects are covered, including distributed renewable energy systems, hydropower, and those focusing on demand-side energy efficiency. The book also discusses key barriers to financing clean energy development, and innovative policies and measures adopted to overcome them in different country and project contexts.

This book is primarily intended to benefit the potential developers of, and investors in, clean energy projects, as well as financing institutions and policy makers in the region. The materials may also be useful to interested readers in academia and the research community.

The book is organized into two volumes. Volume 1 contains the first four parts and the present volume (Volume 2) contains the remaining two parts.

In Volume 1, Part 1 comprises Chapter 2, which presents an overview of how renewable energy resources—solar, wind, hydro, solid biomass, waste to energy, and geothermal—in different countries and subregions of Asia and the Pacific are currently used. It also presents the potential of renewable energy resources in selected countries, which illustrates significant prospects for their further development across the region. It discusses historical trends of overall energy intensity (i.e., energy use per unit of gross domestic product) of different countries, as well as the specific energy consumption of major sectors in selected countries. The chapter presents historical patterns of investment in renewable energy and discusses prospects for renewable energy development under future low-carbon development scenarios and their investment implications. Because some major countries in the region have already set targets for net zero emissions by around 2050, and others are considering such goals, this chapter discusses the key implications of meeting these targets.

Furthermore, the chapter provides an overview of clean energy policies that promote renewable energy and energy efficiency in various countries.

Part 2, encompassing three chapters, focuses on the role of multilateral development banks, like ADB, and other public institutions in leveraging their funds to mobilize private sector finance for clean energy development. Chapter 3 discusses different initiatives and investments that ADB has undertaken to assist its developing member countries transition to clean energy. It discusses ADB's financing targets, funding sources, and financing modalities for clean energy. The chapter also discusses prospects for clean energy financing with ADB strategies like promoting clean energy uptake through a multisector approach, using appropriate business models to make clean energy more viable and affordable, providing modern energy access to all, advancing technology to improve energy efficiency, and strengthening infrastructures and equipment for better renewable reliability and resilience. The chapter includes an interesting discussion on ADB's financial resources mobilization through the issuance of green bonds. It also looks at the role played by the bank in mobilizing private capital to finance clean energy projects through syndicated loans (or B loans) from commercial banks.

Chapter 4 discusses attracting more private financing in the renewable energy sector in ADB's developing member countries in the Pacific under the bank's Pacific Renewable Energy Program. It describes the role of the program, particularly its credit enhancement mechanism, in encouraging private sector investment in renewable energy power generation projects, and in hedging against the key risks associated with these projects through instruments like partial risk guarantees and letters of credit. The chapter also presents the key barriers to developing renewable energy in these countries.

Chapter 5 showcases the approach and experience of the Green Financing Platform (GFP) project initiated by ADB for accelerating air quality improvement in the Greater Beijing–Tianjin–Hebei Region, one of the most heavily polluted regions in the PRC. The chapter describes the design and implementation approaches of the GFP project and highlights lessons learned from the successful implementation of the project. An innovative aspect of the GFP project involves the use of public financing instruments, such as cofinancing, guaranties, and intermediary loans, to leverage private capital into clean energy projects helping to reduce air pollution and carbon emissions.

Part 3 comprises four chapters discussing national and subregional approaches to clean energy financing.

Chapter 6 looks at clean energy financing of members of the Association of Southeast Asian Nations (ASEAN). It discusses estimated investment needs to meet the regional group's targets for renewable energy and energy intensity by 2025, as well as financing gaps. Furthermore, it describes prevailing sources of finance and financing schemes. It presents an outlook for regional cooperation in energy financing, discusses the barriers to improve clean energy financing in the region, and presents key policy financing instruments adopted and success stories in ASEAN member states. It highlights the diversity of members in terms of the maturity of their clean energy markets and financing. The dominance of public financing in clean energy investments in ASEAN, and the inadequate understanding of domestic banks about green investment markets and credit risks associated with clean energy investments, are also highlighted in the chapter.

Chapter 7 presents the case of developing Southeast Asia's first large-scale national solar park project, in Cambodia, through a public-private partnership. It discusses ADB's instrumental role, which is providing end-to-end support to the government and national power utility of Cambodia. ADB provided financial and technical assistance throughout the development and construction phases of the project in multiple ways, including by helping the utility design and conduct a competitive tender for procuring the first 60-megawatt solar power plant from the private sector within the park. It also discusses ADB's role in the government's adoption of an open and transparent competitive bidding process, which resulted in a low power purchase agreement tariff. In addition, the chapter presents the key factors behind the successful design and implementation of the project, and highlights the structure adopted to allocate risks and accountability among the project's key stakeholders.

Chapter 8 deals exclusively with distributed renewable energy systems, which are important for providing energy access to people in remote and isolated areas. The chapter initially looks at distributed renewable energy technologies and the role different systems play in providing energy access. The major focus of the chapter is on the four common types of business models for distributed energy systems that are typically based on the proponent of the project: (i) community-led; (ii) private sector-led, (iii) utility-led; and (iv) a combination of the three, i.e., a hybrid or multiparty business model that includes a public-private-people partnership model. The chapter discusses a set of criteria that provides a basis for choosing and designing an appropriate business model. It also examines a practical application of the public-private-people partnership model in the case of the distributed renewable energy system in Malalison Island, Philippines. The Malalison Island case study highlights the role of

ADB grants in catalyzing private sector investment in providing energy access to people in isolated areas through distributed renewable energy systems.

Chapter 9 analyzes policies and measures adopted by the PRC to promote clean energy development in different stages of the country's development, and their impact on investment. The chapter discusses the evolution of Chinese clean energy policies, from government-led before 2016 to the market-oriented approach thereafter. It assesses the performance of clean energy policies and discusses the investment implications of clean energy policies, lessons learned, and ways to meet the challenge of carbon neutrality.

Across two chapters, Part 4 deals with two highly important aspects of large-scale, low-carbon energy transition: the mobilization of private sector finance for clean energy, and carbon finance. Chapter 10 discusses the innovative private financial instruments necessary for a low-carbon transition in ASEAN member countries and East Asia. It identifies barriers to the upscaling of private investment for a low-carbon transition, based on a review of recent developments in private financing as well as stakeholder surveys. A major message of the chapter is that regionally coordinated policy solutions could unleash the private financing needed to support a clean energy transition.

Chapter 11 discusses the role of carbon trading in clean energy financing. It includes reviews of current international carbon markets as well as existing and emerging domestic carbon markets in Asia and the Pacific. The critical elements of a carbon market that affect clean energy investment and financing are also discussed. The chapter analyzes the indicators of carbon markets related to clean energy financing—like the number of eligible emissions-reduction projects, certified emissions reductions, and carbon price—and assesses the impact of existing carbon markets on clean energy investment and financing. Key factors that would enhance the role of the carbon market in clean energy financing are examined.

The present volume (Volume 2) contains Parts 5 and 6.

Part 5 has three chapters (Chapters 12, 13, and 14) dealing with the approaches and practices of clean energy financing. Chapter 12 focuses on different options for financing clean energy in general, and renewable energy in particular. The chapter reviews the literature on the public sources of finance, including climate finance, and domestic sources, including private sources. The chapter also presents alternative and

innovative instruments used for financing clean energy investments. It discusses barriers to clean energy financing in two categories: barriers associated with the adverse business environment due to the coronavirus disease (COVID-19), and those associated with the nature of clean energy investment projects. It also describes risk mitigation measures. Four cases of energy financing experiences from developing countries in Asia and the Pacific are included.

Chapter 13 focuses on financing hydropower projects and discusses the role of hydropower in the context of climate change mitigation. It describes the evolution of hydropower finance, from public sector financing, through to public–private partnerships, private sector project financing, and the new bilateral financing mechanism. Variants of financing models are presented, with examples of relevant hydropower projects from Asia and the Pacific. The chapter presents an overview of climate financing used for hydropower and factors behind the relatively low access of hydropower projects to climate finance at present. It also discusses the opportunities and challenges for developing hydropower.

Chapter 14 is dedicated to approaches of financing demand-side energy efficiency projects or programs. It presents a rich discussion on different mechanisms for financing energy efficiency projects and their implementation modalities and institutional frameworks at the conceptual level. It also discusses key factors that need to be considered for the selection of appropriate financing mechanisms. The chapter presents specific country-level examples of energy efficiency financing options and identifies what is needed to achieve energy efficiency market transformation at scale, highlighting the enhanced relevance of energy efficiency in a post-COVID-19 recovery context.

Part 6 consists of three chapters focused on policies and strategies adopted to develop specific clean energy resources in selected countries of South Asia. Chapter 15 discusses the innovative policies, financing mechanisms, and institutional setups that helped the development of solar energy. It describes the development of large solar parks in India (i.e., Charanka Solar Park in Gujarat and Bhadla Solar Park in Rajasthan). Also discussed are innovative policies and financing mechanisms, such as the Partial Risk Guarantee Fund for Energy Efficiency and the Venture Capital Fund for Energy Efficiency and Partial Risk Sharing Facility, as well as measures to mitigate interconnection risks that create enabling conditions for private sector participation. The successful implementation of several energy efficiency projects is discussed, as is the role of institutions like Energy Efficiency Services Limited in reducing energy efficiency project costs by taking performance risks and bulk procurements.

Chapter 16 examines solar power financing in Bangladesh. It includes a review of the status of renewable energy development in the country, and discusses policies for solar power development, including financial incentives for renewable energy development. Financial interventions and mechanisms for solar power development in the country are also discussed, while the chapter identifies key barriers to the development of renewable energy and suggests some measures to overcome them.

The final chapter in this volume reviews the policies, strategies, and financing mechanisms adopted by Sri Lanka to develop renewables-based power generation. It presents the evolution of renewable energy development in the country and discusses energy sector policies, regulatory and institutional frameworks, and innovative measures introduced to promote renewable energy. The chapter discusses sources of financing and risks associated with the financing of renewable energy projects. Key lessons learned during the country's renewable energy development, which could be useful for other developing countries, are also presented.

PART 5

Financing Clean Energy: Approaches and Practices



Subhes Bhattacharyya

Introduction

In 2015, the international community agreed in Paris to limit any rise in global average temperature to “well below 2°C above the preindustrial levels” by the year 2100.¹ Model-based analysis of low-carbon pathways suggests that global net anthropogenic carbon emissions must decline by 46% from 2010 levels by 2030 and reach net-zero by 2050.² Reaching this objective requires unprecedented, urgent efforts nationally and internationally by all stakeholders, including governments, companies, and households (footnote 2). Such efforts must involve a systemic transformation of prevailing fossil fuel-based energy systems to clean and smart energy solutions.

This transformation will require a significant reallocation of investment in the energy sector. The average annual investment in upscaling renewable energy and energy efficiency would have to increase by a factor of six for the period between 2016 and 2050 (footnote 2). Another study estimated that compared to a baseline scenario, an additional average investment in the energy sector of \$320 billion per year would be required until 2030, but if the target was set at 1.5°C, the incremental investment requirement would grow to \$480 billion per year.³ Asian countries face a significant additional investment demand: for India and the People’s Republic of China (PRC), the additional demand would be an increase of 50% compared to the baseline scenario (footnote 3).

¹ United Nations Framework Convention on Climate Change. 2015. *Paris Agreement*. Bonn: United Nations Framework Convention on Climate Change.

² Intergovernmental Panel on Climate Change (IPCC). 2018. *Special Report: Global Warming of 1.5°C*. Geneva: IPCC.

³ D.L. McCollum et al. 2018. Energy Investment Needs for Fulfilling the Paris Agreement and Achieving the Sustainable Development Goals. *Nature Energy*. 3. 589–599.

Recognizing the funding challenge for a low-carbon transition pathway, the United Nations Framework Convention on Climate Change has set up various initiatives since 1990, including the Global Environment Facility (GEF) and the Green Climate Fund (GCF). Official development assistance (ODA) from donor countries has been the traditional source of finance for many developing countries, but over the past 15 years the architecture of development finance has evolved, with financing from development finance institutions, foreign direct investment, and domestic resource mobilizations growing significantly.⁴

A significant level of clean energy investment has been achieved globally, estimated at \$282 billion in 2019 (excluding large hydroelectric projects).⁵ Most finance was privately sourced with only a small share—14% on average between 2013 and 2018—from the public sector.⁶ Solar photovoltaic (PV) and wind technologies accounted for 95% of the investment in 2019 (footnote 6). Some 38% of clean energy finance went to Asian developing countries, of which 77% went to East Asia (footnote 6).

In 2020, only 35% of global investment in the energy sector went to clean energy.⁷ Traditionally, the public sector has played an important role in the development of the energy sector but there has been a slowdown in energy sector investment as a share of gross domestic product due to the economic recession in 2020 as a result of the global coronavirus disease (COVID-19) pandemic (footnote 7). A clean energy-driven post-COVID-19 recovery remains a strategic option, but this would require investment of \$49 trillion in renewable energy and energy efficiency between 2019 and 2030, or \$4.5 trillion per year, on average.⁸ Of this, 32% would need to go to East Asia, and another 12% to the rest of Asia (footnote 8).

In this context, it is important to take stock of the possible sources of finance for clean energy investments and review the mechanisms and instruments being used. This will facilitate a better appreciation of the challenges ahead and ways to meet them.

⁴ D.F. Runde et al. 2016. *Development Finance Institutions Come of Age: Policy Engagement, Impact and New Directions*. Washington, DC: Centre for Strategic and International Studies and Overseas Development Institute.

⁵ Frankfurt School. 2020. *Global Trends in Renewable Energy Investment 2020*. Frankfurt: Frankfurt School–UNEP Centre.

⁶ International Renewable Energy Agency (IRENA) and Climate Policy Initiative (CPI). 2018. *Global Landscape of Renewable Energy Finance 2018*. Abu Dhabi: IRENA.

⁷ International Energy Agency (IEA). 2020. *World Energy Investment 2020*. Paris: IEA.

⁸ IRENA. 2020. *The Post-COVID Recovery: An Agenda for Resilience, Development and Equality*. Abu Dhabi: IRENA.

Clean Energy Financing Options

Finance sources for clean energy interventions are commonly grouped under two categories, public and private, based on who mobilizes them.⁹ Public finance is mobilized by governments and their agencies, such as national, bilateral, and multilateral finance organizations. Private finance is mobilized by private corporations, commercial financial institutions, and households. Public finance flows from general tax income, special charges and levies, and income from auctions, whereas private finance flows from capital markets, corporate cash flows, and household income.¹⁰ In addition, new and innovative approaches to financing have emerged.

Public Sources of Clean Energy Finance

Public finance accounted for 14% of global investment in clean energy between 2013 and 2018.¹¹ Bilateral donor agencies, climate funds, development finance institutions, and domestic public sources are the main providers of public finance for clean energy (footnote 11).

Aid Finance for Clean Energy

ODA is financing of a concessional character provided by government agencies. Its main objective is to boost the economic development and welfare of developing countries (footnote 4). ODA may take the form of a grant, concessional loan to a government, or a contribution to bilateral or multilateral financial institutions for onward disbursement. Economies of the least-developed countries as a group are considerably dependent on ODA for their development finance, and ODA disbursements outstripped other sources of external finance for this group in 2017.¹² For countries like Afghanistan¹³ and small island countries (such as Kiribati, Solomon Islands,

⁹ CPI. 2019. *Global Landscape of Climate Finance 2019*. London: CPI; and C. Watson and L. Schalatek. 2019. *The Global Climate Finance Architecture, Climate Finance Fundamentals 2*. February.

¹⁰ S. Gupta et al. 2014. Cross-cutting Investment and Finance Issues. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

¹¹ IRENA and CPI. 2020. *Global Landscape of Renewable Energy Finance*. Abu Dhabi: IRENA.

¹² United Nations Conference on Trade and Development (UNCTAD). 2019. *The Least Developed Countries Report 2019*. New York: UNCTAD.

¹³ ADB placed on hold its assistance in Afghanistan effective 15 August 2021. *ADB Statement on Afghanistan | Asian Development Bank* (published on 10 November 2021). Manila.

Tuvalu, and Vanuatu), ODA represents the main flow of external financing (footnote 12).

In 2019, net ODA represented 0.3% of the gross national income of donor countries, significantly below the 0.7% target set in Goal 17.2 of the United Nations Sustainable Development Goals. Only a small share of ODA flows to Asian countries, with those in South Asia and Central Asia as the major recipients of assistance in the region. ODA commitment to the energy sector was only 5.8% of bilateral ODA in 2018 and close to 15% of multilateral ODA.¹⁴ Afghanistan and Bangladesh are the two top recipients of energy-related ODA in the region. Concessional loans accounted for about 60% of the disbursements in energy provision and distribution globally between 2015 and 2017 (footnote 12).

As ODA flow has remained stagnant between 2011 and 2017 (footnote 12) and disbursements have mainly benefited the social sectors and humanitarian interventions, ODA finance for infrastructure and productive activities remains limited (footnote 12). ODA is unlikely to emerge as a major source of clean energy finance for Asian countries, although it is expected to play some role in vulnerable economies, including the small island economies of the Pacific.

Clean Energy Finance from Multilateral Development Banks

Multilateral development banks (MDBs) are financial institutions set up by two or more sovereign states to foster economic and social development in developing countries. Multilateral ODA and some bilateral ODA fund MDBs but they also leverage their balance sheets to raise capital from the market to deliver more grants and lending to developing countries (footnote 13).

In 2019, MDBs jointly committed almost \$62 billion toward climate finance, with 76% slated for interventions related to mitigation (i.e., efforts aimed at reducing and stabilizing the emissions and minimizing the possible impacts) and the remainder going towards adaptation (i.e., efforts aimed at adjusting life to the changed conditions).¹⁵ Their support for clean energy derives from their focus on climate change. Almost half of

¹⁴ Organisation for Economic Co-operation and Development (OECD). 2020. *2020 Multilateral Development Finance*. Paris: OECD.

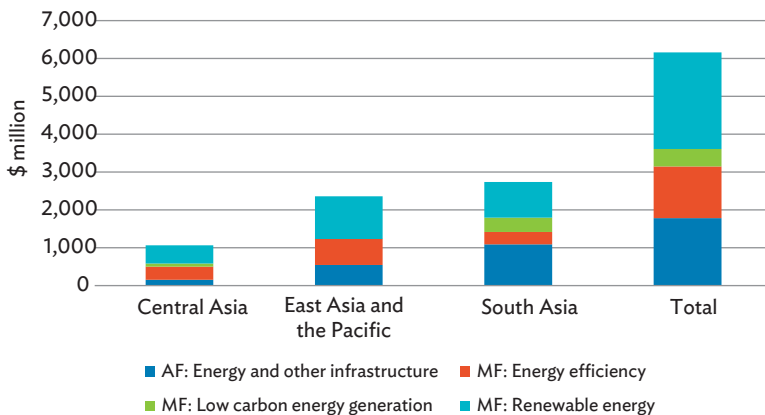
¹⁵ European Bank for Reconstruction and Development (EBRD). 2020. *2019 Joint Report on Multilateral Development Banks Climate Finance*. London: EBRD.

the mitigation finance was committed to low-carbon energy and energy efficiency interventions, while 26% of adaptation commitment went to energy and other built-environment infrastructure (footnote 14).

Asian countries are major beneficiaries of MDB climate finance and a significant share of this goes to support clean energy (Figure 1). More than \$6 billion went to the region in 2019; 44% of this went to South Asia and another 38% went to East Asia. Around 71% of the MDB funding to the region went to mitigation efforts, with renewable energy accounting for 53%, and another 31% went to energy efficiency projects.

The World Bank and Asian Development Bank (ADB) are the main MDBs for clean energy investment in Asia and the Pacific but Central Asian countries also receive funding support from the European Bank for Reconstruction and Development. The region is also benefiting from new MDBs such as the Asian Infrastructure Investment Bank and the New Development Bank, set up in 2016, which are targeting transport and clean energy projects as important investment areas. For example, by 31 December 2019, the New Development Bank had committed \$3.5 billion to clean energy projects.¹⁶

Figure 1: Summary of Energy-Related Multilateral Development Bank Climate Finance Committed to Asia, 2019



AF = adaptation finance, MF = mitigation finance.

Source: European Bank for Reconstruction and Development (EBRD). 2020. *2019 Joint Report on Multilateral Development Banks Climate Finance*. London: EBRD.

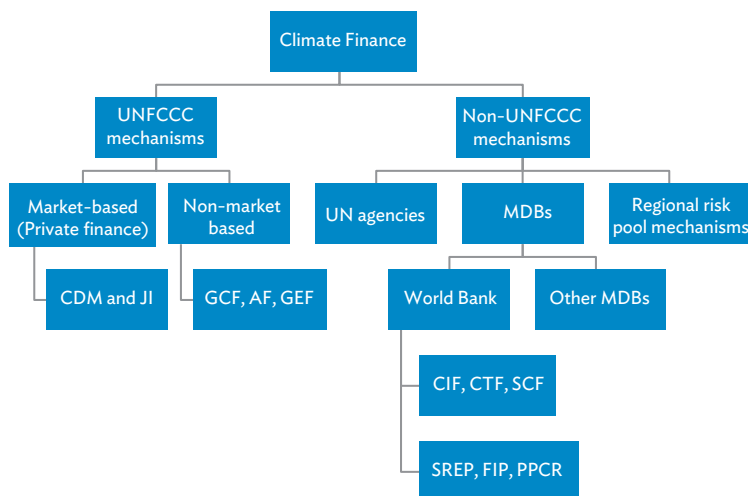
¹⁶ NDB. 2020. *Annual Report 2019: Investing for Innovation*. Shanghai: NDB.

Clean Energy Finance Through Climate Funds

Climate finance comes either from mechanisms set up under the United Nations Framework Convention on Climate Change or from other bilateral and multilateral agencies (Figure 2). Climate finance mainly comes from bilateral and multilateral ODA but market-based mechanisms such as the Clean Development Mechanism and Joint Implementation of the Kyoto Protocol mobilize private capital as well. MDBs administer and manage funds, each with its own focus and mandate.

Many climate funds aim to promote clean energy and energy efficiency through private sector involvement. The GEF, set up in 1991, has targeted clean energy and energy efficiency projects as part of its climate change interventions and has aimed to transform energy markets in developing countries. But the focus shifted in 2015 when the GCF became operational.

Figure 2: Climate Finance Architecture



AF = Adaptation Fund, CDM = Clean Development Mechanism, CIF = Climate Investment Funds, CTF = Clean Technology Fund, FIP = Forest Investment Programme, GCF = Global Carbon Facility, GEF = Global Environment Facility, JI = joint implementation, MDB = multilateral development bank, PPCR = Pilot Program on Climate Resilience, SCF = Strategic Climate Fund, SREP = Scaling-up Renewable Energy Program, UN = United Nations, UNFCCC = United Nations Framework Convention on Climate Change.

Source: Adapted from C. Watson, and L. Schalatek. 2019. *The Global Climate Finance Architecture: Climate Finance Fundamentals 2*. Climate Funds Update.

Now, GCF supports clean energy and energy access, while GEF focuses on adaptation and sustainable development issues. The Climate Investment Funds (CIF), set up in 2008, is an umbrella fund to support low carbon and resilient development in developing countries. CIF is administered by the World Bank but operates in partnership with other MDBs. The CIF supports programmatic interventions and several initiatives such as the Clean Technology Fund (CTF), the Strategic Climate Fund (SCF), and the Scaling-up of Renewable Energy Program (SREP) in Low Income Countries, which are directly relevant for clean energy finance.¹⁷

Table 1 presents a summary of climate funding for clean energy interventions in selected countries as of February 2019. Major funding sources included the CTF, the GCF and the GEF. The PRC, India, and Indonesia were the top recipients and accounted for 53% of the funding.¹⁸

Several energy efficiency projects have been supported throughout the region via climate finance, including the Developing Market-based Energy Efficiency Program in the PRC through GEF and Kazakhstan Energy Efficiency Project supported by the World Bank (footnote 17). ADB-funded energy efficiency projects included country level projects and regional projects. These included several projects in the PRC (such as in Guangdong, Shandong, Hebei, Hubei, and Shanxi), the Energy Efficiency Investment Programme in Pakistan, the Philippine Energy Efficiency Project, investments in India (such as in Madhya Pradesh), the Industrial Energy Efficiency Programme in Bangladesh, the South East Asia Energy Efficiency Project, and projects in Sri Lanka.¹⁹

Although climate funds are well established in the region, they have benefited larger economies with more developed, mature investment markets. Access for countries with small and weak capital markets and limited institutional capacity remains challenging (footnote 17). Moreover, only a small share of these funds is set aside for the private sector (Figure 3). Public finance could be used as a mobilization tool for crowding-in private investment, which suggests a greater need for expanding the scope beyond loans and grants to make finance more accessible.²⁰ Public finance could contribute to risk mitigation measures to support private capital mobilization.

¹⁷ Bloomberg New Energy Foundation (BNEF). 2019. *The Clean Technology Fund and Concessional Finance: Lessons Learned and Strategies Moving Forward*. New York: BNEF.

¹⁸ REN21. 2019. *2019 Asia and the Pacific Renewable Energy Status Report*. Paris: REN21.

¹⁹ ADB. 2020. *Review of the ADB Clean Energy Program*. March. Manila: ADB.

²⁰ IRENA. 2016. *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance*. Abu Dhabi: IRENA.

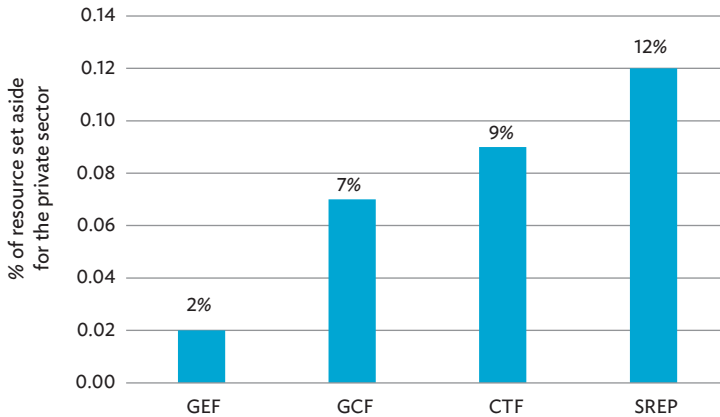
Table 1: Flow of Clean Energy-Related Climate Finance in Selected Countries, February 2019

Region	Country	Funding Amount Approved (\$ million)	Number of Projects	Major Funding Source
Northeast Asia	People's Republic of China	222	24	GEF
	Mongolia	73	9	GCF
Central Asia	Georgia	14	2	GEF
	Kazakhstan	281	12	GCF, CTF
	Uzbekistan	9	2	GEF
South Asia	Bangladesh	79	5	SREP
	India	1,077	34	CTF
	Pakistan	10	6	GEF
	Sri Lanka	6	2	GEF
Southeast Asia	Indonesia	538	22	CTF
	Myanmar	14	4	GEF
	Philippines	104	8	CTF
	Thailand	125	9	CTF
	Viet Nam	136	12	GCF
Pacific	Fiji	1	1	GEF
	Tonga	33	2	GCF
	Others	415	60	
Regional		1,212	45	
Total		4,349	259	

CTF = Clean Technology Fund, GCF = Green Climate Fund, GEF = Global Environment Facility, SREP = Scaling-up Renewable Energy Program.

Source: REN21. 2019. *2019 Asia and the Pacific Renewable Energy Status Report*. Paris: REN21.

Figure 3: Share of Selected Funds Set Aside for the Private Sector (%)



CTF = Clean Technology Fund, GCF = Green Climate Fund, GEF = Global Environment Facility, SREP = Scaling-up of Renewable Energy Program.

Source: C. Trabacchi et al. 2016. *The Role of Climate Investment Funds in Meeting Investment Needs*. London: CPI.

Domestic Public Finance

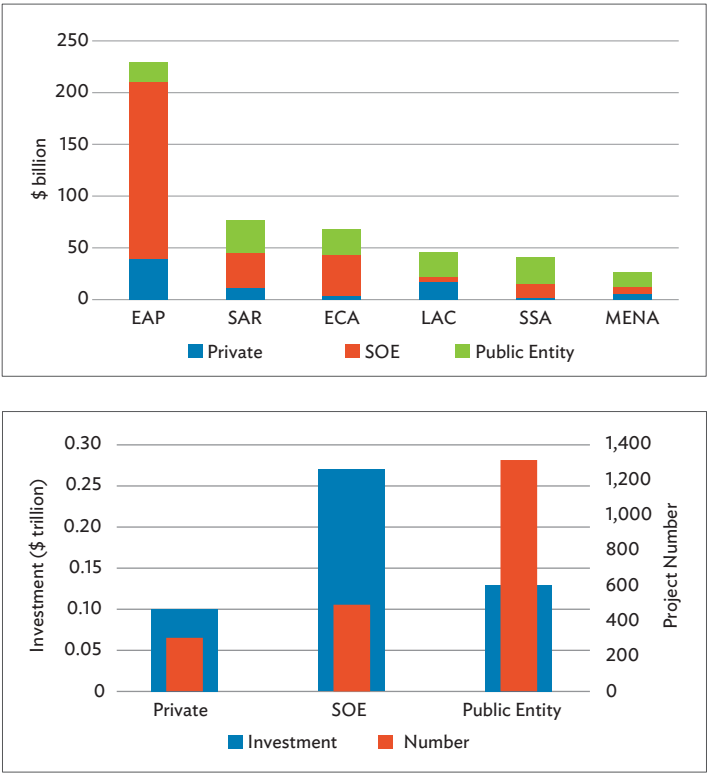
Domestic public finance comes from government budgets at the national, regional, and local levels. It also comes from national development banks and public financial institutions. Tax revenues collected by governments at different levels in Asia and the Pacific countries rely heavily on taxes on goods and services, followed by corporate taxes, and taxes on personal income.²¹ However, the median tax revenue in Asia as a share of gross domestic product is significantly lower than that in Europe or the Americas. Tax revenue is important but governments also resort to debt financing, particularly during periods of low interest rates on debt capital. National budgetary allocations are used to support key development priorities of national development plans, including energy and other infrastructure projects. Redirection of fossil fuel and electricity subsidies towards clean energy could also be considered in Asian economies.

²¹ United Nations Inter-agency Task Force on Financing for Development. 2020. *Financing for Sustainable Development Report 2020*. New York: United Nations.

A World Bank study found that in 2017, \$0.5 trillion was committed to infrastructure investment across low- and middle-income countries, of which \$0.1 trillion came from the private sector and the remainder were provided by public sector entities such as state-owned enterprises. In terms of project numbers, 1,806 projects were from the public sector and 305 projects were from the private sector (Figure 4, right panel).

Asian countries attracted almost 60% of investment commitments, with East Asia and the Pacific attracting the most (\$0.229 trillion) (Figure 4, left panel). The PRC was the top public finance mobilizer for infrastructure, followed by Indonesia, India, and Bangladesh; the PRC,

Figure 4: Infrastructure Project Investment Commitments, 2017

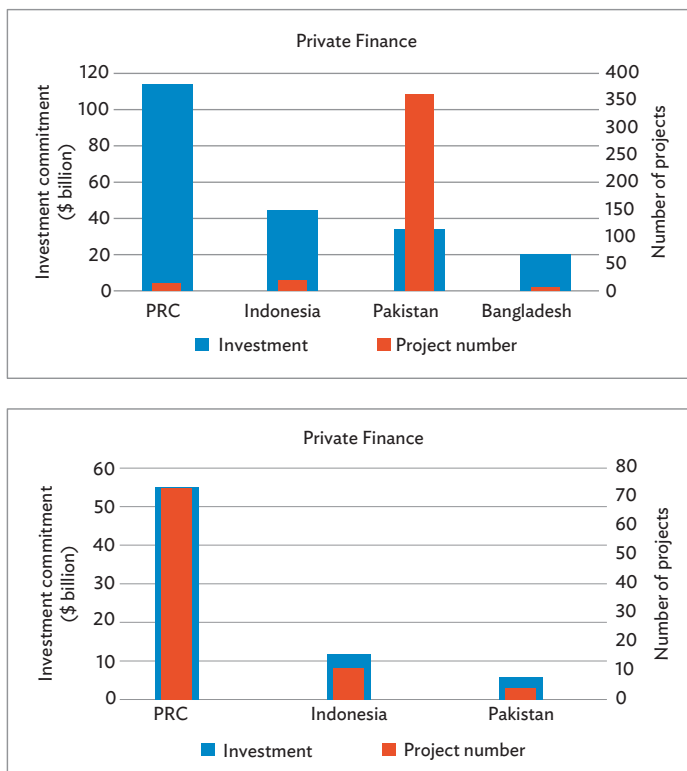


EAP = East Asia and the Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MENA = Middle East and North Africa, SAR = South Asian Region, SOE = state-owned enterprise, SSA = Sub-Saharan Africa.

Source: World Bank. 2019. *Who Sponsors Infrastructure Projects? Disentangling Public and Private Contributions*. Washington, DC: World Bank.

Indonesia, and Pakistan were the top private finance mobilizers for infrastructure projects (Figure 5).²² At the sector level, investment was geared towards energy (half of the total) and transport infrastructure (45%). East Asia attracted 35% of the global energy sector commitments. Most energy sector investments (79%) came from public sources. Public sector finance went to support hydropower projects, particularly in the PRC and Pakistan, whereas renewable energy generation projects received greater support from the private sector (footnote 21).

Figure 5: Top Mobilizers of Public and Private Investments in Asia, 2017



PRC = People's Republic of China.

Source: World Bank. 2019. *Who Sponsors Infrastructure Projects? Disentangling Public and Private Contributions*. Washington, DC: World Bank.

²² World Bank. 2019. *Who Sponsors Infrastructure Projects? Disentangling Public and Private Contributions*. Washington, DC: World Bank.

Governments have relied on national development banks to finance infrastructure projects and even support low-income households.²³ China Development Bank, the largest national development bank in Asia with asset holdings of \$2.5 trillion in 2019, has invested \$370 billion in clean energy projects to support 360 gigawatts (GW) of clean power capacity in the PRC, and has issued sustainability-themed green bonds worth \$1.5 billion.²⁴ India has several generic development banks such as the Industrial Credit and Investment Corporation of India and Industrial Development Bank of India, and nonbanking financial agencies such as the Indian Renewable Energy Development Agency Limited, but their asset holdings are relatively limited. As of 31 March 2020, the Indian Renewable Energy Development Agency Limited for instance had only \$3.73 billion in assets, though all of the agency's investment goes to clean energy.²⁵ National development banks have used infrastructure bonds to finance projects and in some cases, they offer tax relief to retail investors to mobilize finance. Local financial markets and suitable regulatory arrangements have facilitated domestic resource mobilization for clean energy projects in Asia.²⁶

Since the issuance of guidelines for the green financial system in 2016 that aimed at mobilizing and incentivizing capital flow to green sectors, Chinese banks have started to introduce green credit tools.²⁷ The Industrial and Commercial Bank of China and Shanghai Pudong Development Bank are emerging as leaders in green finance in the country. The share of green loans reached 10% of the overall credit balance of Chinese banks in 2019 and these loans are performing better than standard loans (footnote 26). Yet Chinese banks continue to lend significantly to fossil fuel industries and there is significant potential for them to rethink their business strategies.

²³ J. Luna Martinez and C. Vincente. 2012. Global Survey of Development Banks. *World Bank Policy Research Working Paper*. 5969. Washington, DC: World Bank.

²⁴ China Development Bank. 2019. *Sustainability Development Report 2019*. Beijing: China Development Bank.

²⁵ IREDA. 2020. *33rd Annual Report, 2019–20: Renewables for Aatmanirbhar*. New Delhi: Indian Renewable Energy Development Agency.

²⁶ B. Parthan. 2017. *Financing Energy Access in Asia*. In S. C. Bhattacharyya, ed. *The Routledge Handbook of Energy in Asia*. Abingdon, UK: Routledge.

²⁷ J. Choi, D. Escalante, and M. L. Larsen. 2020. *Green Banking in China – Emerging Trends: With a Focus on the Industrial and Commercial Bank of China (ICBC)*. London: CPI.

Private Sources of Finance

Private finance comes from the savings of individuals and corporations. A wide range of intermediaries are involved in the process of their aggregation, investment, and management.²⁸ The corporate sector is an important source of private finance and provides capital for projects from corporate savings. Equity injections can be made directly into a project or a company and often funding is undertaken through a special purpose vehicle for a project or in unlisted companies. Corporations also raise equity capital through capital markets by issuing public offers; they can further raise finance by issuing debt instruments, thereby mobilizing capital from individuals and other intermediaries. Such bonds generally involve larger amounts and allow the general public to participate in the investment process.

Institutional investors such as pension funds, insurance companies, and asset managers of mutual funds or portfolio management entities form the other important category of investors. They channel savings and funds from individuals and corporations and are classified as collective funds. **Commercial financial institutions** form the third source of private finance. They offer financial packages to ensure acceptable risk profiles of deals (footnote 9).

Globally, private finance accounted for 86% of renewable energy investments between 2013 and 2018 (footnote 11). Countries in Asia and the Pacific have attracted significant private finance for clean energy. With the development of bankable, utility-scale projects, the shift to private finance has been noticeable since 2010 (footnote 17). East Asia and the Pacific region has mobilized the most private finance for renewable energy, in the range of \$100 billion per year, while South Asia has attracted about 10% of East Asia, on average (footnote 11). Private investment in renewable energy has mostly remained in its country of origin. Most investment (about 90%) went to solar and wind technologies, indicating the maturity of these technologies (footnote 11). Project developers contributed 46% of the private capital while commercial financial institutions provided another 22% (footnote 11).

Venture capital supported the initial stages of developing renewable energy technologies. As the industry has matured, the need for risky capital has reduced as business entities move research and development in-house. Venture capital and private equity invested \$3 billion in 2019

²⁸ United Nations Environment Programme. 2014. *Demystifying Private Climate Finance*. Geneva: UNEP.

in renewable energy, with 60% going to solar PV.²⁹ India was the largest beneficiary, attracting \$1.4 billion. Solar and wind technologies have become relatively standard technologies, but other emerging technologies still need both venture capital and private equity, such as freshwater and near-shore floating solar PV. Ocean-based, marine, and tidal energy are also increasingly being explored. Progress with biofuels, including for production of green hydrogen and marine energy, has been less than expected. Consequently, venture capital investment remains somewhat low (footnote 28).

Alternative and Innovative Sources of Financing

A range of alternative financing sources may potentially support clean energy. Among them are philanthropic foundations, institutional investors—sovereign funds, pension funds, insurance companies—and high-worth individuals. Philanthropic foundations contributed \$24 billion globally between 2013 and 2015 but most of this went to health, education, and social well-being. Only \$0.8 billion went to environment-related areas.³⁰ This suggests some potential for realignment towards clean energy support. Philanthropic foundations prefer to support innovative ideas that may not attract funding from elsewhere. They also aim to generate positive outcomes to maintain or enhance their reputation.

Large institutional investors such as sovereign wealth funds, pension funds, and insurance funds constitute another potential source. They have more than \$100 trillion worth of assets under their management and their liabilities are long-dated. Clean energy is an appealing investment option for institutional investors because of potential long-term and stable cash flows.³¹ Sovereign wealth funds—“a pool of assets owned and managed directly or indirectly by governments to achieve national objectives”³² have an estimated asset base of \$8.2 trillion. However, sovereign funds derive 57% of their wealth from natural resources, mainly oil and gas, and

²⁹ Frankfurt School. 2020. *Global Trends in Renewable Energy Investment 2020*. Frankfurt: Frankfurt School–UNEP Centre.

³⁰ GCF. 2018. *Policies for Contributions from Philanthropic Foundations and Other Alternative Sources*. Incheon: GCF.

³¹ D. Rottgers, A. Tandon, and C. Kaminker. 2018. OECD Progress Update on Approaches to Mobilising Institutional Investment for Sustainable Infrastructure: Background Paper to the G20 Sustainable Finance. *OECD Environment Working Paper 138*. Paris: OECD.

³² PricewaterhouseCoopers. 2020. *Sovereign Investors 2020 – A Growing Force*. London: PricewaterhouseCoopers.

may have specific investment mandates to meet national objectives. These wealth funds are highly concentrated, with the top 20 funds controlling 90% of assets.³³ While funds in emerging and developing economies are growing faster—recording double digit growth rates between 2008 and 2018 due to the expansion of pension plans and insurance companies—they often take a risk-averse investment approach.³⁴ As commercial investors, they can invest in low-carbon assets and technology innovations, divesting from high carbon assets, and promoting adoption of clean energy in portfolio companies (footnote 32). Only 0.15% of institutional assets are invested in clean energy, due to their low exposure to infrastructure assets, which in turn arises from their passive attitude to climate risk and climate impact (footnote 33). Accordingly, significant scope exists for unlocking further finance from these sources. For instance, the Norwegian government has approved the diversification of Norway's \$1 trillion sovereign funds to invest in unlisted infrastructure projects. Since 2016, the fund manager has excluded firms that derive more than 30% of their income from coal and their divestments will continue to grow in the future, releasing additional finance for clean energy projects (footnote 33).

Pension funds held \$45 trillion in assets globally in 2018 and constitute the largest group of institutional investors (footnote 33). Public pension funds held 68% of the assets in 2016 (footnote 33). With an objective of ensuring future pension payments to members, these investors adopt a conservative approach to investment. Of the two common types of pension plans, defined-benefit plans are more suited to renewable energy investments due to their long-term investment horizon and relatively low return requirements (footnote 33). While 84% of pension funds are concentrated in developed markets, funds in emerging markets are growing faster. Mobilizing these resources could release financial resources for clean energy. Similarly, insurance companies commanded more than \$33 trillion in assets in 2018 but 60% of the assets were located in Western Europe and North America (footnote 33). However, insurance premiums in Asia and the Pacific, and other emerging markets, are growing at a fast rate. Long-term life insurance portfolios are most aligned with clean energy investments.

So far, institutional investors have played a very minor role in financing clean energy projects, with only 2% of institutional investors having made direct investment in the sector globally (footnote 33). Only experienced institutional investors take the direct investment route, while the vast

³³ OECD. 2020. *The Role of Sovereign and Strategic Investment Funds in the Low-Carbon Transition*. Paris: OECD.

³⁴ IRENA. 2020. *Mobilising Institutional Capital for Renewable Energy*. Abu Dhabi: IRENA.

majority prefer indirect investments. More targeted engagement with this group for both direct and indirect investment in the sector will create opportunities for alternative finance.

A new trend is also emerging, where a pool of capital from foundations is being used for specific purposes. For example, four United States (US)-based foundations—the William and Flora Hewlett, John D. and Catherine T. MacArthur, and David and Lucile Packard Foundations, and Jeremy and Hannelore Grantham Environmental Trust—have jointly supported multiple initiatives in India, including the US–India Catalytic Solar Finance Program, to support development of risk mitigation vehicles for the renewable energy sector.³⁵ This trend extends to a global pool of institutional funds, who are willing and prepared to support India’s renewable energy transformation over the next decade.³⁶

Green finance—such as raising funds via green bonds—is an emerging area of interest for clean energy. The European Investment Bank introduced a green bond in 2007, and the World Bank entered the space in 2008.³⁷ The market size grew to more than \$250 billion in 2019. European countries account for 45% of the market volume, followed by Asia and the Pacific (25%) and the US (23%). The proceeds mainly go to energy and buildings, each taking a 30% share each.³⁸ The PRC was the largest green bond issuer in the world in 2019, with a cumulative issuance of about \$140 billion.³⁹ The green bond market in India started in 2015 with most proceeds (83%) going to the energy sector.⁴⁰ Within the members of the Association of Southeast Asian Nations, Singapore is the largest issuer of green loans (\$6.2 billion) followed by Indonesia (\$2.88 billion). One-third of green finance in these member nations has gone to the energy sector (footnote 37).

³⁵ J. Thuard, H. Koh, A. Agarwal, and R. Garg. 2019. *Financing the Future of Asia: Innovations in Sustainable Finance*. Boston: FSG.

³⁶ T. Buckley and S. Trivedi. 2021. *Capital Flows Underpinning India’s Energy Transformation: Global Capital is Primed and Ready*. Lakewood, OH: Institute for Energy Economics and Financial Analysis.

³⁷ D. Azhgaliyeva, A. Kapoor, and Y. Liu. 2020. *Green Bonds for Financing Renewable Energy and Energy Efficiency in South East Asia: A Review of Policies*. ADB Institute Working Paper. No. 1073. Tokyo: Asian Development Bank Institute (ADBI).

³⁸ Climate Bonds Initiative. 2020. *2019 Green Bond Market Summary*. London: Climate Bonds Initiative.

³⁹ Climate Bonds Initiative. 2020. *China Green Bond Market 2019 Research Report*. London: Climate Bonds Initiative.

⁴⁰ Climate Bonds Initiative. 2018. *India Country Briefing—July 2018*. London: Climate Bonds Initiative.

Carbon pricing in the form of taxes, emissions trading (i.e., revenues from auctioned emissions trading allowances), and other direct payments toward climate obligations raised \$45 billion globally in 2019. Carbon pricing initiatives comprising 31 emissions trading systems and 30 carbon tax regimes as of 2020 cover 22% of global carbon emissions.⁴¹ While emissions trading is being introduced in several Asian countries, other market-based mechanisms such as the Clean Development Mechanism and voluntary offset mechanisms have already benefited the region. East Asia and the Pacific accounted for 44% of the total carbon credits issued and these project-based interventions have offered cost-effective solutions and supported uptake of new technologies (footnote 40). However, uncertainties surround the future of Kyoto Protocol instruments. The Paris Agreement has placed significant emphasis on appropriate carbon pricing to mitigate the climate change threat and it is likely that more countries will adopt carbon pricing mechanisms. The revenue from these mechanisms will have the potential of unlocking private investments in clean energy solutions.

Crowdfunding has also been used as a source of finance, particularly for small projects.⁴² Crowdfunding mechanisms may be one of the following:⁴³

- (i) donor-based, where donors do not receive compensation for their support from the project. This is popular with nonprofit and nongovernment organizations;
- (ii) reward-based, where funders receive some compensation for their contribution and such rewards improve their likelihood of contribution;
- (iii) equity-based, where contributors are treated as conventional investors and receive rights for investing in projects; and
- (iv) debt-based, where investors lend money and receive interest payments.

⁴¹ World Bank. 2020. *State and Trends of Carbon Pricing in 2020*. Washington, DC: World Bank.

⁴² Crowdfunding has been defined as “the efforts by entrepreneurial individuals and groups—cultural, social, and for-profit—to fund their ventures by drawing on relatively small contributions from a relatively large number of individuals using the internet, without standard financial intermediaries.” E. Mollick. 2014. The Dynamics of Crowdfunding: An Explanatory Study. *Journal of Business Ventures*. 29: 1–16.

⁴³ J. Horisch. 2018. ‘Think Big’ or ‘Small is Beautiful’? An Empirical Analysis of Characteristics and Determinants of Success of Sustainable Crowdfunding Projects. *Int. J. Entrepreneurial Venturing*. 10 (1): 111–129.

Debt crowdfunding forms the largest share of global crowdfunding volume.⁴⁴ While institutional investors rely on a commercial logic for investment, small investors are also influenced by noncommercial factors such as community well-being and improving the world. This can benefit the clean energy sector through direct support for projects as well as investments in innovative ideas that may be difficult to finance through conventional channels. Some \$34 billion is estimated to have been raised globally for projects through crowdfunding in 2015 and by 2025 this may reach \$100 billion (footnote 29).

Status of Clean Energy Finance in Asia

Globally, \$282 billion was invested in 2019 in renewable energy technologies, with wind power (\$138 billion) overtaking solar PV (\$131 billion) investments in the year (footnote 28). Significantly more investment went to renewable energy compared to conventional technologies—fossil fuel-based power received \$130 billion and nuclear power received \$39 billion in the same year (footnote 7). The PRC (\$83.4 billion), the US (\$55.5 billion), European Union (\$54.6 billion), and countries in Asia and the Pacific (\$45.1 billion, with about \$15 billion in developing countries) accounted for about 85% of the global investments. Table 2 provides the technology breakdown for the PRC, India, and the rest of Asia and the Pacific developing countries (footnote 28). Between 2010 and 2019, \$2.7 trillion was invested in new renewable energy, with solar PV attracting \$1.4 trillion and wind receiving \$1.1 trillion.

Table 2: Renewable Energy Investment in Asia, 2019
(\$ billion)

Technology	People's Republic of China	India	Other Developing Countries in Asia and the Pacific
Solar photovoltaic	25.7	6.6	5.0
Wind	55.0	2.2	8.6
Small hydro/geothermal	1.2	0.1	0.4
Biomass and waste	1.5	0.3	0.4
Biofuels/others		0.2	0.8
Total	83.4	9.3	15.2

Source: Frankfurt School. 2020. *Global Trends in Renewable Energy Investment 2020*. Frankfurt: Frankfurt School–UNEP Centre.

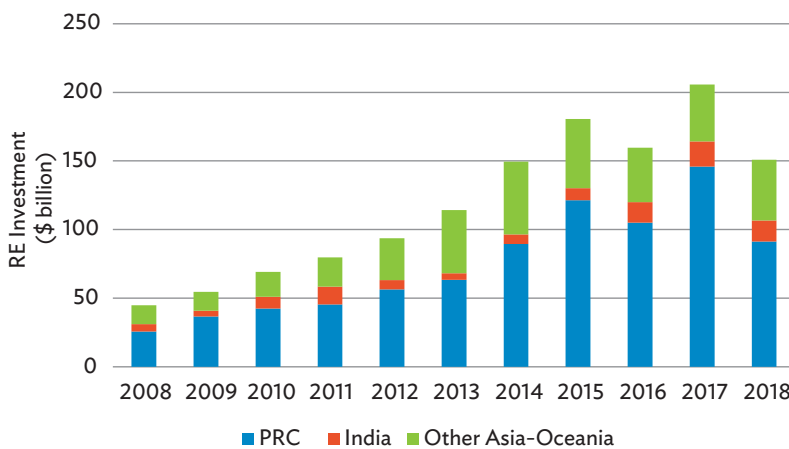
⁴⁴ A. Bockel, J. Horisch, and I. Tenner. 2020. A Systematic Literature Review of Crowdfunding and Sustainability: Highlighting What Really Matters. *Management Review Quarterly*. 71: 433–453.

The PRC alone invested \$818 billion during this period, while India invested \$90 billion (footnote 28).

The investment trend in renewable energy in Asia and the Pacific between 2008 and 2018 shows significant growth in investment (Figure 6). The PRC accounted for 62% of the investments on average (footnote 17). Government incentives and support mechanisms have always played an important role in ensuring the bankability of renewable energy projects. Three types of instruments were widely used: (i) feed-in tariff, which guarantees a fixed long-term tariff for the output; (ii) renewable energy certificates, which provide supplementary income to projects in addition to income received from the sale of electricity in the market; and (iii) tax-subsidy incentives (footnote 28). Similarly, power purchase agreements (PPAs) have also emerged as a contractual arrangement to ensure project viability. Wind power projects dominate in the utility-scale projects, followed by utility-scale solar projects, and both have benefited from purchase agreements. Corporate PPAs have emerged as a new instrument to manage risk in renewable energy investment (footnote 17).

In line with global trends, private investments formed the major share of financing in the Asia and the Pacific region, and public source finance played a supporting role.

Figure 6: Investment Trends, 2008–2018
(\$ billion)



PRC = People's Republic of China, RE = renewable energy.

Source: REN21. 2019. *2019 Asia and the Pacific Renewable Energy Status Report*. Paris: REN21.

Financing Instruments and Mechanisms

A range of financial instruments is commonly used to channel financial resources to users (footnote 10).

Grants do not require any repayment and can come in the form of a capital subsidy or operating cost subsidy. **Concessional debt** on the other hand offers lending at below market rate and the purpose is to bring down the cost of borrowing. **Asset financing** for large utility-scale projects relies on two common approaches: (i) financing on the strength of the project sponsor's balance sheet (on-balance sheet financing), and (ii) nonrecourse basis of financing (project finance). In the case of on-balance sheet financing, the utility or energy company will rely on its financial abilities to promote the project. The risk of any debt or finance raised is borne by the company and is reflected in its balance sheet. For nonrecourse financing, a special purpose vehicle is set up where the parent company only makes an equity contribution. The developer bears only a part of the project risk in this case and debt finance is raised based on the strength of the project, which is not related to the financial abilities of the promoters. The lenders have no recourse of recovering the debt beyond the special purpose vehicle. In 2019, 65% of asset financing for clean energy was done through on-balance sheet financing and the remainder was done through nonrecourse financing (footnote 28). High preference for on-balance sheet financing is attributed to ease of execution and non-familiarity with nonrecourse financing in newer markets where risks are not well understood.

Most utility-scale projects are financed through a combination of debt and equity. There is some variation in debt–equity ratio across technologies and across countries. However, transactions do not always reveal the financial structure and accordingly, a truly reflective picture is hard to obtain. For 2015–2016, global average debt–equity ratio for solar projects was reported at 69% whereas for onshore wind projects it was estimated at 77%.⁴⁵ In Asia, the PRC projects tend to report a higher share of debt compared to Indian projects. For example, solar projects in the PRC were reported to have a debt–equity ratio of 69% during 2015–2016, whereas in India it was 61%. Similarly, onshore wind projects in the PRC have an average debt share of 80%, whereas in India the share is reported at 62% (footnote 45).⁴⁶

⁴⁵ IRENA and CPI. 2018. *Global Landscape of Renewable Energy Finance 2018*. Abu Dhabi: IRENA.

⁴⁶ A limited number of projects disclosing their financial details in India may be responsible for the lower figure.

The dominant role of private sector finance in renewable energy has meant that debt finance at commercial rates is widely used. This is true for balance sheet financing and project finance. Concessional debt plays a minor role and benefits only a small set of countries with less mature clean energy markets.

Building generation capacity, both grid-connected and off-grid systems, on the other hand, involves a range of players, such as households and small and medium enterprises. These projects rely on a combination of own capital (equity), grants, and loans. Government subsidies in the form of capital grants have played an important role in incentivizing the capacity addition. Own-capital contribution tends to vary but is considered to play a small role. Depending on the business model used, the loan capital can consist of a combination of concessional loans and loans at commercial rates. However, access to debt finance remains challenging for small-scale projects due to them being in the early stage of the business and a lack of track record of small investors. Consequently, the role of concessional finance remains crucial (footnote 19).

Financial instruments are generally related to the purpose of the funding source. For example, as of 15 June 2020, GCF funds were distributed in the form of grants (50%), debt (40%), equity (4%), results-based payments (4%), and risk guarantee instruments (2%). Some 64% of the funds went to the public sector, and the rest to private sector entities.⁴⁷ GEF only provided grant funding until 2014, but during that year a non-grant instrument was piloted to improve leveraging of financing through enhanced private sector contribution. Based on the experience of the pilot, funding using the non-grant instrument has been expanded.⁴⁸ Multilateral and bilateral climate finance has mainly come in the form of grants and concessional loans, while MDBs have mainly provided concessional loans and only a limited number of grants (Figure 7). However, MDB financing varies depending on the country, with states in fragile and conflict-affected situations tending to be eligible for concessional finance. For example, out of 40 members eligible for grant assistance from ADB, 10 are classified as fragile and conflict-affected situations and eight of them are small island developing states (SIDS). Seven SIDS receive 100% concessional finance and 13 have access to concessional finance.⁴⁹

⁴⁷ GCF. 2020. *GCF at a Glance – Project Portfolio*. Incheon: Green Climate Fund.

⁴⁸ GEF. 2018. *GEF-7 Non-Grant Instrument Program*. Washington, DC: GEF.

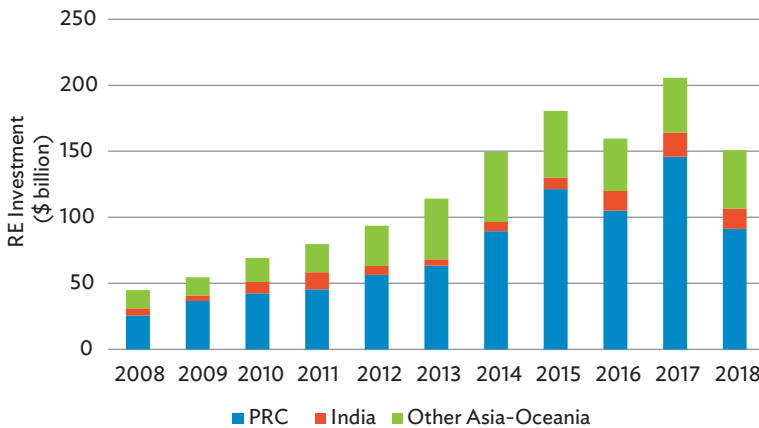
⁴⁹ ADB. 2019. *A Framework for Addressing the Financing Needs of Small Island Developing States*. Manila: ADB.

National development banks on the other hand offer long-term loans, loans for working capital, short-term loans, and syndicated loans. They also offer loan guarantees, private equity, and venture capital. National development banks offer loans at market rates and at concessional rates, with low-priced debt sourced through government funding, low-cost lines of credit from bilateral and multilateral financial institutions, and cross-subsidization from other profitable products.⁵⁰

In 2017, state-owned projects globally on average had 59% equity component whereas privately promoted projects had only 30% equity (Figure 8). Similarly, for public infrastructure projects, bilateral and multilateral financing support accounted for more than 70% of debt while for private projects, 65% of the debt came from commercial and public banks (footnote 21).

Creating an ecosystem to support project sponsors to ensure access to affordable, flexible, and tailored financing solutions for clean energy projects across Asia and the Pacific remains a challenge. Tested and widely

**Figure 7: Mix of Instruments Used
for International Public Climate Finance, 2015–2016**



PRC = People's Republic of China, RE = renewable energy.

Source: UNFCCC Standing Committee on Finance. 2018. *2018 Biennial Assessment and Overview of Climate Finance Flows, Technical Report*. Bonn: UNFCCC.

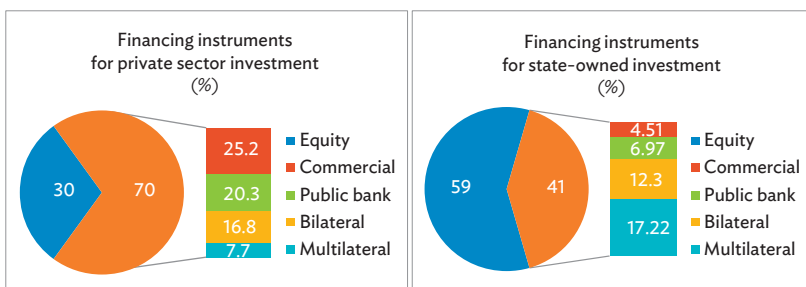
⁵⁰ World Bank Group and World Federation of Development Financing Institutions. 2018. *2017 Survey of National Development Banks*.

used instruments include guarantees, letters of credit, down payment refinancing, and joint liability instruments (footnote 11). Loan guarantee mechanisms were used in Asia at the early stage of market development. MDBs have offered loan guarantees and partial guarantee mechanisms to de-risk private investment in renewable energy investments (footnote 25).

A range of policy instruments have been used to mobilize private finance for clean energy. Among these, feed-in tariffs, auctions, and renewable obligations were most effective.⁵¹ Innovative instruments for financing and risk mitigation are gaining attention—for instance, the Global Innovation Lab for Climate Finance promoted by the Climate Policy Initiative (CPI) has supported various ideas in this area, including securitization, structured funds, result-based payments, insurance, and conditional lending (footnote 11).

Similarly, various financial institutions are participating in developing debt-based instruments such as on-lending, syndication, and co-lending structures to facilitate and improve access to local debt capital. In addition, financing vehicles such as YieldCos are emerging in some markets. This is where developers spin-off renewable assets to form new companies for accessing new equity capital through initial public offerings. This allows institutional investors to acquire renewable energy assets (footnote 19).

Figure 8: Comparison of Financing Structure of Public and Private Infrastructure Projects Globally, 2017



Source: World Bank. 2019. *Who Sponsors Infrastructure Projects? Disentangling Public and Private Contributions*. Washington, DC: World Bank.

⁵¹ F. Polzin et al. 2019. How Do Policies Mobilize Private Finance for Renewable Energy?—A Systematic Review with an Investor Perspective. *Applied Energy*. 236: 1249–1268.

Tailor-made solutions for small-scale clean energy investments include support for microfinance institutions and financial intermediaries. Small-ticket investments by small-scale enterprises and households can be facilitated by microfinance institutions. Here concessional public finance can help reduce the cost of finance. An ecosystem of financial intermediaries to channel the funds is essential (see Overcoming Barriers below).

Key Barriers Related to Investment in Clean Energy

Investment in clean energy projects faces a range of barriers. These can be categorized into relating to: (i) the business environment, (ii) the nature of the investment, and (iii) the weakness of financial markets.

The Business Environment

The COVID-19 pandemic and recession in 2020 have caused a significant slowdown in energy sector investments due to reduced income and lower demand. Restrictions on mobility as well as delays in shipping have also affected investments due to a slowdown in construction activities. Governments around the world face higher debt burdens in order to provide more support to citizens, which may lead to reduced support for state-owned enterprises. Liquidity problems could hinder investments in clean energy. In addition, the bankability of clean energy projects may be affected as support is reduced or withdrawn (footnote 7).

Expansionary monetary policies being followed by central banks could lead to unsustainable levels of debt in emerging economies. Higher sovereign risk is likely to force commercial lenders to increase their risk premiums, implying reduced equity funds available for investment. Taken together, the cost of capital may rise, which in turn may slow improvements in the leveled cost of electricity from clean energy sources. The pandemic has also affected the supply chain and availability of skilled staff, which in turn may disrupt project completions. Due to the long lead times of energy projects, the effects of investment curtailments show up with a lag, and this may create market imbalances as the world enters the post-recession recovery period. Imbalances in supply and demand may lead to market volatilities and uncertainties (footnote 7).

Investment in clean energy reduced in 2020, and may also fall short of the level of investment needed for a sustainable future. More importantly, the present crisis may also make investors more risk averse (footnote 7).

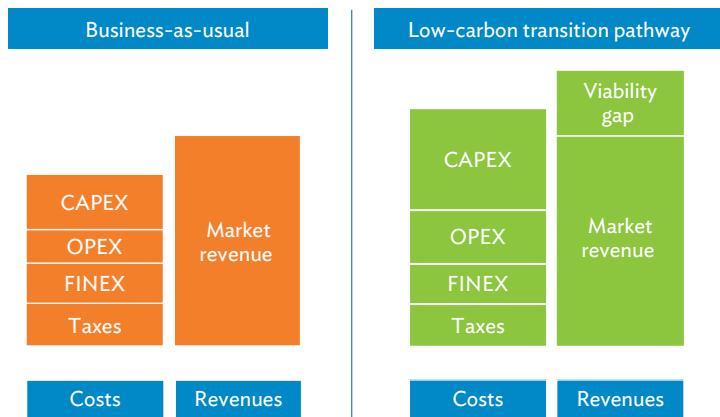
The Nature of the Investment

Several barriers arise due to the nature of the projects being financed.

Viability Gap

Despite falling costs of renewable energy technologies, a viability gap can still exist between the business-as-usual development scenario and the low-carbon, climate resilient pathway (Figure 9).⁵² Up-front capital costs for hydro, wind, and PV power projects globally account for 84%–93% of the project cost, while for gas-based plants they account for 24%–37%, and for coal 66%–69%.⁵³ Falling technology costs may not benefit all countries equally. For instance, the small island economies of the Pacific still face

Figure 9: Viability Gap



CAPEX = capital expenses, FINEX = financial expenses, OPEX = operating expenses.

Source: C. Trabacchi et al. 2016. *The Role of Climate Investment Funds in Meeting Investment Needs*. Climate Policy Initiative.

⁵² C. Trabacchi et al. 2016. *The Role of Climate Investment Funds in Meeting Investment Needs*, Climate Policy Initiative.

⁵³ D. Abramskieln et al. 2017. *Supporting National Development Banks to Drive Investment in the Nationally Determined Contributions of Brazil, Mexico, and Chile*. Washington, DC: Inter-American Development Bank.

relatively high costs to implement well-established clean technologies due to their remote location and small market size. In addition, the cost of capital in developing countries remains significantly higher compared to developed countries. The benchmark weighted average cost of capital in Organisation for Economic Co-operation and Development (OECD) countries for 2017–2018 varied between 2.5% and 6.5% while the same for emerging economies was between 5% and 11% (footnote 16).

Other Barriers

Other barriers include political and regulatory risks, off-taker risks, technical risks related to resources (as in geothermal projects) and grid connectivity, and currency and liquidity risks (footnote 19). In addition, small project sizes compared to the investment threshold of funding agencies, high transaction costs, and limited creditworthiness of enterprises affect access to institutional finance (footnote 19).⁵⁴ Competition from dirty projects, low demand, the high risk of green investment projects, and lack of capacity of financial institutions also obstruct investment (footnote 26).⁵⁵ Structural issues such as network capacity constraint in the power sector in Asian developing countries add to the investment risk.⁵⁶ In Southeast Asia, larger economies (Indonesia, Malaysia, the Philippines, and Thailand) have more experience with renewable energy investments but smaller economies have weaker capital markets and face greater political and commercial risks. Similarly, lack of risk mitigation options, inadequate equity capital availability, and small project size are barriers to accessing finance.⁵⁷

The Weakness of Financial Markets

Several developing Asian countries do not have developed bond markets nor mature capital markets (footnote 53). Moreover, traditionally financial institutions of the region have high exposure to conventional energy projects, and mobilizing additional loans for renewable energy projects is difficult due to the crowding-out effect, particularly in India (footnote 55). Access to low-cost finance and a shortage of sufficient long-term capital

⁵⁴ Also see M. Hossain. 2018. *Green Finance in Bangladesh: Policies, Institutions and Challenges*. ADBI Working Paper Series. No. 892. November. Tokyo: ADBI.

⁵⁵ A. Khan et al. 2017. *Financing Green Growth in Bangladesh: Challenges & Opportunities*. Dhaka: UKAID.

⁵⁶ G. Sarangi. 2018. *Green Energy Finance in India: Challenges and Solutions*. Tokyo: ADBI; and L. Jena and C. M. Shrimali. 2018. *Getting to India's Renewable Energy Targets: A Business Case for Institutional Investment*. London: CPI.

⁵⁷ IRENA. 2018. *Renewable Energy Market Analysis Southeast Asia*. Abu Dhabi: IRENA.

are important barriers. Lack of national development bank capacities in terms of project risk assessment and conservative investment mandates are also obstacles. Local teams meanwhile may lack the technical ability to identify green projects and assess their risks, while also lacking an understanding of innovative financial instruments (footnote 52). In addition, being state-sponsored entities, national banks often support projects with questionable bankability, leading to higher than average nonperforming assets and financial losses. As new development banks are rarely allowed to fail, governments must intervene through fresh capital injection, which ultimately passes the burden on to taxpayers (footnote 49).

Overcoming Barriers

A suite of interventions and measures can be considered to overcome these barriers to investment in clean energy. A strategy of post-COVID-19 recovery focused on a clean energy transition offers the opportunity for stimulating a structural shift towards a sustainable future. In the short term, a stimulus for clean energy investment will create jobs, boost economic outputs, and offer environmental benefits. Simultaneously, it allows better alignment with a long-term low-carbon pathway and supports national pledges made under the Paris Agreement (footnote 8).

In order to implement a clean energy-driven recovery strategy, mitigation measures to overcome financial risks will play an important role. Considering that most investments will come from the private sector, risk mitigation instruments such as guarantee instruments and currency and liquidity risk management instruments will be essential. For example, to reduce off-taker risk, a transparent payment security mechanism with a risk mitigation measure could be implemented; to reduce exchange rate risk, a hedging facility and an exchange risk guarantee could be useful.⁵⁸ A concessional capital grant would help reduce the capital investment requirement of an investor, while a concessional loan would reduce the weighted cost of capital. One study found that concessional finance can reduce the levelized cost of electricity by 2%–7% for solar PV projects and 4%–8% for onshore wind projects (footnote 16).

Developing a pipeline of clean energy investment projects will facilitate project identification, and scaling-up of projects could be achieved through standardization and aggregation (footnote 19). Aggregation is particularly relevant for small-ticket projects and an aggregator as an intermediary

⁵⁸ L. Jena and C. M. Shrimali. 2018. *Getting to India's Renewable Energy Targets: A Business Case for Institutional Investment*. London: CPI.

entity can be the missing link. Dedicated national financing vehicles could help bridge the gap between international finance and domestic finance. The issuance of green bonds could support mobilization of national capital markets (footnote 56).

Technical assistance and capacity building will be important to help new development banks make better decisions about their interventions. Meanwhile, better corporate governance through autonomy of boards of directors and independence from the political decision-making process is essential.

Clean Energy Financing Experiences from Asia and the Pacific

This section focuses on five case studies to highlight how countries in Asia and the Pacific have approached clean energy financing. Lessons for other countries are summarized at the end.

Green Finance in the People's Republic of China

The PRC is the global leader in green finance. Since the publication of the *Guidelines for Establishing a Green Financial System*⁵⁹ in 2016 by the People's Bank of China, the PRC has made significant progress in mobilizing resources through green bonds and in offering green financial instruments.⁶⁰ The National Development and Reform Commission also issued separate guidelines in 2016 to establish the market.

The PRC's first green bond issue was made offshore by the Goldwind company in 2015. Since then, the PRC has mobilized more than \$170 billion through green bonds.⁶¹ In 2019, the PRC issued close to \$56 billion worth of green bonds through financial corporations, nonfinancial corporations, local government entities, and asset-backed securities. The finance raised through the bonds in 2019 mainly went to the transport (26%) and energy sectors (27%). Around 60% of the bonds have a tenor of 5 years or less—these are mainly issued by financial corporations. Another 33% of the bonds

⁵⁹ The People's Bank of China. 2016. *Guidelines for Establishing a Green Financial System*.

⁶⁰ B. Jiang, J. Guo, and R. Gordon-Jones. 2018. *Financial Services Report: China's Green Finance Market*. Beijing: British Embassy, Beijing.

⁶¹ Climate Bonds Initiative. 2020. *China Green Bond Market 2019 Research Report*. London: Climate Bonds Initiative.

have a tenor of 5–10 years, and these are mainly issued by nonfinancial corporations. The longest tenor bond of 30 years was issued by Jiangxi Province. Most of the bonds have an AAA rating by domestic ratings agencies; the average coupon rate for AAA-rated bonds was 4.22% in 2019 (footnote 60). Almost one-fifth of the green bonds were issued in offshore markets.

The green credit portfolio has proliferated as well. By 2019, green loans reached a cumulative size of 10 trillion yuan (\$1.5 trillion) and an overall share of more than 10% in the overall credit balance (footnote 60). The introduction of state-owned commercial banks—now the main players in the green loans market—has started to change lending behavior, with banks starting to integrate green criteria into their lending decisions. The performance of assets has improved, reducing the share of nonperforming loans in overall nonperforming assets (footnote 26).

It is worth noting that the PRC's green bond definitions do not always align with international definitions. In addition, more transparency is required in terms of use of proceedings, because there is some concern about use of the finance to support working capital needs of the companies (footnote 60). While banks have dominated the market, there is potential for expanding the scope by including pension funds and even the issuance of a sovereign green bond (footnote 60).

Microfinance in Bangladesh

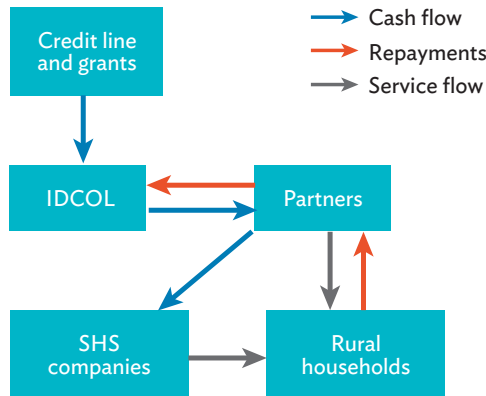
Bangladesh pioneered the microfinance model, and its flagship solar home systems (SHS) program is one of the most successful green energy finance programs in the world. Through a nonbank public financing institution, Infrastructure Development Company Limited (IDCOL), the SHS program has distributed more than 4 million SHS and provided access to electricity for 20 million people (footnote 53). IDCOL received initial support for its SHS program from the World Bank and GEF in the form of credit and grants in 2003. Many other multilateral organizations and donor agencies (including ADB) have since provided financial support to the program.⁶² As of 2016, IDCOL had invested \$696 million in its SHS program, of which \$600 million was in the form of loans, and the rest as grants (footnote 61).

⁶² A. Khan, B. F. Khan, N. Uddin, G. I. Azim, and S. Islam. 2017. *Financing Green Growth in Bangladesh: Challenges and Opportunities*. Dhaka: UKAID.

IDCOL provides soft loans and grants to 56 partner organizations who implement the SHS program in the field. Partner organizations receive capital buy-down grants, institutional development grants, and credit for refinancing the SHS. IDCOL offers the credit at an interest rate of 6%–8% per year for a repayment period of 6–8 years. A household buys the SHS in installments over a 3-year period and pays interest of 12% (footnote 53). The financing model is described in Figure 10.

The sale of SHS peaked in 2013 and has declined sharply since then due to a reduction in subsidies, provision of free SHS by the government, and extension of the grid by the Bangladesh Rural Electrification Board (footnote 61). The subsidy is important to ensure the affordability of SHS for low-income households, but the need for such a capital subsidy makes the commercialization of the program difficult. IDCOL was accordingly not successful in transforming its successful program into a commercial activity and had to abandon the SHS program in the end (footnote 53). This raises questions about the sustainability of such a program in the long term and suggests the need for stronger coordination and planning of electricity supply activities within a country.

Figure 10: Bangladesh Solar Home Systems Financing Model



IDCOL = Infrastructure Development Company Limited, SHS = solar home system.

Source: Adapted from B. Parthan. 2017. Financing Energy Access in Asia. In S. C. Bhattacharyya, ed. *The Routledge Handbook of Energy in Asia*. Abingdon, UK: Routledge.

Corporate Power Purchase Agreements for Clean Energy in India

In 2018, commercial and industrial users in India accounted for 51% of electricity consumption; 3% of overall electricity came from renewable sources.⁶³ These users have three options for renewable power procurement: (i) on-site generation, mainly using rooftop solar PV; (ii) purchasing from off-site producers using open-access wheeling; and (iii) buying renewable energy certificates.

However, Indian on-site models have been difficult to develop due to space restrictions, while purchasing from off-site producers has been difficult due to the removal of a waiver of cross-subsidy surcharges. In this context, the corporate power purchase agreements (PPAs) is emerging as an option.⁶⁴ The Indian Electricity Act allows commercial and industrial consumers to set up group-captive power plants for collective use, where they must own 26% equity and consume 51% of the produced electricity.⁶⁵ Renewable energy producers can develop the projects and wheel the power to the captive users and sell the rest as part of the renewable purchase obligation of the distribution companies. These arrangements allow the corporations to control their electricity expenditure over a long period and offer an opportunity to contribute towards the climate change challenge (footnote 64). Indian corporations have signed more than 5 GW of clean power procurement deals as of 2019, making it the largest market in Asia.⁶⁶

In the first phase of this development, PPAs with off-site generators for wheeling dominated the market. But most Indian states have withdrawn open-access fee waivers for these PPAs, giving rise to group-captive PPA models. Some states have waived open-access charges for private solar energy projects if they are used within the state and this can be used to fulfill their renewable purchase obligations. This change in policy has made the group-captive power projects more attractive for corporations (footnote 64).

⁶³ V. Aggarwal, B. Prasad, and A. Makhija. 2019. *Global Corporate Renewable Power Procurement Models: Lessons for India*. New Delhi: WWF India.

⁶⁴ A corporate PPA is a contractual arrangement between corporate buyers and renewable power producers specifying the terms and conditions of purchase electricity.

⁶⁵ World Business Council for Sustainable Development (WBCSD). 2019. *Corporate Renewable PPAs in India: A Market & Policy Update*. December. Geneva: WBCSD.

⁶⁶ A. Gadre et al. 2020. *India's Clean Power Revolution: A Success Story with Global Implications*. New York: BNEF.

Several Indian corporations, such as Infosys, Tata Motors, and Dalmia Cement, have committed to 100% renewable energy by joining the global corporate renewable energy initiative known as the RE100 initiative.⁶⁷ The corporate PPA arrangement could support them in meeting their voluntary targets. The cost of landed power is less than the price offered by third-party generators and the commitment is short compared to feed-in tariffs. While the arrangement may be beneficial for corporations, it may not be a direct substitute of feed-in tariffs, as bankable projects would require too much equity contribution, which is unlikely to materialize through nonrecourse financing.⁶⁸

Financing Energy Efficiency in Thailand

Members of the Association of Southeast Asian Nations have set a target of reducing energy intensity by 20% by 2020 and 30% by 2025 compared to 2005. Financing energy efficiency interventions remains an important challenge and projects with potentially high rates of return are not being taken up due to high investment risks, lack of information and awareness about incentives, and lack of skills.⁶⁹

Traditionally, energy efficiency has been self-financed, but this may be inadequate in several cases, such as for replacement of inefficient equipment, during design and construction of new buildings, and in cases where investors are not convinced about the benefits of the investment (footnote 36). Bank loans predominantly finance energy efficiency interventions but supply tends to be inadequate. This means alternative sources of finance are needed.

Energy service companies (ESCOs) provide energy-related services, including energy efficiency projects, financed through energy savings. However, as large financial institutions show limited interest in the average investment of \$1 million required by ESCO projects, several countries in the region have set up dedicated funds to support energy efficiency interventions. For example, Thailand has set up an ESCO Fund to provide equity finance and equipment leasing to ESCOs. Thailand also set up the Energy Efficiency Revolving Fund to provide low-cost loans to banks for onward lending to project developers.⁷⁰ The fund offered loans at 0.05%

⁶⁷ RE100 Climate Group.

⁶⁸ K. Ryszka. 2020. *Renewable Project Finance: Can Corporate PPAs Replace Renewable Energy Subsidies?* RaboResearch.

⁶⁹ ACE and GIZ. 2019. *Mapping of Energy Efficiency Financing in ASEAN*. Jakarta: ASEAN Centre for Energy and GIZ.

⁷⁰ IEA. 2019. *Southeast Asia Energy Outlook 2019*. Paris: IEA.

interest to participating local commercial banks who could charge up to a maximum of 4% interest rate on the loan. The first phase of the funding was launched in 2003 as a 3-year program and it was renewed for two further 3-year terms. By April 2010, the fund had supported 335 energy efficiency projects and 112 renewable energy projects at a total investment of \$453 million, generating estimated energy cost savings of \$154 million and a payback period of 3 years on average.⁷¹

Thailand also uses a range of other financing arrangements for energy efficiency projects. Table 3 indicates some options (footnote 70).

Table 3: Other Financing Models for Energy Efficiency Projects in Thailand

Finance Model	Actor	Examples of Project Size (\$)
Loans	Banks	20 million
Leasing	Leasing companies	220,000
Tax incentive	Board of investment, tax office	Not available
Technology subsidy	Government	Government: 3 million Private: 9.5 million

Source: Energy Working Group, Asia-Pacific Economic Cooperation (APEC-EWG). 2017. *Energy Efficiency Finance in Indonesia: Current State, Barriers and Potential Next Steps*. Singapore: APEC-EWG.

Clean Energy Financing in the Pacific

The SIDS of Asia and the Pacific face specific challenges due to the small size of their economies, remote geographic locations, and vulnerability arising from climate change impacts and disasters (footnote 68).

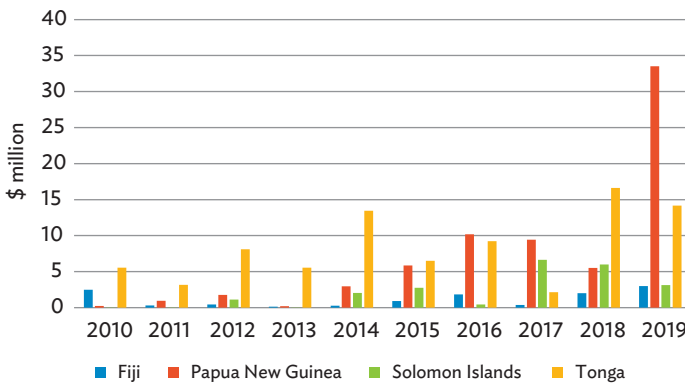
The financing challenge is most acute for the smallest and remotest islands. SIDS generally rely on external sources of finance to meet their developmental needs as domestic revenues are insufficient to meet their expenditure needs. However, their access to commercial finance is also limited, and accordingly, they are heavily reliant on bilateral and multilateral finance.

⁷¹ Basal Agency for Sustainable Energy (BASE). 2019. *Manual of Financing Mechanisms and Business Models for Energy Efficiency*. Basel: BASE.

The energy sector is a high-priority area for SIDS because of the direct financial burden and economic vulnerability arising from their heavy dependence on imported oil in their energy mix.⁷² Consequently, a transition to cleaner energy solutions through integration of renewable sources of energy and improvements in energy efficiency represents a major element of their sustainable development strategies. This is highlighted in the Samoa Pathway declaration.⁷³

However, access to finance has constrained expansion of clean energy systems in SIDS and investment in the energy sector has heavily dependent on donor finance.⁷⁴ Based on the Creditor Reporting System Database, donor finance flow to the energy sector in selected SIDS varies considerably from one year to another (Figure 11). Larger economies such as Papua New Guinea and Tonga have attracted higher volumes of donor funding in recent times. The share of energy sector ODA finance in the overall ODA finance flow remained relatively low (1%–3%) in most cases.

Figure 11: Donor Funding Flow to the Energy Sector in Selected Small Island Developing States
(\$ million, constant 2018 prices)



Source: Creditor Reporting System Database (accessed on 3 February 2022).

⁷² A. Atteridge and G. Savvidou. 2019. Development Aid for Energy in Small Island Developing States. *Energy, Sustainability and Society*. 9 (1).

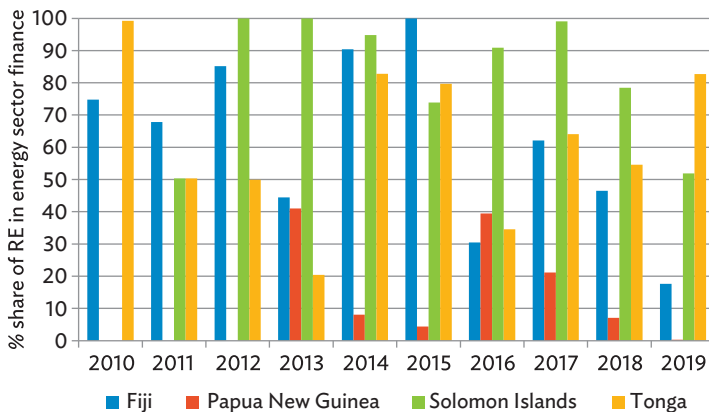
⁷³ UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLS). 2014. *SIDS Accelerated Modalities of Action (SAMOA) Pathway*. New York: UN-OHRLS.

⁷⁴ IRENA. 2012. *Policy Challenges for Renewable Energy Deployment in Pacific Island Countries and Territories*. Abu Dhabi: IRENA.

Similarly, non-resource-based economies have invested a higher share of finance for renewable energy within these countries (Figure 12). For example, a larger share of the energy sector donor finance in Solomon Islands and Tonga went to support renewable energy. On the other hand, most of the energy sector finance in Papua New Guinea went to fossil fuel projects. Higher dependence on resource-based sectors in Papua New Guinea has contributed to its continued fossil fuel reliance.

ADB is the largest source of finance for clean energy interventions in the Pacific islands and supported installation of 62 MW of renewable energy generation capacity between 2007 and 2018. ADB has adopted a differentiated approach for supporting the SIDS considering their specialized needs and tailoring solutions accordingly (footnote 48).

Figure 12: Renewable Energy Share in Energy Sector Donor Finance in Small Island Developing States



RE = renewable energy.

Source: [Creditor Reporting System Database](#) (accessed on 22 August 2020).

Lessons for Other Countries

The cases presented offer important lessons for other developing countries in Asia and the Pacific. The experience of green finance in the PRC indicates the potential for adopting the same approach in other countries. National banks will have to play an important role in supporting the low-carbon transition and this will require them to restructure their operations by

introducing green products and greening existing products. The case also suggests that the environment has to be created through regulatory guidance and amending existing policy frameworks. Ambitious targets, continued regulatory support, and strong monitoring and reporting arrangements are essential for a successful transition to green finance. Banks could introduce specialized instruments such as clean energy loans, energy efficiency loans, and asset-backed securitization. The diversity of products and flexibility will improve the overall finance system. Similarly, the success with green bonds highlights the potential for mobilizing domestic capital for energy projects as well as for energy efficiency improvements. This can be an appealing source of capital with low interest and less restrictive terms and conditions. The Chinese experience suggests that finance can be raised by different organizations both domestically and from offshore markets, which can diversify funding sources for them.

The role of microfinance in supporting access to electricity and efficient energy use can be learned from the example of Bangladesh. Consumers with limited income and poor credit records find it challenging to access finance for clean energy use and efficient energy projects. A large section of the population in Asian and the Pacific countries comes under this category and significant potential exists for expansion of microfinance systems to reach this section of the population.

The corporate PPA experience from India may be replicated elsewhere. These PPAs offer credible and bankable contracts for project financing, and various options for corporate procurement of green electricity allow the clean energy sector to grow without relying heavily on the local distribution utilities. The Indian case shows that even with limited corporate participation so far, several GW of capacity may be added, which may be a small fraction of the overall potential that could be harnessed through corporate involvement. However, the regulatory environment has to support the corporate engagement through favorable open-access regimes for electricity trade. Off-site generation and bulk-trading arrangements as well as power evacuation infrastructure are essential to support more corporate PPA engagements in clean energy supply.

Energy efficiency improvements remain one of the lowest-cost clean energy options. The experience from Thailand with regard to ESCOs suggests that with appropriate financing arrangements, significant energy savings can be successfully achieved in the region.

The need for a differentiated approach to support small and fragile economies has been highlighted through the final case study on SIDS. Limited access to external finance makes SIDS dependent on ODA

but smaller and remotely located island countries are generally at a disadvantage. This justifies a strategy of tailored solutions, which ADB has adopted in its strategy for support until 2030 (footnote 48).

Conclusion

Asia and the Pacific region attracted close to \$150 billion for clean energy investments in 2018, with the PRC alone investing close to \$100 billion per year. India comes a distant second, with investments worth around \$10 billion per year. Access to finance remains limited for small and vulnerable economies. This calls for a more dedicated focus on smaller economies and island countries. Domestic public finance has played an important role in supporting clean energy in the region. However, public finance availability remains a concern for clean energy as the demand from social and other sectors grow in the future.

Most investments came from private sources, with project developers making significant contributions. Solar PV and wind power remained the most preferred technology choices and maturity of these technologies facilitated private sector involvement. Although grants and concessional finance has supported clean energy development, they have played a relatively limited role. Domestic sources of finance have outweighed other sources of finance in general. In general, on-balance sheet financing has played a major role. This also suggests the role of domestic debt finance in supporting clean energy development. In this context, mobilization of the local capital market assumes importance and realignment of the local debt market to support clean energy projects, shifting their focus from fossil fuel technologies requires greater attention. Access to debt finance remains challenging for small-scale projects due to the early-stage nature of the businesses and lack of track record of small investors. There is need for supporting access to debt capital.

Greening of national financial systems however requires strong regulatory intervention to create an enabling environment and to monitor timely implementation of financial system reform. Clean energy offers an attractive investment opportunity for institutional investors such as pension funds and insurance funds. However, more targeted engagement with this group is required to benefit from direct and indirect investment from this group.

The emergence of green bonds is worth more attention. Asian countries have already started to take advantage of this development to support clean energy technologies as well as energy efficiency interventions. This area has significant potential for further development and ties very well with the domestic capital mobilization theme. Green bonds offer clear advantages in terms of interest rates, nonperforming assets, and flexibility, but developments in Asia suggest a need for greater harmonization of local bond categorization with the international system and improvements in transparency.

The economic recession triggered by the COVID-19 pandemic has increased uncertainty in energy sector investments. Governments around the world now face higher debt burdens. Past recessions have made investors more risk averse. Expectation of returns is likely to increase, meaning investments in marginal projects are likely to not be made. The viability gap of projects remains a concern for clean energy projects and support mechanisms to bridge the gap are often required, which suggests a need for concessional finance. However, access to finance remains an issue, particularly for small projects due to higher transaction costs. There is also limited supply of appropriate risk mitigation measures and support of the international financial agencies and domestic development banks will be important in providing risk protection instruments.

A clean energy-driven post-COVID-19 recovery and risk mitigation instruments such as guarantee instruments and currency and liquidity risk management instruments will be essential. In addition, developing a pipeline of bankable projects, aggregation of small-ticket projects, and dedicated national financing vehicles could allow scaling-up and replication of investment projects. Capacity building and technical assistance to develop domestic financial sector skills are also essential to this transformative change ahead.

References

- Abramskiehn, D. et al. 2017. *Supporting National Development Banks to Drive Investment in the Nationally Determined Contributions of Brazil, Mexico, and Chile*. Washington, DC.
- Aggarwal, V., B. Prasad, and A. Makhija. 2019. *Global Corporate Renewable Power Procurement Models: Lessons for India*. New Delhi.
- ASEAN Centre for Energy (ACE) and Deutsche Gesellschaft für International Zusammenarbeit (GIZ). 2019. *Mapping of Energy Efficiency Financing in ASEAN*. Jakarta.
- Asian Development Bank (ADB). 2019. *A Framework for Addressing the Financing Needs of Small Island Developing States*. Manila.
- . 2020. *Review of the ADB Clean Energy Program*. Manila.
- Atteridge, A., and G. Savvidou. 2019. *Development Aid for Energy in Small Island Developing States*. Stockholm.
- Azhgaliyeva, D., A. Kapoor, and Y. Liu. 2020. *Green Bonds for Financing Renewable Energy and Energy Efficiency in South East Asia: A Review of Policies*. ADBI Working Paper Series. No. 1073. Tokyo.
- Basel Agency for Sustainable Energy. 2019. *Manual of Financing Mechanisms and Business Models for Energy Efficiency*. Basel.
- Bloomberg New Energy Foundation (BNEF). 2019. *The Clean Technology Fund and Concessional Finance: Lessons Learned and Strategies Moving Forward*. New York.
- Bockel, A., J. Horisch, and I. Tenner. 2020. *A Systematic Literature Review of Crowdfunding and Sustainability: Highlighting What Really Matters*. Management Review Quarterly. Lüneburg.
- Buckley, T., and S. Trivedi. 2021. *Capital Flows Underpinning India's Energy Transformation: Global Capital is Primed and Ready*. Ohio.
- China Development Bank. 2019. *Sustainability Development Report 2019*. Beijing.

Choi, J., D. Escalante, and M. L. Larsen. 2020. *Green Banking in China – Emerging Trends: With a Focus on the Industrial and Commercial Bank of China (ICBC)*. London.

Climate Bonds Initiative. 2018. *India Country Briefing–July 2018*. London.

———. 2020a. *2019 Green Bond Market Summary*. London.

———. 2020b. *China Green Bond Market 2019 Research Report*. London.

Climate Policy Initiative (CPI). 2019. *Global Landscape of Climate Finance 2019*. London.

Energy Working Group, Asia-Pacific Economic Cooperation. 2017. *Energy Efficiency Finance in Indonesia: Current State, Barriers and Potential Next Steps*. Singapore.

European Bank for Reconstruction and Development (EBRD). 2020. *2019 Joint Report on Multilateral Development Banks Climate Finance*. London.

Frankfurt School. 2020. *Global Trends in Renewable Energy Investment 2020*. Frankfurt.

Gadre, A., A. Jain, S. Jaiswal, V. Gombar, and D. Traum. 2020. *India's Clean Power Revolution: A Success Story with Global Implications*. New York.

Global Environment Facility. 2018. *GEF-7 Non-Grant Instrument Program*. Washington, DC.

Green Climate Fund (GCF). 2018. *Policies for Contributions from Philanthropic Foundations and Other Alternative Sources*. Incheon.

———. 2020. *GCF at a Glance – Project Portfolio*. Incheon.

Gupta, S. et al. 2014. *Cross-cutting Investment and Finance Issues. In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge.

Horisch, J. 2018. 'Think Big' or 'Small is Beautiful'? An Empirical Analysis of Characteristics and Determinants of Success of Sustainable Crowdfunding Projects. *Journal of Entrepreneurial Venturing*. 10 (1): 111–129.

Hossain, M. 2018. *Green Finance in Bangladesh: Policies, Institutions and Challenges*. ADBI Working Paper Series. No. 892. Tokyo.

Indian Renewable Energy Development Agency. 2020. *33rd Annual Report, 2019–20: Renewables for Aatmanirbhar*. New Delhi.

International Energy Agency (IEA). 2019. *South East Asia Energy Outlook 2019*. Paris.

———. 2020. *World Energy Investment 2020*. Paris.

Intergovernmental Panel on Climate Change (IPCC). 2018. *Special Report: Global Warming of 1.5°C*. Geneva.

International Renewable Energy Agency (IRENA). 2012. *Policy Challenges for Renewable Energy Deployment in Pacific Island Countries and Territories*. Abu Dhabi.

———. 2016. *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance*. Abu Dhabi: IRENA.

———. 2018. *Renewable Energy Market Analysis South East Asia*. Abu Dhabi.

———. 2020. *Mobilising Institutional Capital for Renewable Energy*. Abu Dhabi.

———. 2020. *The Post-COVID Recovery: An Agenda for Resilience, Development and Equality*. Abu Dhabi.

IRENA and Climate Policy Initiative (CPI). 2018. *Global Landscape of Renewable Energy Finance*. Abu Dhabi.

Jena, L., and C. M. Shrimali. 2018. *Getting to India's Renewable Energy Targets: A Business Case for Institutional Investment*. London.

Jiang, B., J. Guo, and R. Gordon-Jones. 2018. *Financial Services Report: China's Green Finance Market*. Beijing.

Khan, A., B.F. Khan, N. Udin, G. I. Azim, and S. Islam. 2017. *Financing Green Growth in Bangladesh: Challenges and Opportunities*. Dhaka.

Martinez, J. L., and C. Vincente. 2012. *Global Survey of Development Banks. World Bank Policy Research Working Paper 5969*. Washington, DC.

McCollum, D. L., W. Zhou, C. Bertram. 2018. *Energy Investment Needs for Fulfilling the Paris Agreement and Achieving the Sustainable Development Goals*. *Nature Energy*. 589–599. 2 July.

Mollick, E. 2014. *The Dynamics of Crowdfunding: An Explanatory Study*. *Journal of Business Ventures*. 29: 1–16.

New Development Bank. 2020. *Annual Report 2019: Investing for Innovation*. Shanghai.

Organisation for Economic Co-operation and Development (OECD). *Creditor Reporting System Database*. (accessed on 3 February 2022)

———. 2020a. *2020 Multilateral Development Finance*. Paris.

———. 2020b. *The Role of Sovereign and Strategic Investment Funds in the Low Carbon Transition*. Paris.

Parthan, B. 2017. Financing Energy Access in Asia. In S. C. Bhattacharyya, ed. *The Routledge Handbook of Energy in Asia*. Abingdon.

Polzin, F., F. Egli, B. Steffen, and S. Schmidt. 2019. *How Do Policies Mobilize Private Finance for Renewable Energy?—A Systematic Review with an Investor Perspective*.

PricewaterhouseCoopers. 2020. *Sovereign Investors 2020 – A Growing Force*. London.

RE 100 Climate Group. *RE100 2021 Annual Disclosure Report*.

REN21. 2019. *2019 Asia and the Pacific Renewable Energy Status Report*. Paris: REN21.

Rottgers, D., A. Tandon, and C. Kaminker. 2018. OECD Progress Update on Approaches to Mobilising Institutional Investment for Sustainable Infrastructure: Background Paper to the G20 Sustainable Finance. *OECD Environment Working Paper*. No. 138. Paris.

Runde, D. F., C. M. Savoy, D. W. te Velde, P. Carter, and A. Lemma. 2016. *Development Finance Institutions Come of Age: Policy Engagement, Impact and New Directions*. Washington, DC: Centre for Strategic and International Studies and Overseas Development Institute. October 2016.

Ryszka, K. 2020. *Renewable Project Finance: Can Corporate PPAs Replace Renewable Energy Subsidies?* Utrecht.

Saranghi, G. 2018. *Green Energy Finance in India: Challenges and Solutions. ADBI Working Paper Series*. No. 863. Tokyo.

The People's Bank of China. 2016. *Guidelines for Establishing Green Financial System*. Beijing.

Thuard J., H. Koh, A. Agarwal, and R. Garg. 2019. *Financing the Future of Asia: Innovations in Sustainable Finance*. Boston.

Trabacchi, C., J. Brown, R. Boyd, D. Wang, and J. Falzon. 2016. *The Role of Climate Investment Funds in Meeting Investment Needs*. London.

UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States. 2014. *SIDS Accelerated Modalities of Action (SAMOA) Pathway*. New York.

UNFCCC Standing Committee on Finance. 2018. *2018 Biennial Assessment and Overview of Climate Finance Flows, Technical Report*. Bonn.

United Nations Conference on Trade and Development (UNCTAD). 2019. *The Least Developed Countries Report 2019*. New York.

United Nations Environment Programme. 2014. *Demystifying Private Climate Finance*. Geneva.

United Nations Framework Convention on Climate Change (UNFCCC). 2015. *Paris Agreement*. Bonn.

United Nations Inter-agency Task Force on Financing for Development. 2020. *Financing for Sustainable Development Report 2020*. New York.

Watson, C., and L. Schalatek. 2019. *The Global Climate Finance Architecture, Climate Finance Fundamentals 2*. February.

World Bank. 2019. *Who Sponsors Infrastructure Projects? Disentangling Public and Private Contributions*. Washington, DC.

———. 2020. *State and Trends of Carbon Pricing in 2020*. Washington, DC.

World Business Council for Sustainable Development. 2019. *Corporate Renewable PPAs in India: A Market & Policy Update*. Geneva.

Ram M. Shrestha

Introduction

Hydropower remains the second-largest source of renewable energy in the world after biofuels and waste. Asia has witnessed the largest growth in hydroelectricity production over the last 4 decades. The importance of renewable energy has been growing in light of international efforts to drastically reduce greenhouse gas (GHG) emissions, as pledged by countries during the Paris Agreement in 2015. In most cases, hydropower produces low-carbon electricity, with life-cycle GHG emission intensity significantly less than those of fossil fuel-based generation. More importantly, the development of storage and pumped storage hydropower is crucial for the transformation of the energy system to a large-scale deployment of non-dispatchable sources like solar and wind energy. Hydropower provides grid stability and the flexibility to manage the demand fluctuations and supply uncertainties associated with intermittent renewable sources. Hydropower plants, however, involve high initial investment, long construction period, and several risks and uncertainties. Given this, large hydropower projects rely on several sources of funding (domestic and foreign) in many developing countries.

This chapter presents a brief discussion on the role of hydropower in climate change mitigation in the next section (Section 2). This is followed by a discussion of sources of hydropower financing in Section 3. Section 4 discusses the evolution of hydropower financing. Section 5 presents a discussion of selected financing models in practice in public sector, public-private partnership (PPP), and private sector hydropower projects in Asian developing countries. Section 6 discusses sources of climate finance and key factors affecting the hydropower's access to climate finance. The subsequent two sections briefly discuss the opportunities and challenges for hydropower financing. Some conclusions are offered in the final section.

Role of Hydropower in Climate Change Mitigation

This section discusses the role of hydropower in two respects, i.e., GHG emission intensity of hydropower as a low-carbon technology, and hydropower as a provider of ancillary services that facilitate large-scale development of intermittently available renewable technologies like solar and wind.

Hydropower as a low-carbon technology. Most hydropower projects have relatively low GHG emission intensity (i.e., emission per unit of electricity production). According to the International Hydropower Association, if hydropower were to be replaced with coal-based power generation, there would be more than 4 billion metric tons of additional GHG emissions annually.¹

Most reservoir hydropower projects (HPPs) have GHG emission in the range of 4–14 grams (g) of carbon dioxide equivalent (CO₂eq) per kilowatt-hour (kWh) on a life-cycle basis, although some HPPs are also reported to emit much larger quantities of GHGs under certain scenarios.² The emission intensity is, however, reported to vary with the type (i.e., run-of-river plants, storage); size (i.e., mini, small, medium, and large); and age of hydropower plants, among others. A study of 178 single-purpose hydropower reservoirs and 320 multipurpose reservoirs has reported the median GHG emission intensity to be 18.5 g CO₂eq per kWh.³ The emission intensity of run-of-river HPPs is reported by the World Energy Council⁴ to vary from 3–4 g CO₂eq per kWh. A study in India has estimated it to vary from 35–75 g CO₂eq per kWh.⁵ Thus, for many HPPs, the emission intensity is 50–100 times less than that of electricity generation-based on coal.⁶ This has an important implication for GHG mitigation strategy. The current global average emissions from the power sector is 475 g of CO₂ per kWh

¹ International Hydropower Association (IHA). 2020. *Greenhouse gas emissions*. London: IHA.

² Intergovernmental Panel on Climate Change (IPCC). 2011. *Special Report on Renewable Energy Sources and Climate Change Mitigation*. IPCC.

³ IHA. 2018. *2018 Hydropower Status Report*. London: IHA.

⁴ L. Berga. 2016. The Role of Hydropower in Climate Change Mitigation and Adaptation: A Review. *Engineering*, 2(3). pp. 313–318.

⁵ Varun, I. K. Bhat, and R. Prakash. 2008. Life Cycle Analysis of Run-of River Small Hydro Power Plants in India. *The Open Renewable Energy Journal*. 1. pp. 11–16.

⁶ For example, according to National Energy Administration of the People's Republic of China (PRC), the emission intensity of coal-fired power generation in the PRC is 822 g CO₂ per kWh. Source: T. Jiang et al. 2018. Carbon Footprint Assessment of Four Normal Size Hydropower Stations in China. *Sustainability*. 10(6).

and a substantial reduction of power sector GHG emissions to 50 g CO₂ per kWh (i.e., an almost 90% reduction) is required for meeting the global warming target of well below 2°C (more specifically 1.5°C) under the Paris Agreement.⁷ Hydropower, with its low-emission intensity, can contribute significantly to the reduction of power sector emissions toward meeting the climate change target of the Paris Agreement.

Provider of important ancillary services. Besides being a relatively low-carbon technology, hydropower can provide ancillary services like energy storage, operational flexibility, and stability to the power system (note that although batteries can also provide energy storage, they are still relatively more expensive than hydropower). These ancillary services contribute significantly to the expansion of the power generation capacity based on intermittent renewable resources like solar and wind power. Thus, hydropower can play an important role toward significant additional GHG mitigation by making large-scale implementation of solar and wind power technically and economically viable.

Sources of Hydropower Finance

HPPs have several sources of finance, such as multilateral development banks, bilateral development banks and agencies, and export credit agencies (ECAs). There are also private commercial lenders and public financing institutions.⁸

Multilateral development banks. Also called international financial institutions (IFIs), multilateral development banks (MDBs) include organizations like the World Bank, Asian Development Bank (ADB), Islamic Development Bank, European Investment Bank, Asian Infrastructure Investment Bank (AIIB), and New Development Bank. MDBs have been playing a major role in financing hydropower in developing countries for a very long time by financing equity and debt through governments. Modern finance provided by these organizations is diverse, and includes credit enhancement facilities or guarantees for risks (e.g., political risk guarantees, partial risk guarantees, credit or

⁷ S. Patel, C. Shakya, and N. Rai. 2020. *Climate finance for hydropower incentivising the low-carbon transition*. Issue Paper. January. London: IIED.

⁸ For a more detailed discussion on sources of clean energy finance and financing instruments, see the chapter on Clean Energy Financing Options: Sources, Instruments, Risks, and Mitigation Options in this volume.

partial credit guarantees); climate and green bonds; start-up financial assistance and co-development; and refinancing facilities that can then extend a commercial bank's loan tenure. Private sector financing arms of MDBs, like the International Finance Corporation of the World Bank, focus on providing finance directly to the private sector in less-developed countries. Organizations like the Multilateral Investment Guarantee Agency, a member of the World Bank Group, provide guarantees or insurance to cover political risks (which would enhance bankability of export-oriented projects). They also provide credit guarantees, which improve loan terms and enhance access to private commercial funds.

Bilateral development banks and agencies. Some of the well-known bilateral development banks (BDBs) and agencies involved in hydropower development in Asia include the Japan International Cooperation Agency, Agence Française de Développement (French Development Agency), German Development Bank (KfW), Norwegian Agency for Development Cooperation, and Kuwait Fund for Arab Economic Development. They provide finance in concessionary terms such as grants or loans at a low rate.⁹ In recent years, the sources of bilateral finance have shifted with countries like the People's Republic of China (PRC) and the Republic of Korea emerging as a new major source of bilateral finance.

Export credit agencies. A new form of bilateral finance originates mostly from ECAs or development banks of upper middle-income countries.¹⁰ Examples of ECAs are the Japan Bank for International Cooperation (formerly Japan Export-Import Bank), Export-Import Bank of China, and Export-Import Bank of Korea.

Unlike traditional bilateral finance, which generally have some grant element, the new form of bilateral financing is driven by more commercial consideration. ECAs are usually government-sponsored institutions that provide government-backed financing and guarantees to their home-based corporations aiming to do business overseas.¹¹

⁹ C. Head. 2006. *The Financing of Water Infrastructure: A Review of Case Studies*. January. World Bank. Washington, DC.

¹⁰ S. Markkanen and J. P. Braeckman. 2019. *Financing Sustainable Hydropower Projects in Emerging Markets: an Introduction to Concepts and Terminology*.

¹¹ International Renewable Energy Agency (IRENA). 2016. *Unlocking Renewable Energy Investment: The Role of Risk Mitigation*. Abu Dhabi: IRENA.

Private commercial lenders. Private finance for hydropower can come from domestic as well as foreign sources. Sources of private finance for hydropower include domestic and international power developers, investment funds, commercial banks, pension funds, insurance companies, and social welfare funds.¹²

In many Asian economies, banks are the largest source of domestic private finance for energy projects.¹³ After banks, insurance companies and pension funds hold the second-highest share. According to Merme et al. (2014), the capacity of private financing has grown in Asia, especially in the Association of Southeast Asian Nations region. However, except in countries with a developed private finance market (such as India, the Philippines, the PRC, the Republic of Korea, and Thailand), domestic financing institutions in other Asian countries mostly hesitate to provide long-term loans needed for hydro projects.

Public financing entities. Public sources of finance in hydropower include: government; public utilities (e.g., Nepal Electricity Authority, Electricity Generating Authority of Thailand); power development authorities (e.g., National Hydroelectric Power Corporation in India, Hydroelectricity Investment and Development Company in Nepal, Water and Power Development Authority in Pakistan); river basin authorities; and regional power companies.

Climate and environmental funds are other potential sources of finance for hydropower development. They are discussed in a subsequent section (“Climate Finance and Hydropower”) of this chapter.

Evolution of Hydropower Financing

This section first discusses the evolution of hydropower financing beginning with fully public sector project financing and followed by PPP, private sector financing, and new bilateral finance.

¹² For more information on these and other sources of private finance in a more general context, see the chapter on Clean Energy Financing Options: Sources, Instruments, Risks, and Mitigation Options in this volume.

¹³ N. Yoshino and F. Taghizadeh-Hesary. 2018. *A Model for Utilizing Spillover Taxes and Community-Based Funds to Fill the Green Energy*. Issue 899. Tokyo: Asian Development Bank Institute.

Public Sector Project Financing

Most of the large HPPs in developing countries were fully public sector projects until the 2000s.¹⁴ These projects received funding support from MDBs and BDBs besides national public funding sources. However, the MDBs' and BDBs' support for large projects were concentrated in few large developing economies like Brazil, India, and the PRC. The number of fully public sector-funded HPPs has been declining since the 2000s.

A major strength of full public financing of HPPs is that the host government has control over the ownership and operational aspects from the very beginning of the project development process. A disadvantage of the public sector financing is that the investments in large HPPs would reduce funds for other public sectors. Due to constraints to concessional finance available from MDBs and limits to national indebtedness, low-income countries faced difficulty in mobilizing finance for large-scale hydropower development in the second half of the 20th century (footnote 14).

Public–Private Partnerships

As the financial resources needed for large-scale hydropower development are huge, governments in developing countries find it difficult to finance large HPPs on their own and look for participation of the private sector. The PPP model gained attraction as it could involve financing institutions of diverse characteristics (i.e., private and public) and mobilize adequate financial resources jointly. PPPs become attractive as the private sector may not be in a position to finance a large hydropower project in developing countries on its own. Further, the private sector will not be solely interested in a project unless the project is bankable. PPPs can become attractive also from a risk-sharing perspective; while some risks can be shared by the private sector, the public sector may find it more economical to assume certain risks that the private sector may find extremely expensive and uninsurable (footnote 10).

PPPs generally require the establishment of a separate company (or special purpose company, also called special purpose vehicle), to carry out development, construction, and operation. The only business of such company is the project itself, and the financing is of nonrecourse

¹⁴ J. P. Braeckman, S. Markkanen, and P. Souvanneseng. 2020. *Mapping the Evolving Complexity of Large Hydropower Project Finance in Low and Lower-Middle Income Countries*. FutureDAMS Working Paper 007. Manchester: The University of Manchester.

or limited recourse type.¹⁵ It is almost common for PPPs to finance HPPs under a build–own–operate–transfer arrangement.

There are several strengths and limitations of PPPs (footnote 14). A major strength of PPPs is that they help develop HPPs despite the constraints and limits faced by the governments on borrowing from MDBs. However, unlike fully public projects, PPPs involve multiple actors, i.e., several MDBs, BDBs, IFIs, and commercial banks as well as off-takers. PPPs also differ from fully public projects in terms of the project structure and the role of MDBs. As such, PPPs would require complex financing packages and agreements, which would take longer time for financial closure for HPPs.

Private Sector Project Financing

During the 1990s, concerns started to appear regarding the adequacy of public funds to develop large-scale infrastructure projects such as hydropower in developing countries. Opinions in favor of involving the private sector started to grow (footnote 10). The entry of the private participants in the power sector was helped by structural adjustment programs promoted by the International Monetary Fund and supported by the World Bank since the early 1980s. Structural adjustment programs were designed to open national economies, and the outcomes of these programs were liberalization, deregulation, and privatization, which would ease the flow of private capital into the power sector.¹⁶ These reforms created environments for the participation of domestic and foreign private entities and changed the model of developing hydropower.¹⁷

Private sector financing led to the establishment of independent power producers (IPPs) as private commercial entities. IPPs own, finance, and develop facilities to generate electricity with commercial (i.e., profit) motive. IPPs can also be considered as a kind of PPP in which the private investors are guaranteed financial protection through a long-term power purchase agreement with the government (or a government-backed entity).

¹⁵ C. Head. 2000. Financing of private hydropower projects. *World Bank Discussion Paper*. Washington, DC: World Bank.

¹⁶ V. Merme, R. Ahlers, and J. Gupta. 2014. Private Equity, Public Affair: Hydropower Financing in the Mekong Basin. *Global Environmental Change*. 24(1). pp. 20–29.

¹⁷ P. Ljung. 2001. *Trends in the Financing of Water and Energy Resources Projects*. Cape Town: World Commission on Dams (WCD).

Public ownership is not always required by IPPs.¹⁸ Generally, after the concession period, the ownership of the project is handed back to the host government. In principle, the IPP model of financing a HPP would shift the responsibilities and risks to a private company and the public sector would not have any role in the HPP other than to grant the concession and buy the output (footnote 10).

New Bilateral Finance

PPPs involve multiple actors and as such, they often take up to several years before financial closure. The PPP process may also be slow in the implementation process. A new form of bilateral finance has emerged as an alternative approach of financing. In such scheme of financing, ECAs or development banks of some upper middle-income countries (like the PRC and the Republic of Korea) are engaged in funding HPPs. Such financing mechanism involves typically only two parties, i.e., a bilateral financing agency (ECA or development banks) of the upper middle-income country and the host country government (in some cases commercial banks are also involved in providing some part of the loan). This makes the process of such bilateral finance much simpler and faster (footnote 14).

However, unlike traditional bilateral finance, the new form of bilateral financing is mostly a commercial debt or export credit. Further, such financing is often tied with a condition requiring the award of contracts to lending country's companies, which constrains the borrowing countries in the selection of technology and materials (footnote 14).

Several HPPs in Africa and Asia have been financed by the PRC through its ECAs and BDB.

Hydropower Financing Models

A hydropower financing model describes the mix of actors (or sources of funding) and financial instruments (equity, debt, grants, and risk mitigation measures, i.e., guarantees) involved in a hydropower project. Another element of the financing model is to characterize whether an HPP is a project in the public sector or private sector or a PPP. Some studies also categorize the financing models by the major source of funding. In a study

¹⁸ ECON. 2008. *A Review of Private–Public Partnership Models in Hydropower Projects*. Econ Pöyry AS.

on financing of large dams (mostly including storage hydropower projects), Worm et al. (2003) classify financing models in three broad categories based on the sources of funding, i.e., as “development,” “national interest,” and “commercial” models of financing: The “development” model refers to financing of projects through foreign development loans and grants from multilateral or bilateral agencies; the “national interest” model refers to priority projects funded with domestic public and private capital; and the “commercial” model refers to projects funded with foreign private loans.¹⁹

Important to note is that no two HPPs are exactly alike. HPPs have different features not only because they are site-specific, but they also vary in terms of project type and country context. So, it is not possible to have an exhaustive set of financing models to cover all kinds of HPPs. Therefore, this section limits to selected financing models that have been adopted in Asian countries. First, it discusses some models of PPPs. This is followed by a discussion of some financing models of fully public sector projects and private IPPs.

Public–Private Partnership Models

This section discusses the following variants of PPP models:

- (i) Financing by MDBs, BDBs, IFIs, regional banks, and other investors.
- (ii) Financing solely by regional banks and use of bonds.
- (iii) Financing with a combination of A/B and other loans.
- (iv) Financing solely by domestic public–private community sources.

Financing of by Development Banks, International Financial Institutions, Regional Banks, and Other Investors

A number of HPPs have been developed in the Lao People’s Democratic Republic (Lao PDR) under the PPP framework. The HPP financing model in the country has evolved with some variation in the mix of funding sources, sponsors, and financing instruments. Financing models for the HPPs also vary in terms of project ownership, debt finance, equity finance, and guarantees. Financing of a large HPP started with the involvement multiple financing sources, i.e., MDBs, BDBs, as well as IFI and regional commercial banks. Besides loan and equity, the project financing instruments included guarantees provided by multilateral agencies.

¹⁹ J. Worm, J. M. Dros, and J. W. van Gelder. 2003. *Policies and Practices in financing large dams*. Netherlands: AidEnvironment, Amsterdam and Profundo, Castricum.

The Nam Theun 2 (NT2) Hydropower Project in the Lao PDR, which aimed primarily to export power to Thailand, is one such example (Box 1). The Government of the Lao PDR received loans and grants from MDBs and a bilateral development agency for its equity contribution in NT2 project. The Multilateral Investment Guarantee Agency provided guarantees against political risks in both the Lao PDR and Thailand. An important factor behind the successful development of NT2 is the involvement of MDBs, the Electricity Generating Authority of Thailand (EGAT) (the buyer of electricity), and Thai commercial banks. They provided greater confidence to other stakeholders of the project.

The model of financing in the Lao PDR has, however, gradually evolved over time toward one with predominant funding by regional institutions.

Box 1: Nam Theun 2 Hydropower Project, Lao People's Democratic Republic

Nam Theun 2 (NT2) is a 1,070-megawatt (MW) hydropower project in the Lao People's Democratic Republic (Lao PDR). About 995 MW of the power is exported to Thailand, and 75 MW is supplied to the domestic market. The project is developed in a build–own–operate–transfer scheme, with a concession period of 31 years, which includes the operating period of 25 years. Nam Theun 2 Power Company Limited (NTPC), a special purpose company, was the developer of the NT2 project. The shareholders of NTPC were Electricité de France International (EDFI), Electricity Generating Public Company of Thailand (EGAT), Italian-Thai Development Public Company Limited of Thailand, and Nam Theun 2 Power Investment Company (NTPI), which invested into NTPC on behalf of Electricité du Lao (EDL), the state-owned power company of the Lao PDR.

The total estimated cost of the project at the time of the project appraisal was \$1.25 billion with 28% of equity and 72% of debt. The total cost had increased to \$1.30 billion at loan closure.

The Government of the Lao PDR contributed \$87.5 million (25%) of the equity, while the other three shareholders of NTPC paid the rest. The government's share of the equity was financed by different sources, i.e., through loans and grants from the Asian Development Bank (ADB), grants from the International Development Association (IDA) and Agence Française de Développement, and a loan from the European Investment Bank.

continued on next page

Box 1 *continued*

Several sources of debt financing were involved in the project. They included a number of multilateral and bilateral institutions, export credit agencies, nine international dollar lenders, and seven Thai banks. ADB, the Multilateral Investment Guarantee Agency, and IDA provided guarantees against political, currency convertibility or transfer, and other debt-related risks.

The fact that ADB provided three different types of funds—grant fund to the Government of the Lao PDR's equity investment, debt and partial risk guarantee—illustrates the level of complexity involved in such public–private partnerships. Multiple roles were played by other entities as well. EGAT was not only a shareholder but also an off-taker of the power produced by the project under a power purchase agreement between EGAT and NTPC. Similarly, EDFI was a contractor as well as a principal shareholder.

Sources: ADB. 2019a. *Evaluation Approach Paper - Project Performance Evaluation Report for Loans 2161 and 2162-LAO: Greater Mekong Subregion Nam Theun 2 Hydroelectric Project*. Manila.

J. P. Braeckman, S. Markkanen, and P. Souvannaseng. 2020. *Mapping the evolving complexity of large hydropower project finance in low and lower-middle income countries*. Green Finance, 2 April. pp. 151–172.

Multilateral Investment Guarantee Agency (MIGA). 2005. *Hydropower in Asia: The Nam Theun 2 Project*. MIGA: Washington, DC.

Financing Solely by Regional Banks

The Nam Ngum 2 (NN2) Hydropower Project in the Lao PDR provides an example of another approach of financing. Like Nam Theun 2, the power produced by NN2 is exported to Thailand via EGAT. However, unlike in NT2, there were only two shareholders of NN2, i.e., the Government of the Lao PDR represented by Electricité du Lao (EDL) and a Thai company. More importantly, NN2 is solely financed by a syndicated loan from a consortium of Thai banks. These reflect rising confidence on the part of Thai banks as well as the project sponsors. Another feature of the NN2 project finance is that the EDL issued Thai Baht-denominated bonds to raise fund for its equity contribution for which the Export-Import Bank of Thailand provided guarantees (Box 2). Xayaburi Hydropower project in the Lao PDR is another case with a similar financing approach (Box 2). That EGAT has agreed to buy electricity from these projects and banks from Thailand are involved in financing is again a key factor behind the success of this kind of HPP financing.

Box 2: Two Examples of Hydropower Projects Financed by Regional Banks

Nam Ngum 2 Hydropower Project, Lao People's Democratic Republic

The Nam Ngum 2 (NN2) is a reservoir type of hydropower plant with an installed capacity of 615 megawatts (MW). The plant came into operation in January 2013. Electricity produced by NN2 is exported to Thailand via the Electricity Generating Authority of Thailand (EGAT).

Nam Ngum 2 Power Company Limited, a company registered in the Lao People's Democratic Republic (Lao PDR), developed the NN2 project. The company has been awarded the concession by the Government of the Lao PDR for the design, development, construction, and operation of the NN2 power plant for 25 years from the commercial operation date.

The total cost of the NN2 project was \$760 million. SouthEast Asia Energy Limited (SEAN) of Thailand holds 75% of the shares and Electricité du Lao (EDL) Generation Public Limited of the Lao PDR holds 25%.

The entire debt finance for the project was provided by three Thai commercial banks: Krung Thai Bank, Siam City Bank, and Thai Military Bank. The Export-Import Bank of Thailand provided guarantee for a Thai Baht-denominated bond issue by EDL totaling B1.5 billion to finance EDL's 25% stake in the project, with the Lao PDR Ministry of Finance acting as a counter-guarantor.

Xayaburi Hydropower Project, Lao PDR

The 1,285 MW Xayaburi Hydroelectric Power Project is managed by Xayaburi Power Company Limited (XPCL), a company registered in the Lao PDR. XPCL is majority-owned by a consortium of Thai companies led by CK Power Public Company Limited, while EDL holds a stake of 20%.

XPCL has a concession agreement with the Government of the Lao PDR to develop the project on a build-own-operate-transfer basis. Under the agreement, XPCL is allowed to operate the hydropower plant for a period of 29 years from the first day of commercial operation.

Ninety-five percent of the electricity produced by the project is for export to Thailand. The project has a power purchase agreement with EGAT to this effect. The rest of the production is guaranteed for supply to EDL.

continued on next page

Box 2 *continued*

The total cost of the project is \$3.25 billion, of which 80% is financed by a syndicated loan provided by six Thai banks which include four commercial banks, i.e., Bangkok Bank, Kasikorn Bank, Krungthai Bank, and Siam City Bank.

Sources: EDL-GPC. 2017. *Nam Ngum 2 Hydropower Project*. EDL-Generation Public Company (EDL-GPC).

V. Merme, R. Ahlers, and J. Gupta. 2014. Private Equity, Public Affair: Hydropower Financing in the Mekong Basin. *Global Environmental Change*. 24(1). pp. 20–29.

C. Middleton. 2009. *Thailand's Commercial Banks' Role in Financing Dams in Laos and the Case for Sustainable Banking*. December. p. 39.

World Bank. 2020. *Nam Ngum 2 Hydro Power Plant*. Washington, DC: World Bank.

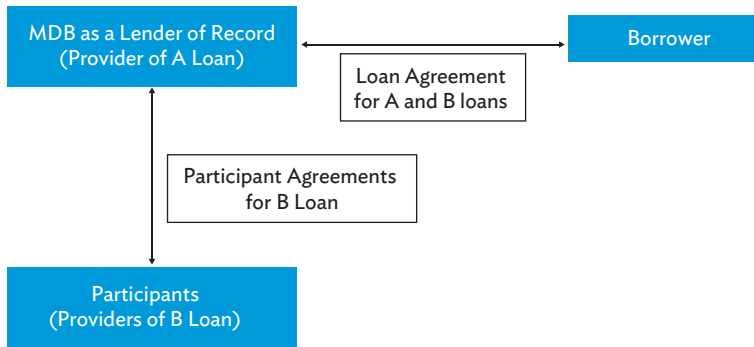
CK Power Public Company Limited. 2022. *Xayaburi Hydroelectric Power Plant*. Bangkok.

Financing Involving A/B Loans

Another variant of the financing model uses the A/B loan structure in which an MDB serves as the lender of record (LoR) and directly provides a certain part of the loan (as “A Loan”) and mobilizes the remaining part of the loan (“B Loan”) from other participants (or sources). The LoR enters into agreements with participating institutions for the B loan, while the borrower has a single agreement with the LoR for both A and B loans—that is, the LoR becomes the sole contractual lender for the borrower (Figure 1). The advantage of the A/B loan structure is that it allows the participating institutions (i.e., providers of B Loan) to fully benefit from the status of the LoR as a multilateral development institution. That is, all payments (including principal, interest, and fees) enjoy the benefits of the LoR’s preferred creditor status.²⁰ An example of the partial application of such financing structure is the Nam Ngiep 1 (NN1) Hydropower Project in the Lao PDR. Note, however, that NN1 was implemented partly using the A/B structure with ADB, as the LoR, providing A Loan, and three Japanese partner banks providing the B Loan (Figure 2). The remaining loan was provided by Japan Bank for International Cooperation (JBIC) and four Thai banks including the Export-Import Bank of Thailand (Box 3). The shareholders of NN1 were the Government of the Lao PDR, KPIC Netherlands B.V., and EGAT International, a wholly owned subsidiary of EGAT, which is also the off-taker of the electricity.

²⁰ International Finance Corporation (IFC). 2021. *B Loans*.

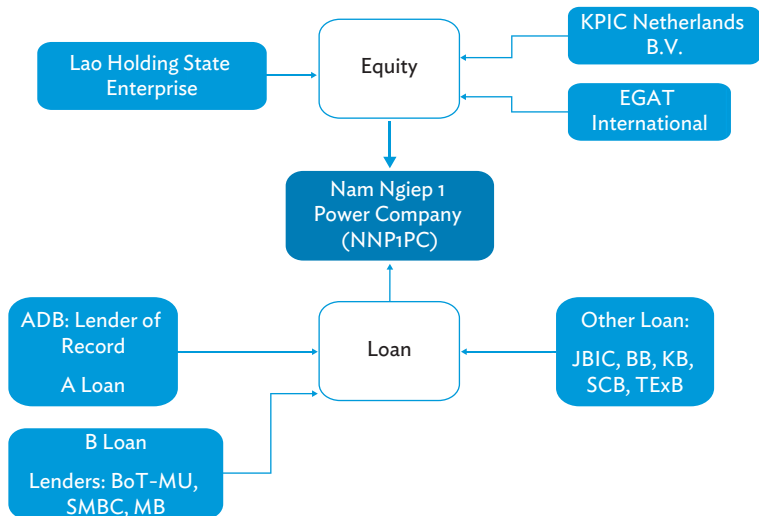
Figure 1: Financing Scheme of A/B Loans



MDB = multilateral development bank.

Source: Adapted from the International Finance Corporation, 2021.

Figure 2: Financing Structure of Nam Ngiep 1 Hydropower Project, Lao People's Democratic Republic



ADB = Asian Development Bank, BB = Bangkok Bank, BoT-MU = Bank of Tokyo-Mitsubishi UFJ, EGAT = Electricity Generating Authority of Thailand, JBIC = Japan Bank for International Cooperation, KB = Kasikorn Bank, MB = Mizuho Bank, SCB = Siam Commercial Bank, SMBC = Sumitomo Mitsui Banking Corporation, TExB = Export-Import Bank of Thailand.

Source: Author.

Box 3: Nam Ngiep 1 Hydropower Project, Lao People's Democratic Republic

The 290-megawatt (MW) Nam Ngiep 1 (NN1) Hydropower Project on the Nam Ngiep River of the Lao People's Democratic Republic (Lao PDR) is implemented on a build–operate–transfer basis under a public–private partnership arrangement. The project is constructed by the Nam Ngiep 1 Power Company (NNP1PC), a special purpose company jointly owned by Kansai Electric Power of Japan through KPIC Netherlands B.V., EGAT International of Thailand, and the Government of the Lao PDR. The project was developed to export bulk of the power to Thailand. The buyer of the electricity is the Electricity Generating Authority of Thailand (EGAT), which is the sole owner of EGAT International.

Total estimated cost of the NN1 project was \$982 million, of which \$336 million was equity. The shareholders of NNP1PC and their respective equities are KPIC (45%), EGAT (through EGAT International) (30%), and the Government of the Lao PDR (through Lao Holding State Enterprise) (25%).

The Asian Development Bank (ADB) provided (i) a direct loan of up to \$50 million; (ii) a baht-denominated direct loan of up to B3,040 million; and (iii) a B Loan of up to \$77 million financed by three Japanese banks (The Bank of Tokyo-Mitsubishi UFJ, Ltd., Sumitomo Mitsui Banking Corporation, and Mizuho Bank, Ltd. with ADB acting as the lender of record). The remaining loan component was financed by Japan Bank for International Cooperation and four Thai banks (Bangkok Bank, Kasikorn Bank, Siam Commercial Bank, and Export-Import Bank of Thailand).

Sources: ADB. 2014. *Proposed Loans to the Lao People's Democratic Republic for the Nam Ngiep 1 Power Company Limited - Nam Ngiep 1 Hydropower Project*. Manila. World Bank. 2021a. *Snapshots: Nam Ngiep 1 Hydropower Project*. Washington, DC.

Financing Solely by Domestic Public–Private Community Sources

One of the variants of hydropower financing with PPP involves equity investment partly by a state agency and partly by the private sector. In several states of India, a state nodal agency is designated, with the option of investing in the equity along with the private sector to facilitate the development of HPPs through the PPP and joint venture modes.²¹

²¹ PricewaterhouseCoopers Private Limited (PwCPL). 2017. *Accelerating Hydropower Development in India for Sustainable Energy Security*. India: PwCPL. According to this report, by 2017 a total of 3.2 GW of hydropower capacity was installed in India by the private sector.

As another variant of PPP, some HPPs in Nepal are being developed with equity provided by a consortium of public sector institutions led by the state-owned electric utility, local people from areas affected by the project, employees of the project itself, employees of corporate equity holding entities, and the public. An innovative feature of this financing structure is the community participation in the financing through equity contribution by the local people. Allocation of certain shares in equity to the local people is driven by the objective of developing a sense of ownership of the project in the local communities and partly to improve the economic well-being of the local people. The involvement of the public electric utility, which is also the off-taker of electricity produced, as a major equity holder helps to reduce the off-taker risk and boosts the confidence of other investors. The Upper Tamakoshi Hydropower Project in Nepal, a project financed fully through domestic sources, is based on this model (Box 4). The model appears to be attractive for countries that face difficulties in mobilizing external funding due to low creditworthiness and other risks. However, it should be noted that the potential for replication of such a model of sole domestic financing of large HPPs in low-income countries like Nepal is limited because domestic capital is scarce (Ogino et al., 2019).²²

Public Sector Project Financing Models

This section discusses four variants of public sector financing models:

- (i) Financing solely through government loan and grants from importing country.
- (ii) Financing through joint venture between host and power importing countries.
- (iii) Financing by public sector of the importing country as the sole project sponsor.
- (iv) New bilateral financing of public sector projects.

²² K. Ogino, J. Son, and M. Nakayama. 2021. Effectiveness of hydropower development finance: evidence from Bhutan and Nepal. *International Journal of Water Resources Development*. 37:3. pp. 491–507.

Box 4: Upper Tamakoshi Hydropower Project, Nepal

The 456-megawatt (MW) Upper Tamakoshi Hydropower Project (UTHP) is a peaking run-of-river hydropower project on the Tamakoshi River in the Dolakha District of Nepal. Upper Tamakoshi Hydropower Limited (UTHL), a special purpose company established by Nepal Electricity Authority (NEA), is the developer of the project.

The project cost was initially estimated to be NRs35.29 billion in 2011. In April 2018, the project cost was revised to NRs49.29 billion (without interest during construction) and NRs66.18 billion (including interest during construction) due to various reasons, including the 2015 earthquake, price escalations, devaluation of currency, and change in tunnel design. As a result, the revised debt–equity ratio of the project has increased to 86:14 from 70:30 at the time of financial closure.

UTHL is owned by two types of shareholders—institutional and individuals holding 51% and 49% of ownership, respectively. There are four public entities as institutional shareholders, i.e., NEA; Nepal Telecom; Rastriya Beema Sansthan (RBS), a public sector insurance corporation; and Citizens Investment Trust (CIT). NEA holds 51% of the institutional shares, while NTC holds 6%; RBS, 2%; and CIT, 2%. Individual shareholders include the public (15%), locals of project-affected areas (10%), employees of Employee Provident Fund (17.28%), employees of UTHL and NEA (3.84%), and employees of lending institutions (2.88%). The government is one of the lenders of UTHL.

About 64% of the debt component (NRs20 billion) is financed by Employees Provident Fund, Nepal Doorsanchar Company Limited, Rastriya Beema Sansthan, and CIT at floating interest rates, taking deposit rates availed by these institutions from banks as a benchmark. The remaining debt is arranged by the government as soft loans that has been routed through NEA.

Source: KCL Astute Capital Research Team (KCLACRT). 2019. *Equity Research Report—Upper Tamakoshi Hydropower Limited*. KCLACRT.

Financing Solely through Government Loan and Grants from Importing Country

This model of financing can benefit both the host country (where HPPs are located) and the importing country. The host country gets necessary funding resources as well as the revenue from the assured sale of surplus power whereas the importing country benefits from the supply of cleaner and cheaper electricity. In addition, the foreign currency risks are also minimized when the project costs and revenues are both in the currency of the importing country.

As an example of this approach of financing, the Government of India has wholly funded four large HPPs with a combined capacity of over 2,100 MW in Bhutan over a time span of few decades with this financing model. The Government of India provided loan and grants for the projects under government-to-government agreements. Such HPP financing started with a high grant-to-loan ratio of 60:40 and a low interest rate. India, with huge demand for electricity and being heavily dependent on coal for power supply, has benefited from the clean electricity supply from HPP, while Bhutan has gained from the assured flow of electricity export revenue, which accounts for a large share of the country's income. However, a financing model with a high grant-to-debt ratio and low interest rate is neither likely to be replicable nor sustainable for developing larger HPPs. Indeed, the grant-to-loan ratio has declined over time for similar projects funded by India in Bhutan. Also, the interest rate has increased for the subsequent HPPs (Box 5).

Financing through Joint Venture between Host and Importing Countries

In this approach, a joint venture company to develop an HPP is established by state-owned agencies of the host and importing countries under an intergovernmental agreement. A concession agreement is signed between the joint venture company and the government of the host country. The ownership of the HPP assets are transferred to the host country government after the concession period. As an example of this approach, Bhutan and India have recently signed an agreement to develop a 600 MW HPP in Bhutan as a 50:50 joint venture (Box 6). Under the joint venture arrangement, India will purchase the surplus power from the project. Such a model of financing is likely to be more efficient as it allows joint ownership of the HPP during the concession period as well as sharing of the risks.

Box 5: Hydropower Financing in Bhutan Solely with Loan and Grants from India

India has played a major role in the hydropower development of Bhutan. The development of the hydropower projects (HPPs) by India started with the construction of the 336-megawatt (MW) Chukha HPP in 1979. The project was fully funded by the Government of India, with 60% of the total project cost as a grant and 40% as a loan, which was repayable over 15 years in 30 installments at an interest rate of 5% per year. Subsequently, the Government of India has fully financed the construction of two other HPPs, the Kurichhu HPP (60 MW) and Tala HPP (1,020 MW) also with a debt-to-grant ratio of 40:60. However, the interest rate was 10.75% per year for Kurichhu. In the case of Tala, the interest rate was 9% per year with loan repayable in 12 equal annual installments (Saklani and Tortajada, 2019). All of these Government of India-financed HPPs are now under Druk Green Power Corporation of Bhutan.

In 2009, the governments of India and Bhutan signed a memorandum of understanding on the generation of a minimum of 10,000 MW of additional power by 2020 from 10 more projects. The 720 MW Mangdechhu Hydroelectric Project is one of those projects. The project was developed through Mangdechhu Hydroelectric Project Authority, a special purpose vehicle established through an intergovernmental agreement between the governments of India and Bhutan. The Government of India fully funded the project with 70% loan and 30% grant. The loan is repayable in 30 installments over 15 years following project commissioning (World Bank, 2016). PTC India Ltd and Druk Green Power Corporation of Bhutan have signed a power purchase agreement for Mangdechhu Hydroelectric Project.

Sources: Power Technology. 2021. *Mangdechhu Hydroelectric Project, Bhutan*; U. Saklani and C. Tortajada. 2019. India's Development Cooperation in Bhutan's Hydropower Sector: Concerns and Public Perceptions. *Water Alternatives* 12(2): 734-759.

World Bank. 2016. *Managing Environmental and Social Impacts of Hydropower in Bhutan*. Washington, DC.

Box 6: Intergovernmental Joint Venture for Financing Hydropower Projects in Bhutan

Bhutan and India have signed an agreement to develop the Kholongchhu Hydropower Project with a capacity of 600 megawatts (MW) in Bhutan as a 50:50 joint venture. The joint venture partners of the project are Sutlej Jal Vidyut Nigam (SJVN) (India) and Druk Green Power Corporation (DGPC) (Bhutan)—both public sector undertakings. The project will be implemented by Kholongchhu Hydro Energy Ltd, a joint venture company established under the intergovernmental agreement. The joint venture partners will run the project for 30 years (i.e., concession period) after the project is commissioned. The full ownership of the project will be transferred to the Royal Government of Bhutan. The government will receive power from the project as a “royalty” till then (Haider, 2020).

REC Ltd and Power Finance Corporation (PFC) Ltd, both state-owned companies from India, have signed a memorandum of understanding (MOU) with Kholongchhu Hydro Energy Ltd (KHEL) for financing of the project. The project has been proposed to be financed with debt–equity ratio of 70:30. Based on the MOU, REC (India) and PFC (India) would each provide Indian rupee term loan of ₹20.29 billion, while the National Pension and Provident Fund (NPPF), Bhutan and Bank of Bhutan would each provide loan of ₹2 billion (Tayal, 2021). The Government of India will provide, as a grant, the equity share of the DGPC (Bhutan) in the joint venture Company (Haider, 2020).

Sources: S. Haider. 2020. *India, Bhutan sign pact for first joint venture hydropower project*. *The Hindu*. 29 June; and M. Tayal. 2021. REC, PFC to Finance 600 MW Hydro Electric Power Project in Bhutan. *Energetica India*.

Financing by a Foreign Public Sector Agency as the Sole Sponsor

In this approach of financing, a foreign government through one of its public sector undertakings develops an HPP in a neighboring country through a special purpose company of which the foreign government is the sole equity holder. The HPP is an export-oriented project. The loan is mostly provided by the commercial banks of the sponsoring country.

This model has been used to finance the 900 MW Arun 3 Hydropower Project in Nepal. The project currently being constructed in Nepal is solely sponsored by Sutlej Jal Vidyut Nigam (SJVN)—a public sector institution of India using this approach (Box 7). Majority of the debt component is being provided in Indian rupees by a consortium of commercial banks from India, while some banks from Nepal will provide a small part of the loan. Financing of the project becomes attractive for both countries as the

project will export power to India, as it has large demand for electricity and wants to reduce dependence on thermal power. Nepal benefits from the export revenue and free electricity it receives during the concession period after the HPP comes into operation. Further, there is no currency-related risks involved because project cost and electricity revenue will be both in Indian rupees (as there is a fixed exchange rate between Indian and Nepalese currencies).

Box 7: Arun 3 Hydropower Project, Nepal

The Arun 3 Hydropower Project (Arun 3) is a 900-megawatt (MW) run-of-river project under construction in Nepal on a build–own–operate–transfer basis. Electricity produced from the project is to be mostly exported to India.

Arun 3 is being constructed by SJVN Arun-3 Power Development Company Pvt. Ltd—a company registered in Nepal. The company is a 100% subsidiary of Sutlej Jal Vidyut Nigam, which is a joint venture between the Government of India and state government of Himachal Pradesh in India. The project will have a construction period of 5 years and operation period of 25 years, after which it will be transferred to the Government of Nepal. Nepal will get 21.9% of the monthly power and energy free of cost from the project.

The project is financed with a debt-to-equity ratio of 70:30. Sutlej Jal Vidyut Nigam will provide the equity. Financial closure for the project has been achieved in February 2020. A group of seven banks from India and Nepal has agreed to provide loan facilities worth approximately \$890 million for the project, i.e., five banks from India (State Bank of India, Punjab National Bank, Canara Bank, Union Bank of India, and Export-Import Bank of India) have committed to provide about \$755 million (85%) of the loan, while two banks from Nepal (Everest Bank and Nabil Bank) have committed to provide approximately \$135 million (15%) of the loan.

The purchase price of electricity from the project is being determined through auction. Most of the power output of the project is expected to be exported to India earning project revenue in Indian rupees. As a result, the repayment of loan, which is also mostly in Indian rupees, will not involve the risk of currency fluctuations.

The Government of India has committed to provide an additional investment of approximately \$192 million for the construction of the 400-kilovolt double circuit transmission line for transmission of the power from Arun 3 to the India–Nepal border.

Source: NS Energy. 2021. *Arun-3 Hydropower Project*.

New Bilateral Financing of Public Sector Projects

As discussed earlier, this scheme typically involves only the export credit agency (ECA) or bilateral development bank (BDB) of an upper middle-income country and the government of the host country. The ECA or BDB provides the host country government the entire loan component for an HPP. As fewer actors are involved, financing and project implementation process is faster in this model. However, the borrowing countries may have little or no choice in selection of contractors (footnote 14). The Upper Trishuli 3A Hydropower Project in Nepal presents an example of projects financed predominantly by the PRC with this approach (Box 8).

Box 8: Upper Trishuli 3A Hydroelectric Project, Nepal

The Upper Trishuli 3A HPP is a 60-megawatt run-of-river project. The cost of the project is about \$125 million. The state-owned Nepal Electricity Authority developed the project with concessional loan of around \$116 million from China EXIM Bank with the rest funded by domestic resources. Nepal has to repay the loan to China EXIM Bank in 25 years including a grace period of 5 years. The contracts for major construction works, construction, supervision, and transmission line construction for the project were awarded to three different companies from the People's Republic of China.

Source: Nepal Electricity Authority (NEA). 2020. *A Year in Review - Fiscal Year 2019/20*. Kathmandu: NEA.

Private Sector Project Financing Models

As discussed earlier, private HPPs are normally developed by IPPs typically under the build–own–operate–transfer arrangement through a concession agreement with the government. IPPs become the sole sponsor of the HPPs. Normally the debt-to-equity ratio in private HPP projects is significantly greater than 1. Some private HPPs are financed solely by domestic sources while others are financed with a blend of domestic and foreign sources including MDBs.

Domestic Financing of Private Hydropower Projects

In many developing countries, domestically funded IPPs are mostly engaged in the development of small HPPs in the private sector as it is difficult to mobilize finance for large HPPs. Typically, a special purpose company is created to implement an HPP by an IPP. One or more

commercial banks and other financial institutions of the country may provide loan for such HPPs. Sale of electricity from the HPPs is arranged under a power purchase agreement with the public utility. Normally, IPPs bear the project cost and manage risks. They are also the sole beneficiary of all rewards. IPPs are in operation in several countries. In Nepal, a large number of HPPs are developed by IPPs. The combined capacity of such plants accounted for about 55% of the total installed capacity of HPPs in the country in fiscal year 2019/2020. However, most of the IPP plants were relatively small, ranging from about 1 MW to 60 MW.²³ A total of 131 projects with a combined installed capacity of 3,157.19 MW were under construction by IPPs in 2019/2020 after financial closure (footnote 23).

External Financing of Private Hydropower Projects

Foreign direct investment (FDI) can play a major role to develop HPPs in the private sector. MDBs could play a catalytic role by providing some loan and guarantees. The Upper Trishuli-1 Hydropower Project in Nepal is an example of an FDI-funded private sector hydropower project. The project is almost entirely sponsored by companies from the Republic of Korea, while debt providers include three MDBs (International Finance Corporation, ADB, AIIB), two BDBs, and an ECA. The Multilateral Investment Guarantee Agency is providing the political risk guarantee (Box 9). An innovative feature of the project is the start-up equity financing. IFC InfraVentures²⁴ provided critical support at early stages of project development by helping in contract structuring and negotiations, providing policy and regulatory support, and by providing technical expertise.²⁵ Such support helps to overcome the barrier to HPP financing due to lack of bankable in projects.

Another example of FDI-funded private hydropower project is the Karot Hydropower Project in Pakistan. The project is developed by a joint venture company with both debt and equity financed predominantly by bilateral sources from the PRC (Box 10).

²³ Nepal Electricity Authority (NEA). 2020. *A Year in Review - Fiscal Year 2019/20*. Kathmandu: NEA. .

²⁴ IFC. 2020. *InfraVentures*. Washington, DC: IFC.

²⁵ M. Landy. 2015. *Hydropower Project and Financial Structuring: What are the New Options?* [Presentation Slides]. World Hydropower Congress.

Box 9: Upper Trishuli-1 Hydropower Project, Nepal

The Upper Trishuli-1 is a 216-megawatt run-of-river hydropower plant being developed in Rasuwa, Nepal under a build–own–operate–transfer model by the Nepal Water and Energy Development Company (NWEDC)—a privately owned special purpose company. The project, with an estimated cost of \$647 million, is being almost entirely financed by foreign capital making it one of the largest foreign direct investments in Nepal.

The International Finance Corporation (IFC) provided \$4.25 million for an early-stage development fund in 2013 through IFC InfraVentures in exchange for equity share (initially 15%) of the special purpose company. IFC is a co-developer of the project along with Korea South East Power Company (Landy, 2017). IFC also leads the debt arrangement of the project, which has eight other lenders—including the Asian Development Bank, Asian Infrastructure Investment Bank, Korea Development Bank, Export and Import Bank of Korea, Proparco, and others, providing a total of \$453.2 million. It is the implementing entity of blended finance from several multilateral development banks, bilateral development banks, and international finance institutions.

At the time of financial closure in 2019, IFC committed more finance in the form of additional equity and loan to the project, providing a total of \$190 million (this included equity injected in initial stages through InfraVentures) (IFC, 2019). The key shareholders of the project are Korea South-East Power (52%), Daelim Industrial (16%), IFC (12%), Kyeryong Construction Industrial (10%), and local stake (10%) (NWEDC, 2020).

The Multilateral Investment Guarantee Agency will provide \$135 million in guarantees to cover the political risk.

Sources: IFC. 2019. IFC, *Partners Provide More than \$450 Million to Support Major Hydro-Electric Plant in Nepal*.

M. Landy. 2017. *Financing Hydropower: Tapping New Sources of Investment*. *Hydro Review*.

NWEDC. 2020. Project Summary. *Nepal Water and Energy Development Company Private Limited (NWEDC)*.

Box 10: Karot Hydropower Project, Pakistan

The Karot Hydropower Project (KHPP) is a foreign direct investment (FDI) project with 720-megawatt (MW) capacity. It is being developed on a build–own–operate–transfer basis, with the concession period of 35 years including a construction period of 5 years. Karot Power Company (Pvt.) Ltd (KPCPL) is developing the project. KPCPL is a joint venture company of China Three Gorges South Asia Investment Ltd (CTGSAIL) and Silk Road Venture Investment Company (SRVIC) with shares of 93% and 7%, respectively. CTGSAIL is registered in Pakistan. SRVIC is registered in the United Arab Emirates. The project has a debt-to-equity ratio of 75:25 and is financed by a consortium of China EXIM Bank and China Development Bank, Silk Road Fund, and International Finance Corporation of the World Bank. The cost of capital of the project is below 5% (EPRCP, 2021). The estimated cost of the project is \$1.7 billion. The engineering, procurement, and construction contractor is Yangtze Three Gorges Technology & Economic Development Co., Ltd of China.

Source: Karot Power Company (Pvt.) Limited (KPCPL). 2014. *Stakeholder*. Karot Power Company (Pvt.) Limited.

Financing of Private Hydropower Projects as a Joint Venture

Some hydropower projects are developed by the private sector as a joint venture between a domestic private investor and a foreign investor. As an example, the 86 MW run-of-the-river Malana Hydropower Project in Himachal Pradesh, India has been developed by Malana Power Company Limited—a joint venture project between LNJ Bhilwara Group of India and SN Power of Norway—with the two joint venture partners holding equity shares of 51% and 49%, respectively.²⁶

Climate Finance and Hydropower

This section discusses three approaches of climate-related finance in the specific context of hydropower: i.e., (i) international climate funds, (ii) carbon finance, and (iii) climate bonds. It also discusses the key factors behind the low access of hydropower to climate finance.

²⁶ World Bank. 2021. *Malana Hydro Electric Power Plant. Private Participation in Infrastructure (PPI)*. Washington, DC: World Bank Group.

Climate finance through climate funds. There are various funds involved in climate finance. In broad terms, public sources of multilateral climate finance relevant to hydropower development can be categorized into United Nations Framework Convention on Climate Change (UNFCCC) and non-UNFCCC-based funds. UNFCCC-based multilateral sources include the Global Environment Facility (GEF) that is used to support financing of energy projects. GEF manages the Special Climate Change Fund and the Least Developed Countries Fund. Established in 2010, the Green Climate Fund (GCF) has been focusing on clean energy projects, whereas other funds under UNFCCC have been involved in climate change adaptation and other sustainable development sectors (footnote 7).

Non-UNFCCC-based multilateral funds that have financed hydro projects include the Clean Technology Fund (CTF), Scaling-up of Renewable Energy Program in Low-Income Countries (SREP), and Pilot Program for Climate Resilience (PPCR). These funds are under Climate Investment Funds managed by the World Bank.²⁷

Other sources of climate finance include MDBs. Besides providing finance from their own resources, MDBs administer other climate-related funds. Climate funds are also channeled by some developed countries to developing countries bilaterally, as official development assistance.²⁸

The flow of finance from multilateral climate funds into hydropower sector is low. According to Patel et al. (2020) (footnote 7), of the 23 climate funds (both multilateral and bilateral) reported in the Climate Funds Update database (CFU, 2020a and 2020b),²⁹ only four multilateral public funds (i.e., CTF), SREP, GEF, and GCF have provided support to HPPs. Together, these funds have supported a total of 36 HPPs. The study estimates that the HPPs received \$693 million of the public climate finance between 2003 and 2018 (Table 1). This figure is low when compared to about \$300 billion of the private and public finance that were mobilized for renewables in 2016.

²⁷ Bloomberg NEF. 2019. *The Clean Technology Fund and Concessional Finance|Lessons Learned and Strategies Moving Forward* (Issue February). Bloomberg NEF.

²⁸ For more information on this and other aspects of climate finance, see the chapter on Clean Energy Financing Options: Sources, Instruments, Risks, and Mitigation Options in this volume.

²⁹ Climate Funds Update (CFU). 2020a. *Clean Technology Fund*. (CFU); and CFU. 2020b. *Green Climate Fund*. CFU.

Table 1: Hydropower Projects Funded by Selected Multilateral Climate Funds

Name of Fund	Mandate	Number of Projects Funded	Total Funding (\$ million)
Global Environment Facility (GEF)	Adaptation and mitigation	26	73
Green Climate Fund (GCF)	Adaptation and mitigation	2	136
Clean Technology Fund (CTF)	Mitigation	4	404
Scaling-up of Renewable Energy Program in Low-Income Countries (SREP)	Mitigation	4	80

Source: S. Patel, C. Shakya, and N. Rai. 2020. *Climate finance for hydropower incentivising the low-carbon transition*. Issue Paper. January. London: IIED.

Climate finance often becomes a component of blended finance and is used to mobilize capital resources from private and other financing sources to implement climate-friendly initiatives. The Tina River Hydropower Project in Solomon Islands is expected to generate several benefits related to climate change and sustainable development goals and, as such, presents a good example of GCF climate finance blended with multiple other sources of finance to develop a sustainable hydropower project (Box 11).

Box 11: Tina River Hydropower Project, Solomon Islands

Solomon Islands depends currently almost entirely on diesel power generation for electricity supply. As such, its electricity price is one of the highest in the world and only 16% of the population had access to electricity supply in 2021.

The Tina River Hydropower Development Project (TRHDP) is a national project of the Government of Solomon Islands. It is a storage project with installed capacity of 15 megawatts (MW). TRHDP is developed by a project office under the Ministry of Mines, Energy and Rural Electrification. The project is planned to be completed in 2024.

continued on next page

Box 11 *continued*

The total project cost is estimated at \$240.48 million. The project is financed by the Government of Solomon Islands and six different financiers, which include a global climate fund (Green Climate Fund [GCF]); two multilateral development banks (Asian Development Bank [ADB] and World Bank); two overseas development agency funds (Abu Dhabi Fund for Development and Korea EXIM Bank Economic Development Cooperation Fund); and the Government of Australia. In addition, the Multilateral Investment Guarantee Agency is involved in providing insurance for political risks (TRHDP, 2021). The financing package includes equity, grant, concessionary loan, as well as B loan components (ADB, 2019b). According to ADB (2019b), K-Water and Hyundai Engineering Corp are involved in providing equity.

One of the very few hydropower projects partially financed by a climate fund (GCF), the project is expected to generate the following benefits:

- (i) TRHDP is expected to annually generate on average, 78.35 gigawatt-hours of hydroelectricity and displace equivalent amount of energy to be generated by current and future diesel generators.
- (ii) Electricity price would be reduced and become more affordable. The resulting cost savings could be used for other goods and services (e.g., health, education, and business) to improve the quality of life.
- (iii) It would meet 68% of electricity demand in the capital Honiara by 2025 and thus increase significantly peoples' access to electricity supply.
- (iv) It is estimated that the project will help not only attain the country's 2025 greenhouse gas emissions reduction target but also to exceed it by two and a half times.
- (v) It would provide the country with energy storage capacity, which would provide operational flexibility to the power system and facilitate higher penetration of solar photovoltaic power. These and other benefits seem to have made the project attractive for financing by GCF and other institutions.

Sources: ADB. 2019. *Tina River Hydropower Project: Project Administration Manual*. Manila.

Tina River Hydropower Development Project (TRHDP). 2021. *Project Benefits*. TRHDP. Solomon Islands.

Climate finance can also be used to assess climate vulnerability and develop measures for climate resilience of HPPs. For example, the PPCR, one of the Climate Investment Funds, provided grants to the Strategic Programme for Climate Resilience in Tajikistan for an assessment of the hydropower sector's vulnerability to climate change and to incorporate climate change resilience into the rehabilitation of a pilot hydropower plant in that country.³⁰

Carbon finance. A different form of climate-related finance (more specifically termed as “carbon finance”) is the Clean Development Mechanism (CDM) established by the UNFCCC under the Kyoto Protocol. Several HPPs from different parts of the world have been registered under CDM since February 2005 and benefited in terms of carbon revenue from the sale of certified emissions reductions (CERs). Altogether, 1,408 HPPs were registered under CDM by 7 April 2020.³¹ According to Cames et al. (2016), altogether, 92 GW of hydropower capacity had been installed by using the CDM by the end of 2013. Of this capacity, 63% were installed in the PRC, 13% in Brazil, 6.5% each in India and Viet Nam, with the rest 11% distributed in 44 other countries.³² CDM HPPs are also allowed to be export-oriented. The 126 MW run-of-river Dagachhu Hydropower Project in Bhutan, which has been developed to export its power output to India and displace equivalent thermal power generation in India, is an example of such a project.³³

The use of CDM for HPPs, has, however, also come under heavy criticism due to concerns related to the fulfillment of greenhouse gas (GHG) mitigation requirement and additionality criterion by some HPPs. New HPPs aspiring to earn carbon credits are therefore expected to meet more stringent eligibility criteria on additionality and sustainability than those under the CDM. The Carbon Partnership Facility (CPF) of the World Bank is engaged in bringing together the developing country sellers of CERs and industrial country buyers. CPF is also involved in using the carbon finance to mobilize funds from the private sector to implement clean energy

³⁰ ADB, the European Bank for Reconstruction and Development (EBRD), and the World Bank supported Tajikistan in developing SPCR with a total CIF envelope of \$50 million. In Phase 1, PPCR provided a grant of \$300,000 to EBRD to conduct an assessment of the climate change vulnerability of the hydropower sector in Tajikistan. In Phase 2, PPCR provided a \$10 million grant to build climate change resilience in the hydropower plant (EBRD, 2011. *The EBRD and Climate Investment Funds. European Bank for Reconstruction and Development*).

³¹ UNFCCC. 2021. *Project Activities: Hydropower*. Bonn: UNFCCC.

³² M. Cames et al. 2016. *How Additional is the Clean Development Mechanism?* Berlin: Öko-Institut e.V.

³³ ADB. 2010. *Dagachhu Hydropower Project - First Cross-Border Clean Development Mechanism Initiative*. Manila.

projects. A number of small hydropower development projects have been developed under the Renewable Energy Development Project (REDP) in Viet Nam. REDP was successfully registered as a Programme of Activities project under the [UNFCCC](#) and generated over 1.1 million certified GHG CERs from the small hydropower projects (SHPs) between 2014 and 2017. In 2014, the [CPF](#) agreed to purchase CERs generated by the SHPs developed under REDP.³⁴

Climate finance through climate bonds. Climate bond is another increasingly popular instrument of climate financing. Climate bonds are a subset of green bonds and they function likewise.

HPPs financed with green bonds in Asia are mostly located in the PRC. Of the nearly \$100 billion green bonds issued in the PRC over 3 years from 2016 to 2019, the hydropower sector received \$7 billion. China Three Gorges Corporation was the leading issuer of green bonds for hydropower, with around \$1.9 billion invested for the construction of 10,200 MW Wudongde Hydropower Plant.³⁵ Other HPPs listed in the China Three Gorges' green bond frameworks were also large scale.³⁶

Green bonds are yet to make a major impact in hydropower finance elsewhere in Asia. In fact, HPPs financed by green bonds in Asian countries other than the PRC are rare. The 412 MW run-of-river Rampur hydropower project, for which the World Bank has provided a loan of \$400 million to Satluj Jal Vidyut Nigam Limited, a public listed company in India, as a partial finance to the project using proceeds from the bank's green bonds, seems to be one of such cases.³⁷

Key Factors Behind Low International Climate Financing of Hydropower Projects

As the foregoing discussion shows, hydropower has not figured significantly in climate finance. Major concerns behind an unenthusiastic treatment or rejection of many hydro projects by multilateral climate funds include the following (footnote 7):

³⁴ Z. Cheng. 2020. *Tailored World Bank climate finance package mobilizes market for small hydropower in Vietnam*. 18 JUNE.

³⁵ D. Escalante et al. 2020. *The State and Effectiveness of the Green Bond Market in China, Climate Policy Initiative*.

³⁶ They included the Baihetan Hydropower Plant (15,200 MW), Xiluodu Hydropower Plant (13,860 MW), and Xiangjiaba Plant (6,448 MW).

³⁷ BankTrack. undated. *Issue Brief: Green Bonds*. BankTrack.

- Many HPP proposals do not demonstrate additionality.³⁸ Further, hydropower being a mature technology, HPP proposals fail to provide transformational benefits to existing electrical infrastructure.
- Climate impacts can change hydrology and consequently alter energy output of HPPs. For countries predominantly based on hydropower, overdependence on climate-vulnerable hydro means reduced reliability of energy systems.
- Although most HPPs' GHG emission from reservoirs are similar to other renewable sources, some reservoirs have emission profile worse than thermal plants.
- HPPs often entail political risks and are often viewed as risky investment. More importantly, concerns on social and ecological integrity of HPPs are present as they can impact local communities and downstream ecosystem significantly.

Opportunities

Nationally determined contributions (NDCs) and sustainable development goals require countries to have the energy system transformation with predominance of renewables. Renewables like solar and wind are becoming increasingly competitive and cost-effective and are expected to play an ever-increasing role in such a transformation. However, the intermittency and uncertainty related to these resources require significant additional energy storage facilities for a large-scale development of these resources. This offers significant opportunity for the deployment of low-carbon HPPs, as they can provide energy storage and grid ancillary services (e.g., providing grid stability, dispatchable energy, meeting fluctuating power demand during the peak and other periods).

The International Energy Agency (IEA) estimates that the share of electricity in final energy consumption in the Asia and Pacific region would increase from 23% in 2019 to 26% in 2030 and 30% in 2040 under the Stated Policies Scenario (STEPS), and to 29% in 2030 and 37% in 2040

³⁸ Evidence of additional climate benefits beyond what could be expected without the applied climate finance.

under the Sustainable Development Scenario (SDS).³⁹ It is estimated that the new hydropower capacity in the Asia and Pacific region would be about 243 GW during 2019–2030 and 465 GW during 2019–2040 under the STEPS scenario. Under the SDS, a much larger addition in hydropower capacity (i.e., 390 GW during 2019–2030 and 723 GW during 2019–2040) would be required. In other words, the total hydropower capacity in 2030 and 2040 under the SDS would be almost 56% and 85% higher than in 2019. Table 2 presents the estimated total hydropower generation capacity in selected countries and subregions of Asia and the Pacific. It shows that the hydropower capacity would grow most rapidly in Southeast Asia and India. The addition in hydropower capacity in the PRC would continue to be the largest in the region. Over 44% of the total region-wide capacity addition in the next 2 decades would take place in the PRC compared to 15% in India and 26% in Southeast Asia.

Hydropower is an important component of NDCs of many countries. According to the International Renewable Energy Agency (IRENA), worldwide, 240 GW of renewables-based power generation capacity would

Table 2: Estimated Total Hydropower Capacity (GW) by 2030 and 2040 under the International Energy Agency Scenarios

	2019	2030		2040	
	Total	STEPS	SDS	STEPS	SDS
China, People's Republic of	356	446	495	508	563
India	49	76	86	101	117
Japan	50	51	57	52	60
Southeast Asia	47	77	103	104	167
Rest of Asia and the Pacific	48	69	80	91	109
Asia and the Pacific Region	550	719	821	856	1016

SDS = Sustainable Development Scenario, STEPS = Stated Policies Scenario.

Source: International Energy Agency (IEA). 2020. *World Energy Outlook 2020*. Paris: IEA.

³⁹ IEA. 2020. *World Energy Outlook 2020*. Paris: IEA. The Stated Policies Scenario (STEPS) considers a pathway adopting all policies announced by governments including targets set under NDCs. The Sustainable Development Scenario (SDS) is a more ambitious than STEPS in that it would help attaining the GHG mitigation to limit the global warming well below 2°C.

come from the implementation of technology-specific targets of the NDCs and more than 110 GW of this would be large hydropower plants.⁴⁰ In Asia, hydropower is included as a priority technology for NDCs by several countries in South Asia, Southeast Asia, and Central and West Asia (in the case of South Asia and Central and West Asia, NDCs include both small and large hydropower).⁴¹

Storage hydropower plants can be additionally attractive from the low-carbon energy development perspective because of the potential opportunity they offer to install floating solar PV panels. ADB has financed a combined solar and hydropower project in Viet Nam. An integrated approach for developing hydropower and solar energy could be a new low-carbon energy strategy which could make climate finance of such projects attractive.⁴²

With the growing demand for sustainable low-carbon energy, new opportunities are emerging for the development of hydropower for meeting domestic electricity demand and for cross border power trade in different parts of Asia. Major economies in South Asia, Southeast Asia, and East Asia plan to increase the use of renewables to reduce their heavy dependence on fossil fuels. This offers opportunities for further development and financing of hydropower in hydropower-rich countries (e.g., Bhutan, the Lao PDR, and Nepal).

HPPs have been disadvantaged from access to new funding sources and instruments, i.e., climate finance and green/climate bonds. Until recently, a major reason for this was the lack of internationally accepted climate bonds standard for hydropower. However, this situation is likely to change now after the launch of Hydropower Criteria by the Climate Bonds Standard Board (CBSB) on 25 March 2021.⁴³ It provides the long-awaited screening criteria for investments in sustainable HPPs and provides a strong basis for formal certification of hydropower for issuers of green

⁴⁰ IRENA. 2017. *Untapped Potential for Climate Action - Renewable Energy in Nationally Determined Contributions*. Abu Dhabi: IRENA.

⁴¹ Y. Zhai, L. Mo, and M. Rawlins. 2018. *The Impact of Nationally Determined Contributions on the Energy Sector: Implications for ADB and Its Developing Member Countries*. Sustainable Development Working Paper Series No. 54. July. Manila: ADB.

⁴² C. Stocks. 2020. *Development banks approve hydropower investment in Asia and the Pacific*. NS Energy, 18 February.

⁴³ Climate Bonds Initiative (CBI). 2021. *Media Release: Climate Bonds launches Hydropower Criteria for Sustainable Hydropower Projects New Criteria Expands Green Definitions Under Climate Bonds Standard*. 25 March.

bonds for hydropower financing.⁴⁴ According to the CBSB, HPPs of all sizes, types (including pumped storage), and in all locations, will be eligible for green bonds, provided they meet the criteria. However, the upper limit of emission intensity permitted by the Hydropower Criteria for green bonds is much more stringent than that allowed for traditional hydropower financing by MDBs like the European Investment Bank.⁴⁵

Challenges

Compared to other clean energy projects, HPPs have a long life, require longer-term financing, and face several kinds of risks, which include political and regulatory, economic and financial (including off-taker and foreign currency risks), social, construction-related, hydrological and climate, environmental and ecological, geological, technological, and safety and natural risks.⁴⁶ The risks and their severity vary from project to project and country to country.

Attracting private or foreign investors for large projects becomes especially challenging for countries considered to have high political and credit risks. Countries classified as poor and economically vulnerable by MDBs also face financing challenges as they have limited access to concessional and market-based loans. As a result, such countries face high cost of borrowing from international private financial institutions.

⁴⁴ According to CBI (2021) (footnote 43), the new Hydropower Criteria requires the issuer of green bonds to demonstrate the following to the verifier that the proposed HPP *has “a high-power density or a low emissions intensity: recording either a power density of more than 5 W/m² or an emissions intensity of less than 100 g CO₂eq per kWh if the facility was operational pre-2020, and either a power density of more than 10 W/m² or an emission intensity of less than 50 g CO₂eq per kWh if the facility became operational in 2020 or thereafter.”* It also requires the undertaking of an official assessment using the ESG Gap Analysis Tool, one of the Hydropower Sustainability Tools. Further, such an assessment has to be carried out by an accredited assessor and has to be publicly available. It has to demonstrate: (a) no more than 10 gaps in total against international good practice, and (b) no more than two gaps in each section. There is also a requirement that the majority (>50%) of the gaps must be closed within 12 months and the remaining within 24 months.

⁴⁵ According to Environmental, Climate and Social Guidelines on Hydropower Development of EIB published in 2019, “...the EIB will not consider financing hydropower projects that emit more than 550 g of CO₂ per kWh, or any other value that may be adopted subsequently in the EIB Energy Lending Policy, calculated as average emissions over the first 20 years of the project lifetime.” Source: EIB. 2019. *Environmental, Climate and Social Guidelines on Hydropower Development*. Luxembourg: EIB.

⁴⁶ A. Shaktawat and S. Vadera. 2021. Risk Management of Hydropower Projects for Sustainable Development. *Environment, Development and Sustainability*. 23 (1). pp. 45–76.

Several countries promote renewable energy development with policies like Renewable Portfolio Standard (RPS) (also called renewable purchase obligation [RPO] in some countries). However, large hydropower projects are traditionally excluded from RPS or RPO. Such a policy disadvantages medium and large hydropower projects to compete with electricity produced by solar and wind power projects in the face of the declining per unit electricity cost of the solar and wind power options and relatively high unit cost of hydroelectricity. In countries like India, utilities are reported to have been reluctant to sign power purchase agreements with hydropower producers due to the higher unit cost of hydroelectricity. Policy changes are taking place in some countries to address such issues. For example, the Government of India has announced a policy in 2019 to include hydropower projects over 25 MW in the renewable energy category. The government also introduced a policy of hydropower purchase obligation for distribution companies as a part of RPO in 2019.⁴⁷

According to Landy (2017), there is a relative shortage of thoroughly studied and bankable hydropower projects in many developing countries.⁴⁸ Private financing institutions may not be interested in investing in project preparation, as such activity incurs substantial costs. Start-up investments for detailed studies to assess financial viability and risks and to identify mitigation measures would be needed for such activities as discussed earlier. This is also a kind of challenge to hydropower financing in developing countries.

There are also other well-known challenges to hydropower development associated with social and environmental and other sustainability concerns. MDBs and other major international financing institutions are normally reluctant to finance large HPPs until they consider that an HPP adequately meets the social and environmental sustainability criteria. HPPs are also mostly excluded from climate finance and green bond markets because of the sustainability and environmental concerns. Although many HPPs are in the category of a low-carbon and sustainable resource, HPPs in general face the challenge of having to rigorously prove so in order to be eligible for large-scale financing from MDBs, BDBs, and IFIs.

⁴⁷ Government of India, Ministry of Power (MOP). 2021. *Order No. 23.03.2016 R&R*. India: Government of India/MOP The hydropower purchase obligation is set to increase gradually from 0.18% in 2021–22 to 2.82% in 2029–2030.

⁴⁸ M. Landy. 2017. *Financing Hydropower: Tapping New Sources of Investment*. Hydro Review.

A major barrier to HPP financing is the time and cost overruns of HPPs as they increase the financing requirements and affect the projects' financial viability. A study based on cost overrun data of 184 large-dam HPPs constructed during 1936–2015 in different parts of the world estimates an average cost overrun of 43%, whereas it finds an average cost overrun of 25% using a more recent data of 42 projects constructed during 1994–2015.⁴⁹ Similarly, the same study reports an average time overrun of 32% using the time overrun data of 184 HPPs constructed during 1936–2015 and an average time overrun of 19% based on data of 60 more recent projects constructed during 1994–2015. While country experiences on overruns vary, some Asian countries have experienced much higher cost and time overruns. For example, in Nepal several HPPs have recorded time overruns of 4–8 years with resulting high cost overruns.⁵⁰ In India, the total time overrun in the case of all 41 large HPPs under construction in 2017 has been reported to range from 12 months to 17 years, with the total cost of these projects nearly doubled.⁵¹ Countries experiencing high cost and time overruns are likely to face an added challenge to attract financing for HPPs.

Lack of access to the grid or delays in completion of new transmission lines can also present difficulty to attract investment in and financing of new HPPs. For example, several new hydropower plants have not been able to transmit electricity generated to the grid in Nepal resulting in substantial losses of energy and revenue.

As was mentioned earlier, HPPs—storage projects, in particular—provide ancillary services in that they facilitate large-scale development of intermittent renewables and their integration with the power grid by providing flexibility in the operation of power system and supporting grid stability. By providing these services, they indirectly contribute to low-carbon development. Convincing the potential financing institutions to recognize such services and to value these services appear to be another challenge.

⁴⁹ J. P. Braeckman, T. Disselhoff, and J. Kirchherr. 2019. Cost and schedule overruns in large hydropower dams: an assessment of projects completed since 2000. *International Journal of Water Resources Development*. DOI: 10.1080/07900627.2019.1568232.

⁵⁰ Some projects like Kulekhani III incurred cost overrun of 90% in nominal terms. P. Rijal. 2019. Kulekhani III stirs to life after 12 years in development. *The Kathmandu Post*. 15 October.

⁵¹ *The Hindu*. 2017. *Hydropower projects incur over ₹45,000-cr cost overrun*. 2 August.

Conclusion and Final Remarks

This chapter has discussed the role of hydropower as a low-carbon energy resource and its growing opportunities in the light of the climate change commitments like the NDCs and climate mitigation targets under the Paris Agreement.

The chapter also discussed the evolution of the models of financing hydropower projects in developing countries, i.e., from dominance of public sector in financing in the initial phase to the increasing role of PPP in various forms and IPPs in the private sector. Further, it discussed the changing role MDBs from serving as a major source of funding earlier to increasingly serving as a financing partner that helps to mitigate risks and catalyze a larger mobilization of capital from local sources. The chapter also discussed the growing involvement of regional commercial banks in hydropower financing in Asia and the Pacific.

Despite being a relatively low-carbon resource in most cases, hydropower has yet to be a priority of global climate funds. While green bonds are becoming increasingly popular for renewable energy finance, their use for hydropower development in Asia is almost entirely limited to the PRC. This is largely because of the social, environmental, and other sustainability concerns about hydropower. The Hydropower Criteria launched recently by CBSB has defined the screening criteria for certification of hydropower of all sizes, which can provide strong impetus to identify and finance sustainable hydropower projects with green debt products. However, the criteria also demand more careful and socially responsible approach of hydropower project preparation and development.

Hydropower is a priority resource for many countries in their quest for sustainable and climate-friendly energy development. However, there are both opportunities and challenges for hydropower development. Innovative approaches for financing will be needed to address project and country-specific risks, constraints, and challenges of large-scale hydropower development. The ability of the countries to attract finance for hydropower development would largely depend on how well the governments and other stakeholders create enabling conditions to address the challenges.

References

- Asian Development Bank (ADB). 2014. *Report and Recommendation of the President to the Board of Directors: Proposed Loans to the Lao People's Democratic Republic: Nam Ngiep 1 Power Company Limited - Nam Ngiep 1 Hydropower Project*. Manila.
- . 2019a. *Investing in Asia's maiden green bonds*. Asian Development Bank.
- . 2019b. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Administration of Loan to Nepal for the Water and Energy Development Company Private Limited Upper Trishuli-1 Hydropower Project*. Manila.
- . 2019c. *Evaluation Approach Paper - Project Performance Evaluation Report for Loans 2161 and 2162-LAO: Greater Mekong Subregion Nam Theun 2 Hydroelectric Project*. Manila.
- Berga, L. 2016. *The Role of Hydropower in Climate Change Mitigation and Adaptation: A Review*. Engineering, 2(3): pp. 313–318.
- Bloomberg NEF. 2019. *The Clean Technology Fund and Concessional Finance|Lessons Learned and Strategies Moving Forward*. February. Bloomberg NEF.
- Braeckman, J. P., T. Disselhoff, and J. Kirchherr. 2019. *Cost and schedule overruns in large hydropower dams: an assessment of projects completed since 2000*. International Journal of Water Resources Development. Vol. 36. Issue 5.
- CK Power Public Company Limited. 2022. *Xayaburi Hydroelectric Power Plant*. Bangkok.
- Climate Bonds Initiative. 2019a. Climate Bonds Standard. EN.
- . 2020a. Green Bonds: Global State of the Market-2019. Climate Bonds Initiative.
- . 2020b. *Understanding the Hydropower Bond Criteria and Consultation Process*. Climate Bonds Initiative.
- . 2021. *The Hydropower Criteria*. Climate Bonds Initiative.

———. 2021. *Media Release: Climate Bonds launches Hydropower Criteria for Sustainable Hydropower Projects New Criteria Expands Green Definitions Under Climate Bonds Standard*. Climate Bonds Initiative. 25 March 2020. London.

Climate Funds Update. 2020a. *Clean Technology Fund*. Climate Funds Update.

———. 2020b. *Green Climate Fund*. Climate Funds Update.

Cheng, Z. 2020. *Tailored World Bank climate finance package mobilizes market for small hydropower in Vietnam*. 18 June.

The Central People's Government of the People's Republic of China. 2008. *GoCChina Hydropower Foreign Corporation undertakes to build Kazakhstan's largest hydropower station since the founding of the country*. The Central People's Government of the People's Republic of China.

Dreher, A., A. Fuchs, B. C. Parks, A. M. Strange, and M. J. Tierney. 2017. *Aid, China, and Growth: Evidence from a New Global Development Finance Dataset*. AidData Working Paper #46. Williamsburg, VA: AidData.

ECON. 2008. *A Review of Private–Public Partnership Models in Hydropower Projects*. Econ Pöyry AS.

EDL-Generation Public Company. 2017. *Nam Ngum 2 Hydropower Project*. EDL-Generation Public Company. Vientiane.

Electricity Generating Authority of Thailand. 2019. *Xayaburi Hydropower Plant starts supplying electricity to EGAT*. Electricity Generating Authority of Thailand, Bangkok.

Embassy of the People's Republic of China in Pakistan. 2021. *Karot Hydropower Project*. Embassy of the People's Republic of China in Pakistan, Islamabad.

Escalante, D., J. Choi, N. Chin, Y. Cui, and M. L. Larsen. 2020. *The State and Effectiveness of the Green Bond Market in China*, Climate Policy Initiative. Washington, DC.

European Bank for Reconstruction and Development. 2011. *The EBRD and Climate Investment Funds*.

Fair Finance Thailand. 2019. *Challenges of Dam Financing for Thai Banks The Case of Xayaburi and XPXN Projects*. Fair Finance Thailand. Bangkok.

Giri, S. 2015. *Almost all energy projects facing time, cost overruns*. The Kathmandu Post. 13 September.

Haider, S. 2020. *India, Bhutan sign pact for first joint venture hydropower project*. The Hindu. 29 June.

Head, C. 2000. *Financing of private hydropower projects*. World Bank Discussion Paper. Washington, DC: World Bank.

———. 2006. *The Financing of Water Infrastructure: A Review of Case Studies*. January. Washington, DC: World Bank.

ICF. (n.d.). *Building a Sustainable Hydropower Partnership*. pp. 25–35.

Inter-American Development Bank. 2012. *Costa Rica. Loan and Guarantee 2804/OC-CR – Reventazón Hydropower Project*. Inter-American Development Bank.

———. 2020. A/B Loans and Syndications. Inter-American Development Bank.

IDB Invest. 2020. *What is a B-bond?*

International Finance Corporation. (n.d.). *Hydroelectric Power|A Guide for Developers and Investors*. Washington, DC: IFC.

———. 2015. *The IFC Global Infrastructure Project Development Fund*. Washington, DC: IFC.

———. 2017. *IFC Supports Groundbreaking New Hydropower Project in Pakistan to Address Power Deficits*. Washington, DC: IFC.

———. 2019. *IFC, Partners Provide More than \$450 Million to Support Major Hydro-Electric Plant in Nepal*. Washington, DC: IFC.

———. 2020a. *Emerging Market Green Bonds Report 2019*. Washington, DC: IFC.

———. 2020b. *InfraVentures*. Washington, DC: IFC.

———. 2021. *B Loans*. Washington, DC: IFC.

International Hydropower Association. 2019. *Types of Hydropower*. United Kingdom: International Hydropower Association.

———. 2020. *2020 Status Report Hydropower Sector trends and insights*. United Kingdom: International Hydropower Association.

———. 2021. *Greenhouse gas emissions*. United Kingdom: International Hydropower Association.

International Institute for Environment and Development. 2019. *How climate finance can help repurpose hydropower*.

International Renewable Energy Agency (IRENA). 2016. *Unlocking Renewable Energy Investment: The Role of Risk Mitigation*. Abu Dhabi: IRENA.

———. 2020a. Green bonds. Renewable Energy Finance Brief 03. Abu Dhabi: IRENA.

———. 2020b. *Statistics*. Abu Dhabi: IRENA.

Jiang, T., Z. Shen, Y. Liu, and Y. Hou. 2018. *Carbon Footprint Assessment of Four Normal Size Hydropower Stations in China*. Sustainability. 14 June.

Karot Power Company (Pvt.) Limited. 2014. *Stakeholder*. Karot Power Company (Pvt.) Limited.

KCL Astute Capital Research Team. 2019. *Equity Research Report—Upper Tamakoshi Hydropower Limited*.

Landy, M. 2015. *Hydropower Project and Financial Structuring: What are the New Options?* Presentation Slides. World Hydropower Congress.

———. 2017. *Financing Hydropower: Tapping New Sources of Investment*. Hydro Review.

Latin Finance. 2014. *ICE finances Reventazon with innovative loan, bond package*. Latin Finance. 4 February.

Lewis, S. 2018. *The 10 Largest Pumped-Storage Hydropower Plants in the World*. Engineering News-Record.

Ljung, P. 2001. *Trends in the Financing of Water and Energy Resources Projects*. World Commission on Dams.

Markkanen, S., J. P. Braeckman, and P. Souvannaseng. 2020. *Mapping the evolving complexity of large hydropower project finance in low and lower-middle income countries*. 2 April. pp. 151–172.

- Markkanen, S. and J. P. Braeckman. 2019. *Financing Sustainable Hydropower Projects in Emerging Markets: an Introduction to Concepts and Terminology*. SSRN Electronic Journal.
- Merme, V., R. Ahlers, and J. Gupta. 2014. *Private equity, public affair: Hydropower financing in the Mekong Basin*. Global Environmental Change. 24(1). pp. 20–29.
- Middleton, C. 2009. *Thailand's Commercial Banks' Role in Financing Dams in Laos and the Case for Sustainable Banking*. December. p. 39.
- Multilateral Investment Guarantee Agency. 2020. Rajamandala Hydropower Project|Project Description. Multilateral Investment Guarantee Agency.
- NS Energy. 2021. *Arun-3 Hydropower Project*. NS Energy.
- Nepal Electricity Authority. 2020. *A Year in Review - Fiscal Year 2019/20*. Kathmandu: Nepal Electricity Authority.
- Nicoletti, E. 2018. *What is a B-bond?* IDB Invest.
- Nepal Water and Energy Development Company Private Limited. 2020. *Upper Trishuli 1 HEP*. Nepal Water and Energy Development Company Private Limited.
- Organisation for Economic Co-operation and Development. 2020. *Export Credits*. Paris: Organisation for Economic Co-operation and Development.
- Ogino, K., J. Son, and M. Nakayama. 2021. Effectiveness of hydropower development finance: evidence from Bhutan and Nepal. International Journal of Water Resources Development. 37(3). pp. 491–507.
- Patel, S., N. Rai, and C. Shakya. 2019. *How climate finance can help repurpose hydropower*. Briefing. IIED.
- Patel, S., N. Rai, and N. Rai. 2020. *Climate finance for hydropower incentivising the low-carbon transition*. Issue Paper. January. IIED.
- Power Technology. 2020. *Mangdechhu Hydroelectric Project, Bhutan*.
- Rehman, S., L. M. Al-Hadhrami, and M. M. Alam. 2015. *Pumped hydro energy storage system: A technological review*. Renewable and Sustainable Energy Reviews. 44. pp. 586–598.

Rijal, P. 2019. *Kulekhani III stirs to life after 12 years in development*. The Kathmandu Post. 15 October.

Saklani, U. and C. Tortajada. 2019. India's Development Cooperation in Bhutan's Hydropower Sector: Concerns and Public Perceptions. *Water Alternatives*. 12(2). pp. 734–759.

Stocks, C. 2020a. *Largest pumped storage plants in operation and development*. NS Energy.

———. 2020b. *Development banks approve hydropower investment in Asia and the Pacific*. NS Energy. 18 February.

SÜDWIND. (n.d.). *Green Bonds Project List, 2010-2017*. Accessed 25 August 2020.

Tayal, M. 2021. *REC, PFC to Finance 600 MW Hydro Electric Power Project in Bhutan*. Energetica India.

The Hindu. 2017. *Hydropower projects incur over ₹45,000-cr cost overrun*. 2 August.

Tirpak, D. and H. Adams. 2008. *Bilateral and multilateral financial assistance for the energy sector of developing countries*. 8. pp. 135–151.

TRHDP. 2021. *Project Benefits. Tina River Hydropower Development Project (TRHDP), Solomon Islands*.

Troja, N. 2017. *Green bonds for hydropower financing*. International Hydropower Association.

Trouille, B., J. Plummer Braeckman, J. Devernay, C. Grant, C. Head, M. McWilliams, M. Mondik, T. Stokke, and B. Tarmey. 2008. *Hydro Finance Handbook - Prepared as a companion document for Hydro Finance Tutorial. Session 1C of the New Development Track of the HydroVision 2008 Conference. Under revision*. HCI Publications, Inc.

United Nations Framework Convention on Climate Change. 2021. *Project Activities: Hydropower*. Bonn: UNFCCC.

Vagliasindi, M. 2013. *Revisiting Public-Private Partnerships in the Power Sector*. Washington, DC: World Bank.

Varun, Bhat, I. K., and R. Prakash. 2008. Life Cycle Analysis of Run-of River Small Hydro Power Plants in India. *The Open Renewable Energy Journal*. 1. pp.11–16.

- World Bank. 2016. *Managing Environmental and Social Impacts of Hydropower in Bhutan*. Washington, DC: World Bank.
- . 2019. Green Bond Impact Report 2019. Washington, DC: World Bank.
- . 2020a. *FY19 ANNUAL REPORT*. The World Bank Group Korea Office.
- . 2020b. *Lao Nam Theun 2 Power Project (former was under PE-P004206-LEN)*. Washington, DC: World Bank.
- . 2020c. *PPP Knowledge Lab: Generation*. Washington, DC: World Bank.
- . 2020d. *Nam Ngum 2 Hydro Power Plant*. Washington, DC: World Bank.
- . 2021. *Snapshots: Nam Ngiep 1 Hydropower Project*. Washington, DC: World Bank.
- Wright, C. 2011. *Export Credit Agencies and Global Energy : Promoting National Exports in a Changing World*. 2 (September). pp. 133–143.
- Worm, J., J. M. Dros, and J. W. van Gelder. 2003. *Policies and Practices in financing large dams*. Netherlands: AidEnvironment, Amsterdam and Profundo, Castricum.
- Xinhua. 2019. *Nepali prime minister inaugurates China funded hydro project in Nepal*. 18 November.
- Yau, N. 2020. *Chinese hydroelectric investments in Central Asia: A snapshot*. Eurasianet.
- Yoshino, N. and F. Taghizadeh-Hesary. 2018. A Model for Utilizing Spillover Taxes and Community-Based Funds To Fill The Green Energy. Issue 899. Tokyo: Asian Development Bank Institute.
- Zhai, Y., L. Mo, and M. Rawlins. 2018. *The Impact of Nationally Determined Contributions on the Energy Sector: Implications for ADB and Its Developing Member Countries*. Sustainable Development Working Paper Series No. 54. July. Manila: Asian Development Bank.

Ashok Sarkar and María Rodríguez De La Rubia Gassol¹

Introduction

Often termed as the “first fuel,” energy efficiency² is one of the largest and cheapest options to mitigate climate change. The International Energy Agency (IEA) estimates that to achieve the 1.5°C target, energy efficiency would account for over half of the global carbon emission reduction. Converting the technical energy-saving opportunities across the public and/or municipal; residential; industrial; micro, small, and medium-sized enterprises (MSMEs); and commercial and agriculture sectors into real investments could bring positive and multiple benefits for the government, energy consumers, and the environment. Energy efficiency programs can conserve natural resources, reduce the local pollution impacts and greenhouse gas emissions from the energy sector, enhance energy security by reducing countries’ dependence on fossil fuels, improve system reliability by reducing energy demand and electricity peak load, ease pressures on financing for new power plants and national budgets on fuel subsidies, reduce consumers’ energy bills, help end users to save and cope with rate hikes, increase the competitiveness of public and private sector industries and services, and create new jobs. In addition, energy efficiency is quicker to implement than most supply-side energy resource options. While most energy efficiency measures are cost-effective on a life-cycle basis and cheaper in the long run, their initial cost could be higher, resulting in constraint that needs to be addressed through innovative financing mechanisms and delivery models.

¹ Ashok Sarkar and María Rodríguez de la Rubia are with the World Bank Group’s Energy and Extractives Global Practice. They have benefited from the inputs of various practitioners in the World Bank and other organizations working in the energy efficiency sector. However, the views and opinions presented in this chapter are the authors’ own and do not represent that of the World Bank Group. Any correspondence related to this chapter may be directed to asarkar@worldbank.org.

² Energy efficiency, in the context of this chapter, refers to demand-side energy efficiency, even though not specifically and explicitly mentioned throughout the chapter.

As projected by the IEA in its Efficient World Scenario, if all cost-effective energy efficiency opportunities through 2040 would be implemented, annual growth in energy demand would be only 0.3% (versus 1.0% for the New Policies Scenario³) even while the global economy would increase twofold. To meet the Efficient World Scenario, cumulative global investment in energy efficiency through 2040 must total \$24.5 trillion, which is 55% more than the investment required by the New Policies Scenario. Approximately, 60% should be spent on transport, 30% on buildings, and 10% on the industrial sector.⁴

However, due to the financial and other barriers that the energy efficiency market transformation faces, particularly in the developing and emerging countries, the scale of uptake and implementation of energy-efficient measures remains considerably low. Worldwide, the adoption of energy-efficient technologies and best practices remain behind targets and goals. One of these global targets, the annual rate of global primary energy intensity improvement set as 2.6% under the United Nations Sustainable Development Goal (SDG) target 7.3 for 2030, fell to 2.2% between 2010 and 2017. As a result, meeting SDG 7.3 will now need over 3% of annual improvement until 2030 making the financing and implementation of energy efficiency even more serious.⁵ Asia has shown the highest energy intensity improvements in the last decade above the global average—3.3% in East Asia and Southeast Asia and 2.5% in Central Asia and South Asia. However, after unpacking the reasons for these improvements by applying a decomposition approach, one finds that the reduction in primary energy intensity in Asia are driven largely by changes in economic structure, energy supply, and access, and not much through technical energy efficiency improvements.⁶ As a consequence, there remains a large untapped potential for improvements across a wide cross-section of demand-side end-uses in various sectors, ranging from water pumping and street lighting in municipalities to space cooling and lighting in buildings to motors and drives in industries, to irrigation pump sets in agriculture sector.

Despite multiple benefits energy efficiency could bring, developing countries around the world, including Asian countries, face a diverse range of barriers as these ecosystems are complex and involves multiple stakeholders. Unlike the supply-side energy resources, the most prominent

³ The New Policies Scenario New Policies Scenario accounts for existing strategies and policies under commitments per country under the Paris Agreement on climate change.

⁴ International Energy Agency. 2018. *Energy Efficiency 2018: Analysis and Outlook to 2040*. Paris.

⁵ International Energy Agency; International Renewable Energy Agency; United Nations Statistics Division; World Bank; World Health Organization. 2020. *Tracking SDG 7: The Energy Progress Report 2020*. World Bank, Washington, DC.

⁶ International Energy Agency, et al. (2020).

challenges that demand-side energy efficiency faces at the macro and transaction level are: (i) smaller size of measures; (ii) dispersed nature of interventions; (iii) involvement of multiple stakeholders; (iv) dealing with non-asset based virtual commodity of energy savings; and (v) prevalence of irrational, subsidized energy prices in many developing countries. These barriers not only result in market imperfections in energy efficiency but leads to higher transaction costs and perceived risks, even for measures that are cost-effective, particularly on a life-cycle cost basis. In addition, there could be sector-specific challenges. For instance, in the case of energy efficiency in the buildings sector, owners who invest in buildings (and its energy end-use equipment like air conditioners or heating furnaces or water heaters) and renters (who use these equipment and pay for its energy costs) have misaligned objectives and split incentives resulting in its potential not being tapped to the fullest extent. Furthermore, the other systemic barriers that plague the energy efficiency sector in most low-income and many middle-income developing countries in particular are: (i) inadequate technical capacity, (ii) lack of awareness, and (iii) unavailability of high-quality energy efficiency appliances and equipment.⁷ While the latter can be addressed to a large extent by formulating policies and regulations (like building energy efficiency codes and rating systems, minimum energy performance standards, and energy efficiency labeling systems for appliances and equipment), most developing countries have weaker enforcement and implementation regimes that prevent these policies and regulations to become fully effective and have substantial and quick impacts.⁸

Converting the enormous technical, and even the financially viable potential of energy efficiency across various demand-side sectors to real investments and actual energy savings, continues to be a development challenge. In the last few decades, the focus of energy efficiency development has been on addressing some of the barriers in different countries—technical, awareness, capacity, regulatory, policy, institutional, and market barriers—through policies, regulations, and institutions introduced in many of the Asian and other developing countries. Recognizing the importance of focusing on the implementation elements of energy efficiency, systems, and infrastructure have been put in place to

⁷ Another barrier is the resistance of the local manufacturing industry of energy products to adjust their local resources to meet new and higher energy efficiency standards—developed by developed countries within very short interval of time—which can have high cost implications and jeopardize their survival.

⁸ Appliance minimum energy performance standards or MEPS, energy efficiency labeling, and building energy efficiency codes have taken a relatively longer period to become effective and have impacts after they were formulated (and enacted through energy efficiency legislations and regulations) in developing countries compared to member countries of the Organisation for Economic Co-operation and Development (OECD).

strengthen the enforcement of policies and regulations anchored around robust institutions and governance frameworks. However, it is the financial barrier associated with higher or incremental up-front cost of the measures, coupled with the higher transaction costs and larger risk perception, that remains one of the key constraints to energy efficiency market transformation, thereby exacerbating the challenge of achieving the goals.⁹

Energy efficiency measures are always economically attractive. Most of the measures are also financially viable on a life-cycle cost basis—with reasonable, and even very attractive, payback periods and high returns. However, the higher up-front incremental cost of most energy-efficient equipment and appliances becomes one of the major constraints for the energy end user like a building owner or an industry, or an MSME or a municipality to invest in and adopt energy-efficient lighting and cooling systems, efficient motors and compressors, or energy-efficient urban water and sewage pumping systems, respectively. In developing countries, financial institutions also tend to shy away from lending to energy efficiency projects and programs as these transactions often fall in the category of non-asset-based and nonrecourse financing, and perceived credit risks are higher, as described earlier. Furthermore, the project returns are based on energy savings, which is a virtual commodity and subject to measurement and verification and therefore to technical risks that contributes further to higher transaction costs.

Over the last several decades, energy efficiency financing has significantly evolved. A wide range of experiences have emerged from the design and application of financing mechanisms and structures, their implementation modalities, and associated institutional arrangements for delivering demand-side transactions at scale. These models vary by end-use sectors and by the readiness of individual developing countries. From an overall sector development perspective, innovations in energy efficiency financing have taken place at two broad levels: (i) at macro level, where the focus has been to aggregate in the finance “supply” domain with the objective to bring in private or commercial capital (often blended with concessional financing from public budgets or development partners or climate finance); and (ii) at micro or transaction level, where the innovation has been on finance “demand” domain, wherein innovative structures and business models, and associated implementation models and institutional

⁹ Many of the Asian countries have dedicated and robust energy efficiency institutions and frameworks, such as the Bureau of Energy Efficiency in India, National Energy Efficiency and Conservation Authority in Pakistan, Sustainable Energy Authority in Sri Lanka, and Sustainable and Renewable Energy Development Authority in Bangladesh. All these countries have also enacted legislations and have set up national and sector targets in energy efficiency that are often aligned with their own energy security objectives and global climate change commitments as reflected in their Nationally Determined Contributions.

frameworks have been designed to address the risks at the project delivery or transaction level.

Many of these financing options have been adapted and implemented as stand-alone interventions in the finance “demand” domain or as a combination of finance “supply” and “demand” packaged interventions, broadly labeled as energy efficiency financing mechanisms. These financing options¹⁰ include: (i) utility demand-side management (DSM) rebates/incentives like through on-bill financing, (ii) dedicated funds, (iii) credit lines, (iv) risk-sharing facilities, (v) energy services companies (ESCOs), (vi) public super ESCOs, and (vii) venture capital funds—all of which address the issue of either availability of and/or access to sustainable finance by energy efficiency market stakeholders and specific barriers for doing demand-side energy efficiency investments. As described in the later sections of this chapter, these are tailored toward each market (varying by country and end-use subsector) according to their readiness factors and maturity, including that of the banking sector (to lend to these investments). These are geared toward the objective of using limited public finance (and often supported by concessional multilateral and climate finance) to unlock and leverage private capital mobilization. With the shortage of public finance available in relation to the needs for energy efficiency investments, which is three to four times the available finance, the leverage element is an important building block for attaining the implementation of improvements at scale, which is critical for achieving not only the countries’ own Nationally Determined Contributions, but also global commitments like the Sustainable Energy for All (SE4ALL), and SDG goals aligned with 1.5°C climate change targets.

This chapter is organized as follows: Section 2 presents different financing mechanisms for energy efficiency, and their implementation modalities and institutional frameworks at the conceptual level, covering both the macro and the micro or transaction level dimensions. It also describes key factors to be analyzed for appropriate selection of financing mechanisms. Section 3 provides specific country examples of financing options. Section 4 outlines the increasing relevance of energy efficiency in the post-coronavirus disease (COVID-19) recovery context and section 5 briefly identifies the main pillars needed for achieving market transformation at scale, in addition to the financing mechanisms. While all the pillars like policies and regulations, institutional framework and governance, information and awareness, and technical capacity are equally important, the objective of this chapter is to focus on the financing pillar only and draw lessons and key elements of success from the global experiences.

¹⁰ The terms “financing mechanisms” and “financing options” are used interchangeably in this chapter.

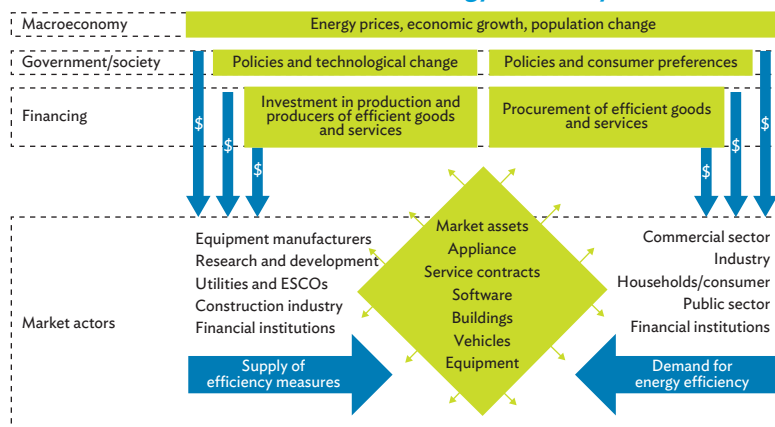
Transforming Energy Efficiency Markets in Asian Countries

Complexities of the Energy Efficiency Market

Evidence from several developed and developing countries shows that realizing the energy efficiency potential, particularly on the demand side, is difficult, due to market failures and barriers at the macroeconomic and project transaction levels. Furthermore, the market of energy efficiency is diffused. Just like energy consumption patterns, the stakeholders are multiple and dispersed, and the dynamics driving the market transformation are multifaceted, as shown in Figure 1. The supply of energy efficiency involves a range of market agents from a variety of stakeholders, which face different constraints and risks, as the demand originates from different sectors. Production and consumption decisions are subject to economic and sociopolitical contexts and energy efficiency is sensitive to energy prices and government policies. Barriers to scaling up are particularly high in the public and residential sectors, where energy-saving measures are smaller and dispersed, and where decisions are driven by multiple actors and in complex ecosystems. In large industries, meanwhile, interventions can focus on specific, high-impact industrial processes which, despite barriers like incremental cost of efficient technologies and associated labor constraints or access to funding, may sometimes be relatively easier to implement.

Member countries of the Organisation for Economic Co-operation and Development (OECD) have been relatively more successful in lowering energy intensities across the energy supply and demand domains through large-scale energy savings in the last several decades, starting with the oil crises of the 1970s. Global experiences demonstrate that interventions have successfully boosted the implementation of demand-side energy efficiency at scale in OECD. A few developing and emerging economies are anchored around five main pillars: (i) policy and regulations, (ii) institutions, (iii) finance, (iv) technical capacity, and (v) information. Collectively, these interventions have created an enabling environment that supports the development of effective and scalable energy efficiency financing and delivery mechanisms and encourage the switch to new technologies and consumer behaviors to support investments for improvements in most OECD countries. Subsection 2.b focuses on the finance pillar and describes different financing sources, instruments, and implementation structures used worldwide to facilitate these investments. The financing mechanisms range from utility DSM programs (such as allowing consumers to finance

Figure 1: The Complexities of Nudging Markets Toward Greater Energy Efficiency



ESCO = energy services company.

Source: A. Sarkar and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank.

efficiency improvements over time on their energy bills) to public revolving funds to dedicated credit lines with existing banks to venture capital investments. Section 5 provides a more detailed description of how barriers are addressed by the other four pillars.

Types of Financing Instruments and Delivery Models

Types of financing. The four main categories of high-level financing instruments are:

- (i) Debt – borrowers commit to pay to the lender the principal and interest (cost of funding) on an agreed schedule;
- (ii) Equity – typically implies selling (buying and owning) a stake in the company receiving the funding from investors;
- (iii) Grant – non-repayable fund contributions donated by a grantor (often government, corporation, foundation or trust funds, including some climate finance) for specified purposes to a beneficiary; and

- (iv) Risk mitigation – de-risking instruments to mitigate the risks of investing, generally to help leverage and mobilize private capital.

The financing itself comes from a variety of different sources:

- (i) Government budget – funding allocation from public budget, generally raised through taxes;¹¹
- (ii) Utility financing – entities offering utility services (e.g., electricity, gas, water) to customers can provide financial incentives;¹²
- (iii) National development banks – financial entities established by a country's government that allocate and provide different types of development financing to targeted sectors for economic development;¹³
- (iv) Bilateral and multilateral development partners – international financing institutions that support economic development and provide support to targeted sectors in collaboration with partner country governments;¹⁴
- (v) Guarantee institutions – dedicated financial risk-sharing or de-risking funds that aim to provide credit enhancement or risk mitigation to lenders and other beneficiaries;
- (vi) Banking institutions – commercial banks, credit unions, and cooperative banks providing financing to energy efficiency on commercial basis, that is, on market interest rates;
- (vii) Institutional investors – investments made on behalf of its members (insurance companies, pension funds, etc.);
- (viii) Microfinance institutions – providers of small loans or financial services to low-income businesses or individuals;
- (ix) Nonbank financial institutions – include insurance firms and venture capitalists that facilitate alternative financial services, such as risk pooling, money transmitting, and consumer credits; and
- (x) Private equity funds – financial vehicles that pool capital to invest in projects or companies that can potentially provide an attractive rate of return.

¹¹ Including carbon tax or access on fossil fuel production and sales.

¹² In most cases, this falls under what is known as electric utility DSM such as through energy-efficient equipment rebates, mandated by the regulators, and recovered through the consumer electricity rate base.

¹³ These financing sources may include concessional loans (having interest rates below market rates) and blending with grant finance.

¹⁴ Multilateral financing institutions also integrate climate finance available through the Global Environment Facility (GEF), Climate Investment Funds, Green Climate Fund, etc., along with the development finance lines.

In the transformation of energy efficiency markets around the world, in the finance “supply” domain, the delivery mechanisms include energy efficiency credit lines with existing banks or stand-alone dedicated funds that are established to address barriers and risk perceptions of associated investments at the macro, aggregated level. The choice of the financing delivery mechanism varies according to (i) the funding source, where supplementary sources beyond government budget funds are usually necessary; (ii) the end-use sector, measures, and market failures being targeted; (iii) maturity and readiness of the local financial (banking) market; (iv) availability or liquidity of finance in general and access to energy efficiency finance in particular; and (v) the approach to allocation, which may be pre-selected, auctions, multi-criteria tenders, or on a first-come-first-served basis.

Credit Lines

Credit lines are among the most common financing mechanisms used especially by international financial institutions and governments to make funds available to local banks and financial institutions. These banks or financial institutions on-lend to (or guarantee) a specific aggregated portfolio of eligible projects for energy efficiency demand-side projects either directly to the beneficiary energy end user in whose premises measures are to be implemented or to the market intermediaries like ESCOs. They can be an appropriate instrument where specific market barriers or information gaps prevent energy efficiency investments from being made and where local financial (banking) markets are relatively more mature and sophisticated.¹⁵

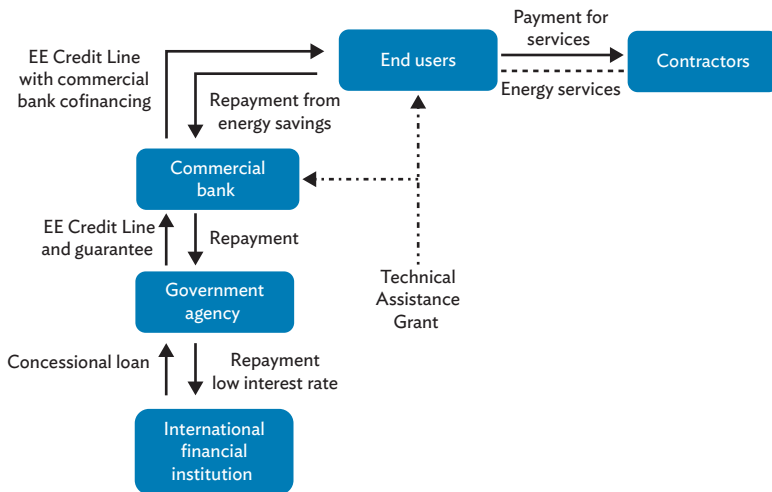
Given the potential complexity of energy efficiency projects and associated barriers and risk perception around investments in these projects, financial mechanisms are commonly integrated as blended financing packages, that may include different macro-level finance “supply” mechanisms (e.g., credit lines, funds, guarantees, and/or grant facilities) and several financial sources (e.g., government budget, multilateral development banks, private equity, and/or climate funds) combined with innovative financial structuring at the micro or transaction level (such as through ESCOs).

¹⁵ Wu, Y., et al. 2018. Live Wire 2018/91. *Financing Energy Efficiency, Part 2: Credit Lines*. Washington, DC: World Bank.

These packaged financing mechanisms have the potential to address a range of typical macro- and transaction-level barriers to the financing of these projects, including perceptions of high technical and financial risks, lack of liquidity, inadequate expertise and capacity, high transaction costs, and inadequate access to finance. For example, energy-efficiency-dedicated credit lines could be designed for specific purpose and target market (e.g., for MSMEs). They could be implemented together with guarantees—a risk-sharing facility to partially cover the risk perceived by banks in extending loans to ESCOs to do energy efficiency projects, and grants to provide technical assistance and capacity-building support.

Figure 2 illustrates how different sources and structures can be blended and aligned to deliver financing for energy efficiency. A development partner (such as an international financial institution) extends a concessional loan (low-interest and/or long-term) to the government agency, which on-lends further to one or more commercial (or national development) banks. These local financial institutions, through dedicated credit lines may service both loans and guarantees to sub-borrowers that implement eligible energy efficiency investments. These sub-borrowers could be the end users (Figure 2) or, alternatively, intermediate ESCOs that implement projects in end-user facilities through a shared savings or guaranteed savings mechanism as described later in this chapter.

Figure 2: Alignment of Financing Mechanisms



EE = energy efficiency.

Source: Authors.

However, credit lines are not designed to address systemic issues in the banking sector or solve underlying inefficient public policies such as energy subsidies that causes some of the fundamental market barriers. The implementation of this financing mechanism involving credit lines require active participation, including marketing, by the banks themselves, along with incentives and capacity to proactively develop a pipeline of energy efficiency projects. Such actions could trigger a sustainable market transformation if emphasis is put toward standardization of transaction tools and templates; capacity building; push toward rational energy pricing; increased awareness; and development of robust policy environment, institutional frameworks, and institutional governance mechanisms.¹⁶

Energy Efficiency Funds

Energy efficiency funds are financing mechanisms implemented in many developed countries to facilitate investment in energy efficiency projects, typically in countries where local banks may not have the technical capacity or interest and/or be ready to set up specific credit lines. These funds, typically set up in the public domain or through public–private partnership modality and managed professionally, receive annual government budgetary allocations or special tax revenues. These are often supplemented by donor and climate funds and offer grants or loans or other incentives (like credit guarantees) to support the implementation of subprojects (including by ESCOs). Such funds depend on continuous budgetary allocations or revenues to cover their administrative costs and maintain their programs and an effective fund management, which may be quite challenging in developing countries.

Energy efficiency funds have evolved specifically to address the barriers of nascent markets and are mostly set up as energy efficiency “revolving” funds, designed to be financially sustainable by lending for energy efficiency retrofits or, in some cases, investing in projects and then recovering the investment costs and associated fees through energy cost savings. Subsequently, the funds are recycled for the next round of subprojects. These funds can help demonstrate the commercial viability of these investments and provide a credit history for public agencies and other borrowers, paving the way for future commercial financing by the local financial institutions (including private commercial banks and financial institutions that may be initially hesitant to establish these credit lines). In some cases, the energy efficiency revolving funds may also cofinance

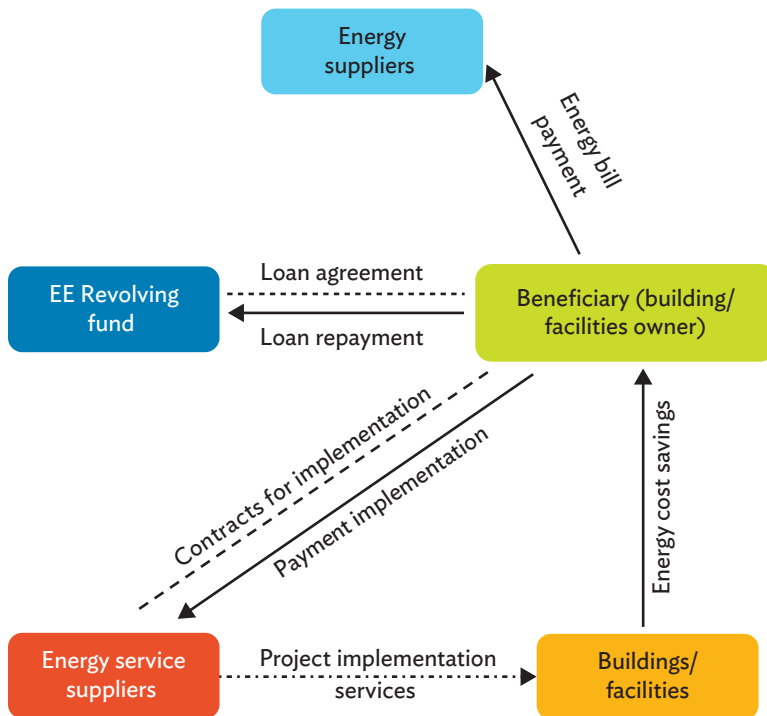
¹⁶ Wu, Y., et al. (2018).

projects with commercial banks and may offer blended financing products that include debt financing, energy service agreements, guarantees, budget capture, grants, and forfeiting.

Figure 3 represents an energy efficiency revolving fund implementation model under debt financing, and Figure 4 describes an implementation model under an energy service agreement.¹⁷

Under debt financing, the revolving fund signs a loan agreement with the beneficiary. The responsibility to contract service providers for audit, design, construction, installation, and other services needed to implement

Figure 3: Energy Efficiency Revolving Fund—Debt Financing



EE = energy efficiency.

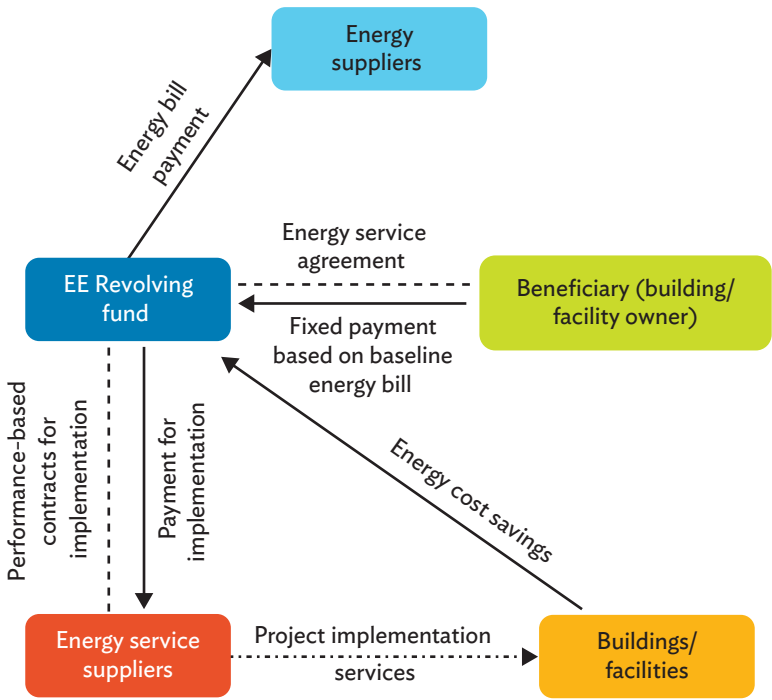
Source: Adapted from A. Lukas 2018. Live Wire 2018/88. *Financing Energy Efficiency, Part 1: Revolving Funds*. Washington, DC: World Bank.

¹⁷ Lukas, A. 2018. Live Wire 2018/88. *Financing Energy Efficiency, Part 1: Revolving Funds*. Washington, DC: World Bank.

the project lies with the beneficiary. Then, the beneficiary uses the energy cost savings accruing from the project to repay the principal, interest, and fees, which allows the fund capital to revolve.

Under the energy service agreement (ESA) option, the beneficiary agrees to make fixed payments to the revolving fund based on the baseline energy bill that bundle together the energy bill payments and repayments to the fund for cost recovery. The fund pays the reduced energy bill and keeps the rest of the payments to recover its costs, resulting in higher risk for the revolving fund than under a traditional debt arrangement. Hence, it is critical for the fund to obtain actual energy cost savings throughout the project implementation. Therefore, the revolving fund directly contracts service providers (like ESCOs) to implement projects and may pass on some of the risk to the contractors using various procurement strategies

Figure 4: Energy Efficiency Revolving Fund—Energy Services Agreement



EE = energy efficiency.
Source: Adapted from A. Lukas 2018. Live Wire 2018/88. *Financing Energy Efficiency, Part 1: Revolving Funds*. Washington, DC.

(e.g., output-based and performance-based procurement). It also may provide the fund some added leverage, since it can cut off the energy supply if the beneficiary default on its payment obligations. Figure 4 represents a typical example of an energy service agreement, however contractual arrangements and payment flows may be adopted to suit country-specific circumstances.¹⁸

Utility Demand-Side Management Rebates and Incentives

Another financial mechanism implemented by utilities falls under the broad energy efficiency financing delivery mechanism category of electric (or gas) utility DSM. Examples of this are on-bill financing and standard offer programs. Utility DSM is often the most common energy efficiency financing mechanism in many low-income developing countries with underdeveloped domestic financial institutions, and those dealing primarily in the residential sectors. Utility DSM actions allow for utilities to finance improvements through on-bill financing relying on a pay-as-you-save (PAYS) modality, by providing up-front incentives to their customers for achieving energy savings as a means to cope with growing electricity demand and/or peak load growth and for avoiding large investment required for new supply capacity or for achieving higher level of reliability by preventing outages (blackouts). The other alternative form of utility DSM is when the utility procures resources just like they procure generation supply, such as in utility standard offer programs. Even when there is a surplus electricity generation capacity, energy efficiency helps utilities to improve system reliability by managing the load shape and growth by reducing energy demand and peak load providing benefit to the utility, and ultimately to the consumer through lower electricity bills.¹⁹ In many countries and jurisdictions, utilities are mandated by regulators to include cost-effective energy efficiency measures through DSM even before they can get an approval for adding new electricity generation capacity to meet the energy and peak demand growth. For instance, if it is cheaper to save a megawatt (MW) of electricity demand (or peak load) by the consumers investing in efficient air conditioners than to invest in

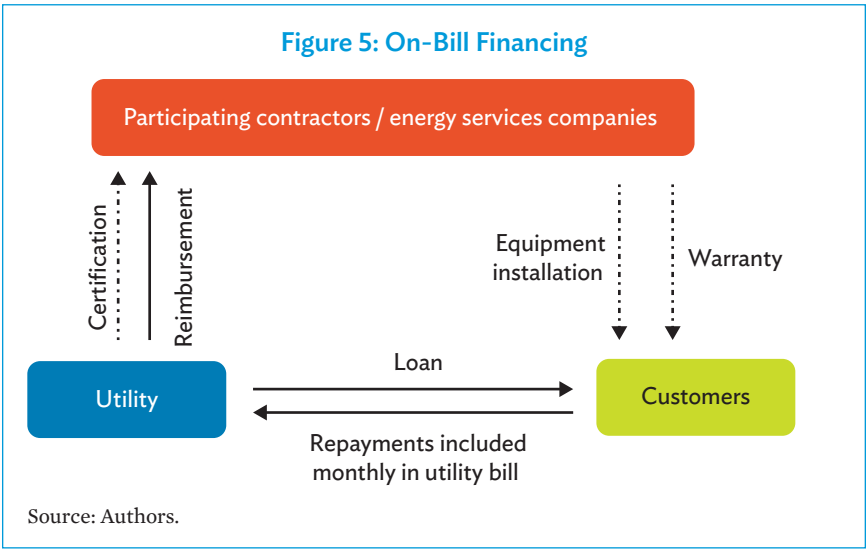
¹⁸ Lukas (2018).

¹⁹ While DSM in utilities is focused on medium- to longer-term energy efficiency options and is mainstreamed through an integrated resource planning (IRP) regime, demand response looks at immediate and short-term operational level integration of energy efficiency actions focused on load management mainly through tariff-based measures, including time-of-use tariffs.

electricity generation capacity to produce that same MW, the regulator would mandate the utility to “invest” in that cheaper energy efficiency resource by requiring the utility to provide financial incentive to the consumer (rebates or on-bill financing) and allowing that expense (cost of the energy efficiency incentive) to be rate-based into the electricity tariffs. This results in a win-win situation for both the utility and its consumers.

Utility on-bill financing programs provide an easy option for consumers to invest in clean energy upgrades that may be expensive and high cost (like air conditioner). Figure 5 shows typical design of on-bill financing delivery model. The utility incurs the initial cost of a clean energy upgrade at its consumer’s premises (through an up-front payment as a loan to the consumer), which is collected periodically through the utility bills of the beneficiary customer, who benefits from monthly energy savings. The up-front capital can be provided by the utility or by a third party (such as through an ESCO working in coordination with the utility or through the equipment vendor).²⁰

Utility standard offer programs are based on purchases by a utility (or government agency) of energy savings or demand reductions from ESCOs or energy consumers using a predetermined and pre-published rate

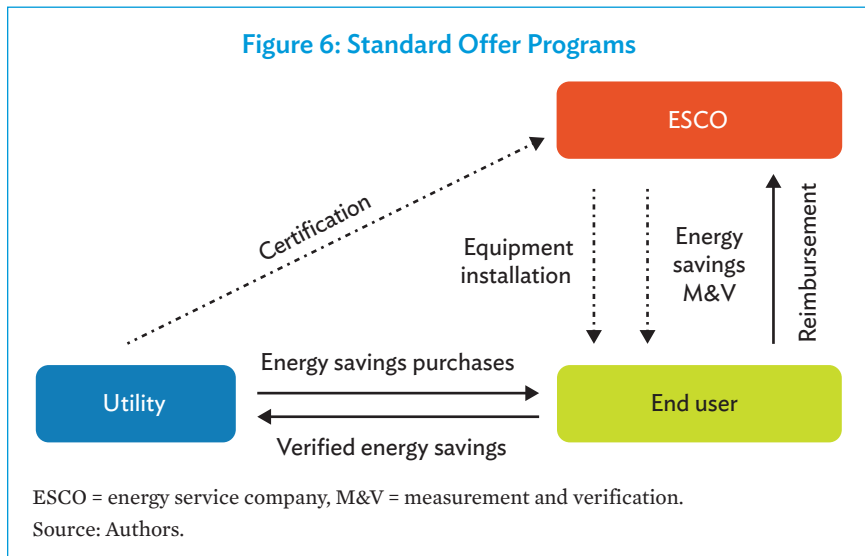


²⁰ These programs can be structured to meet the needs of different markets and provide a secure revenue stream because failure to pay can be tied to disconnection. However, utilities may be reluctant to take on role of financial entity since alterations to billing systems are required, and they may be expose to consumer lending laws.

based on verified savings.²¹ As shown in Figure 6, in a standard offer-based utility DSM regime, essentially the utility is procuring energy efficiency resources similar to procuring new electricity generation resources and this option works typically well in case of public electric utilities or with private utilities when the latter is compensated through the electricity tariff rate base, typically through a regulatory provision. Payments are based on the verified value of electricity savings (in kilowatt-hour [kWh] or kilowatts [KW]) to the power system through the implementation of energy-saving products, technologies, and/or equipment in facilities.

A standard offer DSM program also facilitates ESCO project financing by guaranteeing payments from utility or government soon after implementation. However, these programs require formal framework for utility or regulator to realize energy savings and require strong capabilities for measurement and verification, which are difficult to establish in an emerging ESCO market.²²

Energy service companies. Together with the evolution of financing mechanisms and given the complexity of the energy efficiency market, the role of ESCOs have emerged as a critical one in sustainable and



²¹ These programs are mandated by regulators to encourage the uptake of demand-side energy efficiency along before allowing for new generation capacity additions in the context of IRP, as the latter are more expensive than the former.

²² K. Hofer, et al. 2016. *ESCO Program in Korea*. Presentation at the Energy Transition in Asia: South-South Knowledge Exchange Workshop on Energy Efficiency. 24–28 January. Singapore.

market-driven project implementation in many countries, especially at the micro or transaction level in the finance “demand” domain, described earlier in this chapter. ESCOs offer specialized technical and/or financial services for design through implementation of energy efficiency projects and solutions. Energy cost savings obtained from the project implementation are used by the energy user (or host facility) to pay for the services (technical and/or financial) provided by the ESCO.

ESCOs typically use energy savings performance contracting (ESPC) models, under which payments are contingent on customer satisfaction, and the ESCO assumes most of the technical and performance risks (Hofer, Limaye, and Singh 2016), and sometimes financing risks as well. Box 1 summarizes how ESCOs address barriers to scaling up energy efficiency.

Box 1: Strategies for Scaling up Energy Efficiency

- Mobilize commercial financing with loan repayments made from project cost savings, providing positive cash flow throughout project.
- Utilize standard, streamlined tools for energy auditing option identification and assessment, and energy services agreements.
- Demonstrate benefits of efficient equipment and facility modernization, mobilize external financing, facilitate installation, and offer simplified turnkey arrangements. Aggregate similar projects for smaller facilities to increase project “ticket size” and facilitate financing.
- Provide technical skills and expertise to identify, assess, and implement projects.
- Offer performance-based contracts, clearly define project benefits and costs, demonstrate low risk of projects already implemented, and conduct formal measurement and verification.
- Demonstrate the success of business models and increase the credibility of performance contracting.

Source: Adapted from K. Hofer, D. Limaye, and J. Singh. 2016. Live Wire 2016/54. Fostering the Development of ESCO Markets for Energy Efficiency. Washington, DC: World Bank.

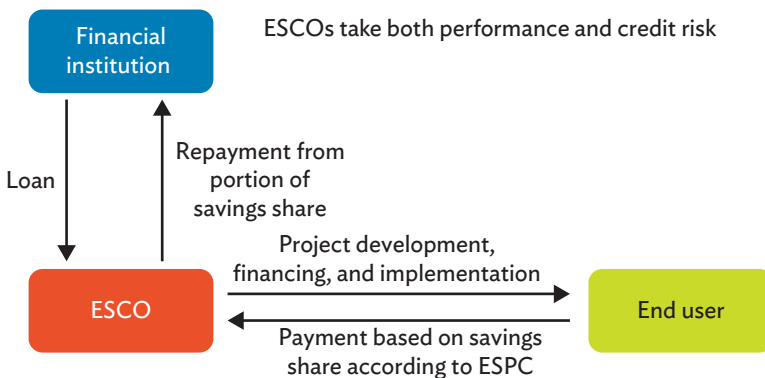
ESCO development globally has had mixed results. While the ESCO markets have been thriving in North America, Europe, Japan, the Republic of Korea, and the People’s Republic of China, there has been limited successes and impacts in developing countries, including even in the major emerging economies. From well-developed energy efficiency markets in the European Union and the United States to nascent ESCO markets of developing countries, there is a wide range of ESCO delivery models. Shared savings and guaranteed savings models are the most commonly used ESCO models.

Shared savings. Typically, under this model, an ESCO provides or arranges for most or all of the financing needed to implement an energy efficiency project. The ESPC agreement between the ESCO and end user specifies how cost savings are shared, measured, and verified. The end user does not invest in the project but receives a relatively smaller share of the energy cost savings during the contract period (while ESCO gets the larger share) and 100% of the savings after it, allowing for a positive cash flow for the duration of the project (Figure 7).

Guaranteed savings. Under this model, the end user invests or borrows the funds needed to finance the project and puts the project finance on its own balance sheet. The ESCO guarantees technical performance through the ESPC and guarantees energy savings based on an agreed-upon measurement and verification (M&V) method. Payments are made by the end user to the ESCO once the ESCO delivers performance (measured and verified energy savings) as per the ESPC (Figure 8). The investment is recovered by the end user through the energy cost savings and the ESCO is paid the fees for services as per the ESPC.

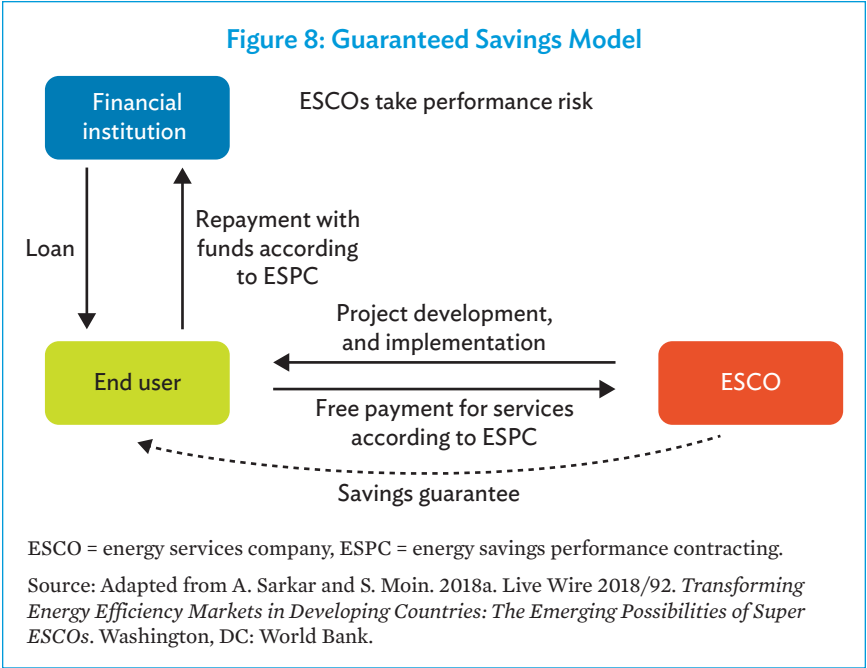
However, common ESCO models are complex and require strong legal, financial, accounting, and business infrastructure, which is often lacking in developing countries. Commercial lenders, even the major financial institutions, in the developing world are unfamiliar with these models and

Figure 7: Shared Savings Model



ESCO = energy services company, ESPC = energy savings performance contracting.

Source: Adapted from A. Sarkar and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank.



lack procedures for technical due diligence and project appraisal, which leads to their perception that ESCO projects carry high risk among end-user beneficiaries and lending institutions.

Nascent ESCOs may also lack credibility with industrial and commercial energy users owing to their limited track record and (perceived) limited technical capabilities. Many ESCOs around the world fall under the MSME category, limiting their financial risk-taking ability as well. Misperceptions about ESCOs often lead customers to expect them to assume all the technical, operational, and financial risks. Their limited assets and weak balance sheets make it difficult for them to credibly back up customer financing with performance guarantees.²³ Therefore, developing energy efficiency markets need to move toward tailored and simpler ESCO delivery models to address common barriers. Box 2 describes some examples of these tailored models and summarizes how each model addresses barriers.

²³ Hofer et al. (2016).

Box 2: Examples of Energy Service Company Delivery Models in Developing Energy Efficiency Markets

Standard product model with “deemed savings” - South Africa

Applies to standard products or equipment where the energy savings are well-known and agreed to in advance. Customer pays the energy service company (ESCO) a predetermined amount after installation.

- Equipment supplier or the ESCO can provide and install standard products or equipment
- Does not require energy audits or measurement and verification

Equipment leasing with verified savings - People’s Republic of China, India, Türkiye, and Viet Nam

The ESCO identifies and installs energy-efficient equipment and retains ownership of the equipment until all lease payments are made. Payments are contingent on energy cost savings, which are usually verified by measurements taken during commissioning.

- ESCO does not need strong balance sheet
- Facilitates bank financing
- Particularly well-suited for small and medium-sized enterprises

One-year contract with partial performance payment - Armenia, Mexico, and Türkiye

The ESCO receives 60%–70% of the payment based on deliverables and measurements taken at commissioning; the remainder is paid 6–12 months later, ensuring continued performance and savings.

- Takes into account contracting limitations for public institutions and short-term loans
- Introduces simplified or partial performance

Energy service agreements - Armenia and Mexico

The ESCO finances, designs, and implements the project, and the customer pays a fixed amount per year (e.g., baseline energy costs with agreed adjustment factors) until the ESCO recovers its investment.

- Reduces perceived risk for ESCO companies
- Provides greater flexibility during transition to complete ESCO models
- Offers possibility of success when project host lacks capacity to implement project
- May be implemented by public (or “super”) ESCO using private ESCO companies as subcontractors for implementation services

Source: Adapted from K. Hofer, D. Limaye, and J. Singh. 2016. Live Wire 2016/54. [Fostering the Development of ESCO Markets for Energy Efficiency](#). Washington, DC: World Bank.

In developing countries, ESCOs play a limited role in the implementation of energy efficiency projects in public facilities due to different barriers. Some of them are: (i) separation of capital and operating budgets that makes it difficult to capture budget savings to repay the ESCO, (ii) borrowing restrictions of public agencies, (iii) unwillingness of banks to provide project financing, (iv) lack of incentive for public sector staff to save energy, (v) limited technical capacity of public buildings managers to understand and implement energy efficiency programs, (vi) restrictive public sector procurement rules that focus on the lowest bid rather than the best value for money, and (vii) private ESCOs perceive higher risks of getting paid for their investment through energy cost savings by the public sector.²⁴

Super ESCOs, mostly in the public domain and therefore also called “public ESCOs,” have emerged as a practical means of addressing the barriers to large-scale implementation of energy efficiency projects, particularly in the public sector, wherein private ESCOs face many barriers.²⁵ A “super ESCO” is generally owned by the government and deals almost exclusively with the public sector. For example, a super ESCO may implement public sector projects like municipal energy-efficient LED street lighting with the support of private ESCOs. A full-service super ESCO supports not only the public sector end users by implementing the energy efficiency measures (which the public sector facility will not finance or implement themselves or will not get it implemented by a private ESCO due to various barriers) but also supports the development of the private sector ESCO market through capacity building; project development; and facilitation as a market, transaction and/or financing intermediary between ESCOs and the public sector end user. The latter helps to reduce the transaction for the private ESCOs and enhances their technical and financial credibility in a sustainable manner.

The functions of the full-service super ESCO are multifaceted and can potentially cover all the building blocks of an energy efficiency ecosystem. This can range from energy audits, project design, performance contracting, procurement of energy efficiency measures or services (including through private ESCOs), and aggregation and bulk procurement of high-quality energy-efficient appliances and equipment. This can also include reducing the cost, installation, and measurement and verification of energy savings to operations and maintenance. Thus, the super ESCO

²⁴ Sarkar, A. and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank.

²⁵ Singh, J. et al. 2009. *Public Procurement of Energy Efficiency Services: Lessons from International Experience*. Washington, DC: World Bank.

not only moderates stakeholders' risks but also helps build trust, including between private ESCOs and public sector end users. It does so by demonstrating the viability of ESPC-based shared or guaranteed savings transactions to raise the comfort level of banks and end users in dealing with ESCOs. It also helps in reducing the transaction costs through standardization of templates and tools required to design and implement ESCO projects. In some cases, the super ESCO provides credit or risk guarantees for ESCO projects; leases equipment; and facilitates interactions among policy makers, private sector ESCOs, financial institutions, and end-use customers. Even in the face of financing, delivery, and implementation challenges, the super ESCO has succeeded where private sector ESCO development has had limited results. India and Saudi Arabia are two of the many countries that have created super ESCOs, albeit not full-service super ESCOs.²⁶ They help tap into their public sectors' energy efficiency potential and facilitate the development of domestic energy services and private sector ESCO industries. Box 3 briefly describes these two super ESCOs—India Energy Efficiency Services Limited and The National Energy Services Company of the Kingdom of Saudi Arabia.²⁷

Box 3: Super Energy Service Companies in India and Saudi Arabia

Energy Efficiency Services Limited (EESL) was established in 2009 as a state-owned energy service company (ESCO), a joint venture of four public sector enterprises under the Ministry of Power of India.^a The super ESCO finances and delivers energy efficiency solutions, especially in the residential and public sectors. Its early success started with the residential sector under the Program Unnat Jyoti by Affordable LED for All (UJALA), where EESL's approach involved aggregating demand for energy-efficient tube lights, light-emitting diode (LED) bulbs, and ceiling fans. The same principles are used by EESL to deploy LED street lighting, super-efficient air conditioners, and others. The super ESCO provides up-front financing using a combination of financing sources (including equity capital from promoters, along with loans from development partners and commercial lenders), and uses competitive bulk procurement that improves affordability through reduced costs while ensuring the quality of high-efficient appliances. The figure

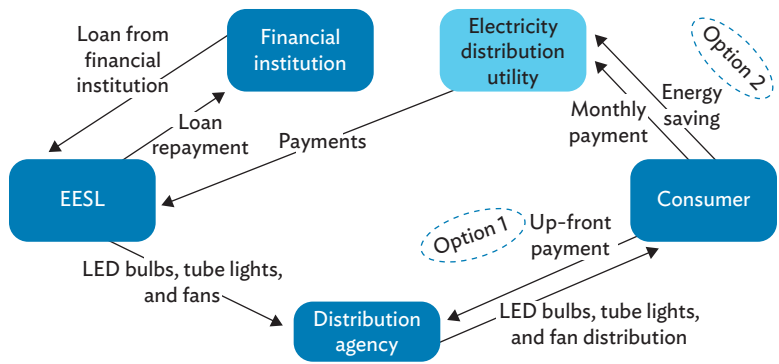
continue on next page

²⁶ Sarkar and Moin (2018a).

²⁷ More details on the super ESCOs are available in A. Sarkar and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank, which is being updated further in an upcoming publication (2021).

Box 3 continued

shows the operating model of this program, where the consumer can choose between two options: a direct up-front payment by the end-use consumer (Option 1) or a pay-as-you-save scheme under an on-bill financing approach (Option 2), where EESL makes the entire up-front capital investment and recovers from the end-use consumer through their monthly electricity bill payments to the electricity distribution utility. In both options, EESL sells the energy-efficient appliance through its own nationwide network of EESL offices or through hired distribution agencies and kiosks, which are mostly co-located within the premises of the electricity distribution utility's main or bill collection or payment offices that consumers frequently visit on a regular basis. Over time, due to the dramatic reduction in cost of energy-efficient appliances through bulk procurement, particularly with UJALA program, Option 2 has been discontinued as more consumers are opting for Option 1 up-front payment, except for more expensive appliances like air conditioners where low-cost financing is also provided through associated financial institutions if consumers do not opt for Option 1.



The National Energy Services Company, also known as **Tarshid**,^b was created by the Saudi Arabia's Public Investment Fund in October 2017 with an initial capitalization of over \$500 million, to increase the energy efficiency of the public sector, such as government and public buildings or public street lighting, and stimulate growth of the country's energy efficiency industry. All government bodies are mandated to contract with Tarshid on an exclusive basis as per a royal decree. This super ESCO is expected to cover 70% of all projects in the country's energy efficiency sector, estimated to be an over \$11 billion market. Tarshid has set up a framework for competitively procuring the services of private sector ESCOs through energy savings

continue on next page

Box 3 *continued*

performance contracting to deliver energy efficiency equipment and solutions in public buildings across the country. In this process, Tarshid is also helping build the capacity of local ESCOs and preparing transaction tools and ESPC templates as well as developing guidance for the measurement and verification of energy savings as per international benchmarks. Since early 2018, Tarshid has started the process of developing and implementing energy retrofit projects in dozens of public office buildings, schools, and mosques, and has also started developing a LED street lighting program.

EESL = Energy Efficiency Services Limited, LED = light-emitting diode.

^a The four public sector enterprises are the National Thermal Power Corporation, Rural Electrification Corporation, Power Finance Corporation, and Power Grid Corporation of India.

^b [Tarshid](#).

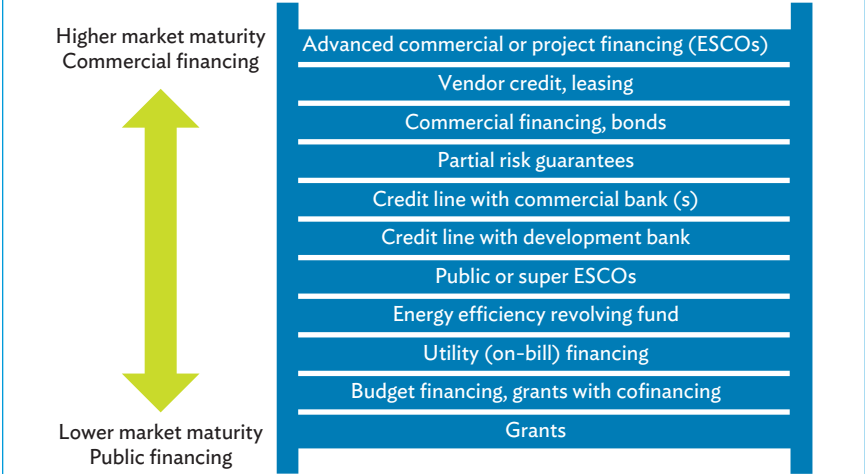
Source: Sarkar, A. and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank.

Selection of the Most Suitable Financing Mechanism for an Energy Efficiency Project

Two key elements of energy efficiency financing mechanisms that are financed by public or donor funds are: (i) to leverage and mobilize private capital to flow into the energy efficiency implementation domain; and (ii) to ensure the sustainability of energy efficiency (EE) market transformation, i.e., large-scale market-driven energy efficiency to continue to get implemented until after the public or donor funds stop. With these objectives in mind, choosing the appropriate financing delivery mechanism and the institutional framework around which its design and implementation are anchored involves a combination of financing options manifested in finance macro level “supply” domain and micro- or transaction-level “demand”-based structures, as described earlier. Several factors determine the choice of the EE financing mechanisms, including: (i) the existence and effectiveness of legislative, regulatory, and institutional frameworks relevant to energy efficiency within the country; (ii) the maturity of local financial and credit markets; (iii) the state of local energy efficiency service markets, including the availability of ESCOs and energy auditors; (iv) stakeholders’ technical and financial capabilities to develop and implement energy efficiency projects; and (v) the targeted end-use demand-side sector. Once the basic mechanisms are selected, they must be carefully adapted to suit the local context and target market (Figure 9).

Depending upon the readiness of different countries, the maturity of local banks, the focus on end-use sector (which the financing is targeting), and the different types of financing delivery mechanisms discussed earlier may be selected from among a menu of financing options as represented by the steps of an energy efficiency financing ladder (Figure 10). Those at the bottom steps of the ladder are frequently used in less-developed markets in low-income developing countries for instance, and where there is a need to rely more on public resources and institutions (e.g., grants and public revolving funds and utility DSM on-bill financing). As markets transform and move up the ladder, mechanisms start to rely more on private or commercial capital (e.g., leasing and project financing), which involves a higher market maturity. The objective of energy efficiency transformation in any country is to start at the bottom and attain the highest level of market-driven commercial energy efficiency project financing, ideally through private ESCOs, wherein commercial financing is utilized to the maximum extent to protect scarce public resources. Countries need not take every step of the ladder and could leapfrog into selecting an appropriate step (or steps) of the ladder or an advanced financing mechanism. However, the development of stable markets capable of sustaining energy efficiency investments in the absence of continued public support generally requires

Figure 9: Shared Savings Model



ESCO = energy services company, ESPC = energy savings performance contracting.
Source: Adapted from A. Sarkar and S. Moin. 2018a. Live Wire 2018/92. *Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs*. Washington, DC: World Bank.

moving up the ladder gradually through incremental, intermediate steps.²⁸ Also, a country or a sector could adopt more than one type of financing mechanism that can be implemented in parallel to and in tandem with each other. For instance, in India, utility DSM, private ESCOs, and super ESCOs co-exist with each other on the micro, transaction level of the energy efficiency finance “demand” domain, while on the finance “supply” side, mechanisms like an energy efficiency fund, credit line, and risk-sharing facilities co-exist as well.

Financial institutions must be aligned with country’s energy efficiency goals, increase their knowledge on delivery models based on energy savings M&V practices and protocols, and offer financial products aligned to the specific energy efficiency market development level. Communication about and awareness among end users is crucial to create an energy efficiency services demand, and capacity building of services providers is vital to stimulate growth of implementation mechanisms, such as utility DSM and ESCOs. Meeting these requirements is a challenge for developing countries. Hence, to establish an aggressive growth trend, capital mobilization will need alternative models of energy efficiency finance, whether in the form of off-balance sheet investments²⁹ or other channels, such as energy funds or government-driven programs.³⁰

As mentioned earlier in this section, readiness of a country or sector specially with respect to its policies, regulations, and enabling environment are important factors that drive the choice of one or more financing mechanisms in the energy efficiency financing ladder. In this context, the Regulatory Indicators for Sustainable Energy (RISE)³¹ is a tool developed by the World Bank’s Energy Sector Management Assistance Program (ESMAP) for energy efficiency market stakeholders in over 110 countries—ranging for public sector policy makers to private sector investors—which compares the policy frameworks, regulatory and institutional readiness, and financing systems. RISE classifies countries

²⁸ Lukas (2018).

²⁹ Off-balance sheet financing is a structure in which the legal and economic ownership of an asset belongs to a party other than the asset’s ultimate user (Ablaza 2020).

³⁰ Ablaza, A., et al. 2020. *Off-Balance-Sheet Equity: The Engine for Energy Efficiency Capital Mobilization*. ADBI Working Paper 1183. Tokyo: Asian Development Bank Institute.

³¹ RISE is a tool developed by the World Bank and supported by Sustainable Energy for All (SE4ALL), ESMAP, and Climate Investment Funds that provides indicators on national policy and regulatory frameworks for sustainable energy. It assesses countries’ policy and regulatory support for energy efficiency, renewable energy, energy access, and clean cooking, building on a wealth of empirical evidence that shows that policies and regulations matter when countries are seeking to attract investment in clean energy, including in energy efficiency.

into different “traffic light” zones in terms of the countries’ readiness of institutional frameworks, policy and regulatory mechanisms, planning systems, and financing mechanisms, etc. which are critical for scaling up energy efficiency investments as described earlier in the chapter and elaborated later in Section 5 (and Figure 19).³² For instance, a green zone signifies strong performers, with the top third of the score (total energy efficiency score between 67 and 100), a yellow zone represents the middle third performers (total energy efficiency score between 34 and 66), and a red zone is assigned to the weaker performers in the bottom third (total energy efficiency score between 0 and 33). Total score is calculated based on the analysis of 11 energy efficiency indicators per country (Box 4). Each one of the 11 indicators is scored between 0 and 100 and is weighted equally to reach the total country energy efficiency score. Figure 10, which includes Asian countries, displays the total energy efficiency score (vertical bars and black labels) and the value of Indicator 6 on “Financing mechanisms for energy efficiency” (circles and blue labels).³³

Box 4: Energy Efficiency Readiness Factors

1. National energy efficiency planning
2. Energy efficiency entities
3. Incentives and mandates: industrial and commercial end users
4. Incentives and mandates: public sector
5. Incentives and mandates: utilities
6. Financing mechanisms for energy efficiency
7. Minimum energy efficiency performance standards
8. Energy labeling systems
9. Building energy codes
10. Transport
11. Carbon pricing and monitoring

Source: Regulatory indicators for Sustainable Energy—RISE. Energy Sector Management Assistance Program (ESMAP). World Bank.

³² EE “Performers” in RISE framework does not refer to performance in terms of improvements in energy efficiency that are measurable through reduction in energy intensities but improvements in the “readiness” of the implementation environment reflected by the existence or non-existence of the policy, regulatory, institutions, planning frameworks, and financing mechanisms.

³³ Figure 10 displays results of RISE analysis for countries beyond Asia and includes countries from the Middle East and North Africa and Europe and Central Asia regions of the World Bank.

As shown in Figure 10, there is a correlation between total energy efficiency score for “readiness” and the value of Indicator 6 (Financing mechanisms for energy efficiency) for the green and red zone countries. Countries in the red zone have lower scores for Indicator 6, revealing a nascent stage for their markets. Almost all countries having total higher score in the green zone also have a high score for Indicator 6, except for Israel, Malaysia, and the United Arab Emirates. Some countries in the yellow zone (meaning a medium value for their energy efficiency total score) show the opposite situation having high score for energy efficiency financing mechanisms, which is somewhat counterintuitive but reveals that the energy efficiency institutional framework or the development and enforcement of energy efficiency technical regulations should be strengthened to boost investments.

A deep analysis of each indicator per country can provide an assessment of strengths and weaknesses of countries’ regulatory policy and market readiness. This analysis can help policy makers to evaluate suitability of financing mechanisms and delivery models for implementing energy efficiency investments at scale. RISE scores are updated every 2 years.

Examples of Energy Efficiency Financing Mechanisms: Experiences, Impacts, and Lessons Learned

The demand-side energy efficiency market is heterogenous and, being spread out in smaller and dispersed projects across a range of end-use sectors, there is no “one-size-fits-all” solution for financing. This section presents several experiences with a diverse range of financing programs for implementing large-scale energy efficiency investments in Asian countries and beyond looking at different end-use sectors. The illustrated examples include: (i) India Partial Risk Sharing Facility for Energy Efficiency, (ii) Energy Conservation Fund of Thailand, (iii) Republic of Korea’s Energy Use Rationalization Fund, (iv) Renewable Resources and Energy Efficiency Fund (R2E2) in Armenia, (v) National Program for Energy Efficiency in Multi-Apartment Buildings in Bulgaria, and (vi) Standard Offer Utility DSM Program in South Africa, which illustrates some of the financing concepts presented earlier in the chapter.³⁴ Broadly utilizing the energy efficiency ladder principles, these financing options were selected and

³⁴ The details of the Armenia and Bulgaria examples in this section draw extensively from personal communication with, and from inputs provided by, Jas Singh and Tamara Babayan of the World Bank.

financing mechanisms were designed and implemented, tailored to the local conditions and target markets. In some cases, the rationale was driven further by the objective to overcome barriers that appeared in the first stages of implementation, coming out with other financing solutions and lessons learned.

India Partial Risk-Sharing Facility for Energy Efficiency

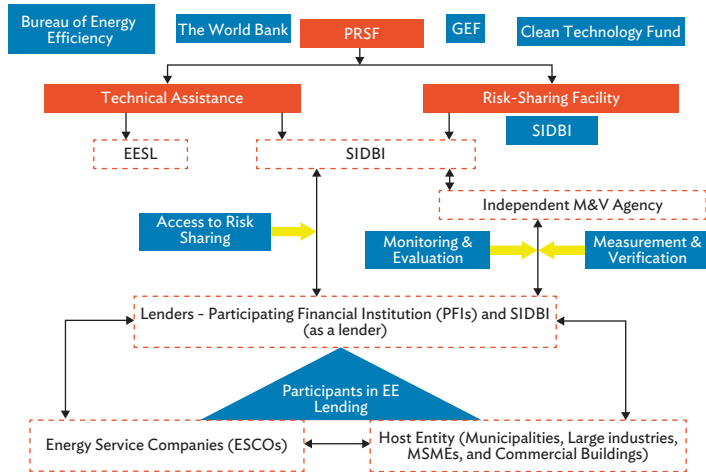
The Partial Risk-Sharing Facility (PRSF) for energy efficiency projects was designed in 2015 by the World Bank in collaboration with India's Bureau of Energy Efficiency (BEE) to unlock financing for energy efficiency through the ESCO market in India. The objective of PRSF is to demonstrate innovative financing and implementation mechanisms that can tap into the significant private sector potential in India. To that end, the facility aims to address barriers faced by ESCOs in accessing finance by minimizing risks perceived by local banks in providing credit to ESCOs and energy efficiency projects.

The facility is supported by \$25 million in contingent finance from the Clean Technology Fund and a \$18 million grant from the Global Environment Facility. It is managed by the Small Industrial Development Bank of India (SIDBI), which provides partial credit guarantees to loans provided by participating financing institutions (PFIs) to energy efficiency subprojects implemented by ESCOs across various demand-side sectors.

The guarantee to ESCO-implemented energy efficiency projects covers up to 75% of the loan principal for up to 5 years of tenor with a risk-based pricing arrangement for ESCOs that are BEE-empaneled (or graded through external rating agencies). These interventions de-risk investments by providing guarantees to commercial banks that lend to ESCOs under ESPCs. PRSF provided \$6 million in technical assistance for programs implemented by SIDBI and EESL to build the capacity of ESCOs and banks. This support also standardizes tools and templates for designing and implementing ESCO-based transactions, which allows them to achieve ESCO market transformation at scale.

Figure 11 shows the financing scheme of the India PRSF for EE Project, where SIDBI has two roles: as project executing agency (PEA), and as lender. The process starts when PFIs and SIDBI (as lender) conduct project appraisal based on project proposals submitted by ESCOs. Then, SIDBI (as PEA) offers PRSF partial credit guarantees to eligible PFIs and SIDBI (as lender) for financing energy efficiency projects. After that, PFIs and SIDBI (as lender) disburse loans alongside equity from ESCO, and ESCO

Figure 11: Financing Scheme of the India Partial Risk-Sharing Facility for Energy Efficiency Projects



EESL = Energy Efficiency Services Limited, M&V = measurement and verification, PRSF = Partial Risk-Sharing Facility, SIDBI = Small Industrial Development Bank of India.

Source: Sarkar, A. and S. Sundararajan. 2020b. *India Partial Risk Sharing Facility for Energy Efficiency Operation. Webinar on Unlocking ESCO Market Transformation in India*. 14 May.

implements the projects using model ESPC contract. An escrow account holds the savings for timely loan repayments, and an independent M&V agency verifies actual energy savings.

The PRSF project implementation is in its sixth year and has made steady improvement during 2019–2020 despite the COVID-19 constraints. As of February 2021, the total number of PRSF guarantees issued to ESCO-implemented subprojects was 29 with total guarantee amount of \$17.17 million, leveraging 3.2 times to a total investment of \$55.7 million. The total number of participating financial institutions for PRSF stands at 14, including the State Bank of India, Canara Bank, and SIDBI itself. The ESCO-implemented subprojects are across a diverse range of energy efficiency measures: LED lighting (commercial and/or urban local bodies); LED street lighting; variable frequency drives; water pumping; heating ventilation and air-conditioning; and energy efficiency measures in hospitals, municipalities, hotels, large industries, and MSMEs.

The PRSF project has also paved the way for commercial banks to take a more serious look at ESCOs as borrowers. By demonstrating that energy efficiency projects with ESCO participation can be successful, PRSF has provided a critical piece of India's energy efficiency market puzzle. PRSF plans to issue many more ESCO subproject guarantees for the next 5 years and mobilize over \$100 million in private sector investment.³⁵ Through PRSF, India is demonstrating the viability of ESCOs in terms of energy savings, financial credibility, and quality of energy services. Within the government's policy environment and framework for energy efficiency, India's market transformation is well underway, anchored in India's developing private sector ESCO industry.

Key lessons learned from the implementation of the India's PRSF are the following:

- (i) The existence of a clear policy and ecosystem by the Government of India provides a strong signal for the consumers and incentivizes to invest in energy efficiency.
- (ii) Technical assistance is key to improving the capacity of ESCOs, PFIs, and hosts, and to unlock market potential.
- (iii) The role of credit enhancement is critical, since financing for energy efficiency is competing with financing demand from other infrastructure sectors.
- (iv) Pipeline generation across various sectors—municipal, industrial, street lighting, buildings, etc.—is essential to incentivize market participants.
- (v) Communication and stakeholder awareness should be part of market outreach to build ESCO market.
- (vi) Potential for scaling-up of ESCO model can be strengthened using standardization of ESPC contractual arrangements, financing models, and simpler M&V protocols.
- (vii) Shared savings (where ESCO is the borrower) is more popular in PRSF, which also allows to build track record for ESCO in accessing commercial financing in future energy efficiency projects.

³⁵ Sarkar, A. and S. Sundararajan. 2020a. Transforming India's energy efficiency market by unlocking the potential of private ESCOs. *World Bank blog*. 2 December.

Energy Conservation Fund of Thailand

The Government of Thailand established the Thailand's Energy Conservation Fund (ENCON) in 1992 to provide financial support for the implementation of energy efficiency and renewable energy projects and has become a government's key financing mechanism. The fund's budget provides from a petroleum tax and has raised approximately \$50 million per year since then. The ENCON program progressed slowly during the first years resulting in a total unspent accumulation of \$350 million by 2002. The major barriers were political and administrative, including poor quality of many of the audits performed by energy consultants, delay in government approval for energy audits, lack of penalty for noncompliance, and lack of authority of energy managers.

The Energy Efficiency Revolving Fund (EERF) was launched in 2003 to stimulate investments by addressing barriers of energy efficiency projects and leveraging participation of commercial banks in providing credit to ESCOs and energy efficiency projects. The Department of Alternative Energy Development and Efficiency (DEDE) within the Ministry of Energy was established as implementing agency. Funding was initially available to large energy-consuming facilities, however, over time was expanded to cover any commercial buildings and industrial facilities. One year after its establishment, the EERF was subdivided into the EERF and the ESCO Fund to meet the financial needs of ESCOs offering co-investments with private sector.

The EERF disbursed \$235 million from 2003 to 2012 and mobilized \$284 million in debt financing from 13 local banks, which resulted in 294 projects mainly involving the replacement of chillers and the installation of biogas facilities. The total financing savings were estimated in \$169 million per year, and the greenhouse gas emissions reduction totaled 0.98 million tons carbon dioxide equivalent. The EERF was successful in stimulating local bank financing of projects in a sector previously avoided by banks. The fund familiarized banks with energy efficiency and renewable energy technology and lending practices. Even though the EERF was discontinued, DEDE still provides technical support, particularly for projects with new technologies, to address the associated performance risks.

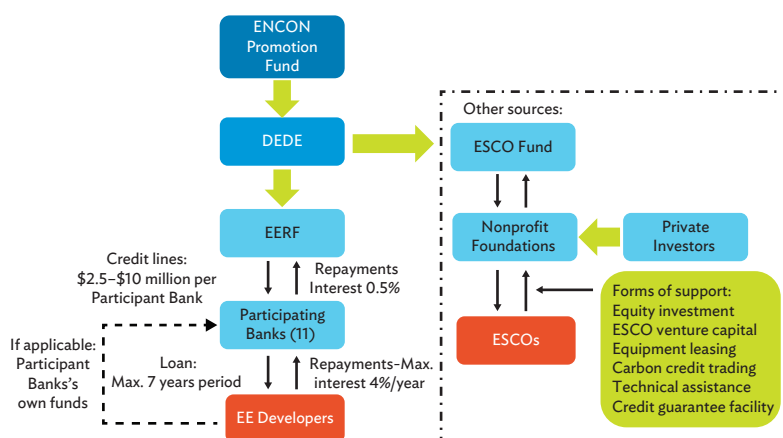
Figure 12 presents the EERF financing scheme. EERF had lent to participating banks at 0.5% interest rate, which in turn lend to energy efficiency projects at maximum 4% per year interest rate and 7 years period. Maximum loan amount was \$1.5 million per project. After the implementation of the projects, clients returned payments and participant

banks payback to DEDE. Then, DEDE allocated budgets for participating banks, making the program sustainable.

Buildings, factories, ESCOs, and project developers were eligible hosts of the program. Project scope covered efficient fuel combustion, energy loss reduction, energy waste recycling, peak shaving, power factor improvements, sunlight heat reduction, efficient lighting and air-conditioning, among others, and had to fulfill at least one of the following requirements: 1,000 kW minimum installed electrical demand or 1,175 kilovolt-ampere of installed transformed capacity or 20 million megajoules per year of minimum commercial energy consumption.

The ESCO Fund was sponsored by DEDE and managed by two government-appointed nonprofit organizations, the Energy Conservation Foundation of Thailand and Energy for Environment Foundation. With a fixed government budget around \$16 million per year, both fund managers could co-invest in energy efficiency or renewable energy projects, and/or ESCOs, and provide assistance in securing funding from other co-investors.

Figure 12: Thailand's Energy Efficiency Revolving Fund and Energy Services Companies' Fund Financing Scheme



ENCON = Thailand's Energy Conservation Fund, EE = energy efficiency, ESCO = energy services company, EERF = Energy Efficiency Revolving Fund, DEDE = Department of Alternative Energy Development and Efficiency.

Source: Ablaza, A., Y. Liu, and M. F. Llado. 2020. *Off-Balance Sheet Equity: The Engine for Energy Efficiency Capital Mobilization*. ADBI Working Paper 1183. Tokyo: Asian Development Bank Institute; and C. Grüning et al. 2012. *Case Study: The Thai Energy Efficiency Revolving Fund*. Frankfurt School of Finance & Management GmbH.

The ESCO Fund provided a variety of financial mechanisms to project developers and/or ESCOs, which can take advantage of to access and leverage capital. The ESCO Fund included six financing mechanisms: equity, venture capital, equipment leasing, partial credit guarantees, carbon credit trading, and technical assistance.

The ESCO Fund deployed \$11 million in its first phase, between 2008 and 2010, and resulted in total investment of \$109 million. Majority of investments were equity investments (76%), while equipment leasing projects received (24%), and venture capital (0.2%).

The Thailand EERF demonstrated how providing loan funds to an energy efficiency project can leverage significant additional investment in the project from nongovernment sources. Some of the key features to achieve EERF success and lessons learned to be applied in similar projects were:

- (i) The government carries no risk, since the possibility of eligible hosts defaulting on loans fall mainly on the hosts themselves and partly on the lending banks.
- (ii) Major costs, incurred in assessing loan applications, administering loans, and promoting the EERF, are carried mainly by the participant banks and the eligible hosts (e.g., the costs of feasibility studies), while the government carries only a small proportion of these costs.
- (iii) All loan principal is repaid, so the only additional cost to the government is the time cost of money in providing the loan principal at 0.5 interest rate for up to 10 years.
- (iv) The repaid loan principal was available for recycling into new loans.

Republic of Korea's Energy Use Rationalization Fund – Energy Services Company System

The Republic of Korea's Energy Use Rationalization Fund was created to address barriers faced by ESCOs in availing finance and boost the start of an ESCO market through performance contracting. The fund was established in 1980 and the ESCO system in 1992. The financing source of the fund are taxes and levies on energy import and sales, among other.

The fund, managed by the Korea Energy Agency, has provided \$11 billion since 1980. Only from 2014 to 2016, it allocated \$1.3 billion, mainly in retrofit of power equipment and heat recovery systems, new renewable energy projects, and process energy efficiency improvement-based ESCO projects. Figure 13 summarizes the capital mobilized by the

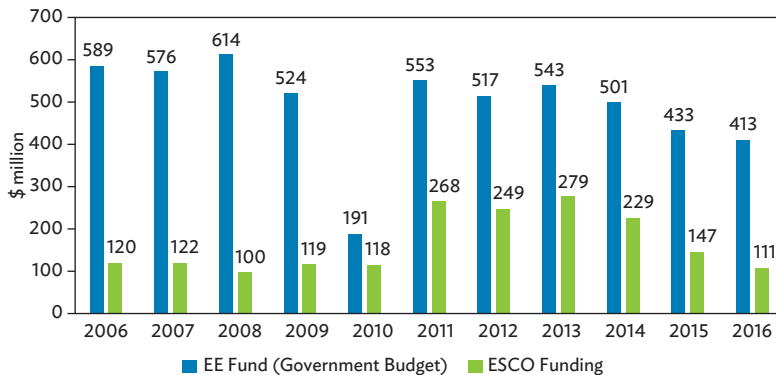
Republic of Korea's Energy Use Rationalization Fund and the private investment leveraged from 2006 to 2016.

Registered ESCOs in 1992 were 4 companies, a number that sharply increased to 159 companies between 1997 and 2001 and raised to 335 companies by 2017 due to a steady increase since 2009.

Beneficiaries are energy-saving facilities projects installing equipment designated as energy saving by the government funding guideline (80 items—list updated annually) and ESCOs. They can access soft loans with an interest rate between 1.5% and 2.75% and a repayment period of 8–10 years with 3 years grace period. Figure 14 shows the financing structure of the fund, where the ESCO or energy savings facility submits a loan application that is evaluated by a committee. If deemed eligible, the Korea Energy Agency issues a recommendation to the bank that subsequently asks for the funds.

ESCO projects can be implemented under three different types of contracts as shown in Figure 15, with confirmed savings contract, guaranteed savings and ESCO financing contract, and guaranteed savings and user financing contract.

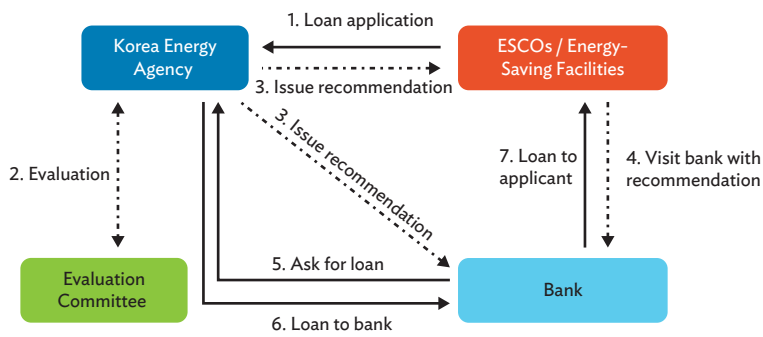
Figure 13: Capital Mobilized and Leveraged by the Republic of Korea's Energy Use Rationalization Fund



EE = energy efficiency, ESCOs = energy services companies.

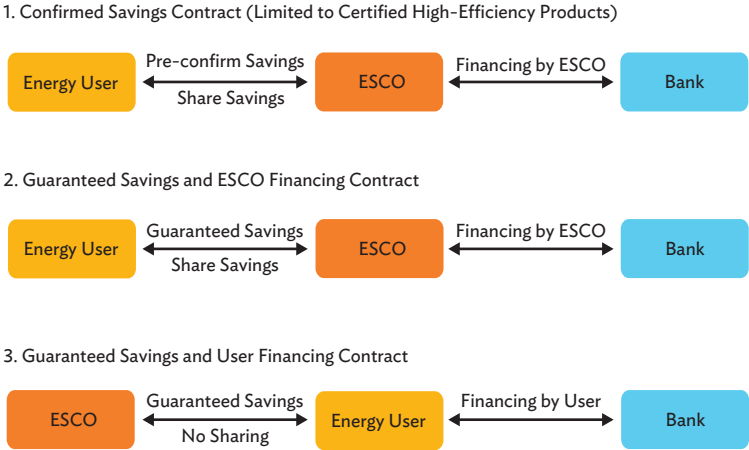
Source: Adapted from Hwang 2018.

Figure 14: Financing Structure of the Republic of Korea’s Energy Use Rationalization Fund



ESCO = energy services company.
Source: Adapted from I. Hwang, 2018, ESCO Program in Korea. Presentation at the Energy Transition in Asia: South–South Knowledge Exchange Workshop on Energy Efficiency, 24–28 January, Singapore.

Figure 15: Republic of Korea: Types of Energy Services Company Contracts



ESCO = energy services company.
Source: Adapted from I. Hwang, 2018, ESCO Program in Korea. Presentation at the Energy Transition in Asia: South–South Knowledge Exchange Workshop on Energy Efficiency, 24–28 January, Singapore.

One of the main lessons learned from the fund was the necessity of introducing a new mechanism to deal with ESCO liabilities issues. ESCOs in the Republic of Korea are highly dependent on soft loans for their business, therefore the more projects ESCOs carry out, their liabilities are bigger. This caused financing difficulties to ESCOs since higher liability ratio involves lower credit rating. Factoring was introduced to revitalize ESCO market as a financial transaction whereby an ESCO can sell its accounts receivable to a third party at a discount in exchange for immediate income.

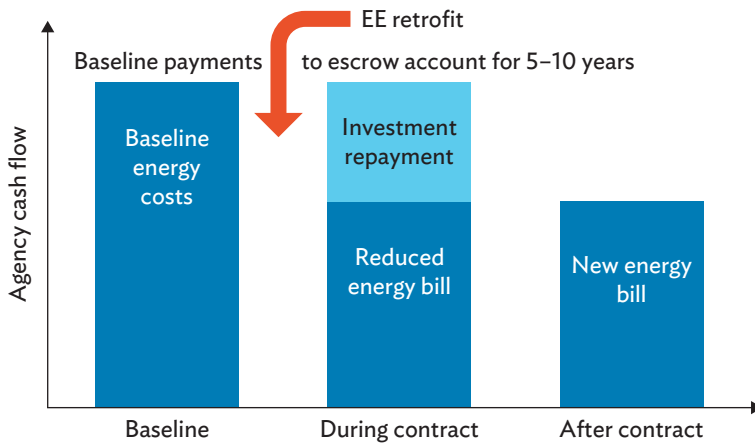
Armenia Renewable Resources and Energy Efficiency Fund - R2E2

The Renewable Resources and Energy Efficiency Fund of Armenia (R2E2 Fund),³⁶ provides turnkey services³⁷ for the energy efficiency upgrades in eligible public buildings. Buildings are pre-selected using certain criteria including: (i) evidence of public ownership of facility; (ii) structural soundness of the facility; (iii) absence of plans for closure, downsizing, or privatization of the facility; and (iv) comfort level of more than 50%. Additional criteria applied to eligible projects are: (i) at least 20% energy savings, (ii) simple payment period of less than 10 years, and (iii) investment size should be \$50,000–\$500,000.

The World Bank–GEF Energy Efficiency Project (EEP) was designed to develop, test, and disseminate—under the R2E2 Fund—replicable and sustainable models for energy efficiency service provision through a new instrument, energy service agreements (ESAs). Under an ESA, the R2E2 Fund offers a full package of services to identify, finance, procure, implement, and monitor projects for clients. The client is only asked to pay what it is currently paying for energy, i.e., its baseline energy costs, from which the R2E2 Fund uses to make the new (lower) energy payments and recover its investment cost and associated fees until the contract period ends. Figure 16 illustrates the basic idea of a client's cash flows under the ESA, with payments equal to their baseline energy bill. For public clients, ESAs are generally not viewed as debt, but rather long-term service contracts, thereby allowing financing of central government entities that are typically not allowed to borrow, and municipalities that may have already reached their debt limits or otherwise have borrowing restrictions.

³⁶ This section draws extensively from World Bank. 2021. *Case study 1: Armenia Renewable Resources and Energy Efficiency Fund (R2E2)*. Washington, DC: World Bank, an internal note prepared by Tamara Babayan of the World Bank. [Renewable Resources and Energy Efficiency Fund of Armenia](#).

³⁷ Energy audit, procurement, detailed design, financing, construction, and monitoring.

Figure 16: Client's Cash Flows under the Energy Service Agreements

EE = energy efficiency.

Source: World Bank. 2021. Case Study 1: Armenia Renewable Resources and Energy Efficiency Fund (R2E2). *Informal Note* (prepared by T. Babayan). Washington, DC: World Bank.

This provides a dual advantage to the client of being relatively simple to implement with very little risk.

Overall, for 3 years (2013–2016), 62 ESAs totaling \$9.89 million have been signed by the fund. The completed and commissioned projects show impressive results. Energy savings have averaged almost 51% and payback periods ranging from 2.6 to 8.8 years. The investment costs required to achieve these savings has been about half of World Bank projects in neighboring countries—at only about \$32.6/square meter (m^2), due in large part to the net present value based procurement scheme.³⁸ Energy savings have been achieved at a cost of only \$1.93/kWh, showing that energy efficiency is the cheapest resource Armenia has.

Under the ESA, the R2E2 Fund recovers its full investment plus fees (2.5% per year based on the outstanding balance) from the public agency's energy cost savings. This ensures a sustainable model while allowing funds

³⁸ Innovative procurement scheme used by R2E2 includes performance-based contracting awarded based on the highest net present value proposed by the bidders, output-based payment after completion of works and verification of savings, 1 year of operation, and maintenance of the installed systems.

to recycle to cover more buildings and generate additional energy savings. To date, repayment stands at 105%. The fees are sufficient to fully recover the fund's financing costs and administrative expenses. Starting from 2017, the fund applies 5% per year given the increasing demand for the ESAs and closure of the World Bank project.

After proven results of the World Bank–GEF EEP, the R2E2 extended its financing of energy efficiency investments for municipalities through the commercial banks. Currently, the ACBA–Credit Agricole Bank finances energy efficiency investments in municipalities that are implemented following the R2E2 scheme, i.e., municipalities pay during the payback period from the generated savings.

The fund also has dedicated program for roof top solar implemented in non-gasified communities. The revolving based financing is provided for installation of solar water heater and solar PV for single-family houses, SMEs, and municipal buildings. For low-income families, there is a subsidy scheme with the United Nations Development Programme. Overall portfolio of the fund is healthy with 100% repayment rate.

The project introduced several innovations in energy efficiency financing and implementation in Armenia. The following lessons emerged:

- (i) The demand-based approach assures commitment of client to the project.
- (ii) Repayments increase ownership, accountability, and quality of energy management of the client.
- (iii) A strong, dedicated institution (R2E2 Fund) which has a clear mandate, well-trained, and motivated staff with adequate compensation and a strong marketing plan was critical to the project's success.
- (iv) Strong marketing campaigns are critical to raise awareness and understanding of energy efficiency.
- (v) EE financing through a revolving fund increases the number of beneficiary institutions.
- (vi) Procurement for design–build reduces the ESA risks, and at the same time it promotes technology supply market.
- (vii) Procurement based on highest net present value encourages innovation and new technologies to be deployed.
- (viii) The introduction of performance-based payments helps ensure quality and accountability of contractors.

National Program for Energy Efficiency in Multi-Apartment Buildings in Bulgaria³⁹

There are about 65,000 pre-1990 residential multifamily apartment buildings (MABs) in Bulgaria. Due to the absence of energy efficiency norms in the building codes of the time, most of these buildings have little or no thermal insulation in their building envelopes. As a result, their energy consumption is at least twice as high as those built to current standards.

To address the need for MAB renovation, since 2007 the Ministry of Regional Development and Public Works (MRDPW) has implemented several energy efficiency programs funded by international financial institutions (IFIs), donors, and European Union structural funds (Box 5). However, so far, these programs have not been implemented on a large scale and have faced difficulties tapping into private funding.

Box 5: The Evolution of Bulgaria's Residential Retrofit Program

The Demonstration Project for the Renovation of Multi-Family Buildings was implemented by the Ministry of Regional Development and Public Works (MRDPW) with support from the United Nations Development Programme. Under this program, which started in 2007, about 54 multi-family buildings were renovated. The project demonstrated that energy savings of over 40%, along with substantial reductions in carbon dioxide emissions, are possible.

The Energy Efficiency Credit Line for Households was set up in 2005 as a collaborative initiative between the Government of Bulgaria, the European Bank for Reconstruction and Development (EBRD), and the Kozloduy International Decommissioning Support Fund (KIDSF) to provide households and homeowner associations (HOAs) with credit lines for energy efficiency and renewable energy sources projects. Working with four local banks, the fund consisted of an EBRD loan of €90 million and KIDSF grant money of €24.6 million. The grant funding provided up to 35% of the

continue on next page

³⁹ This section draws largely from World Bank. 2018. *Bulgaria - National Program for Energy Efficiency in Residential Buildings Program Design Report for the Second Phase*. Washington, DC: World Bank.

Box 5 continued

total loan. The credit line, which expired at the end of July 2014, disbursed approximately €62 million in loans and €11.3 million in grants while supporting over 40,000 projects. Most of these loans were for individual dwelling measures, with an average subloan size of €1,550; only 100 loans for whole-building refurbishments were made available under the credit line.

The Energy Renovation of Bulgarian Homes project was launched in July 2012 with the financial support of Regional Development 2007–2013, a €50 million program cofinanced by the European Union through the European Regional Development Fund. The project extended to 36 urban centers and was implemented through 2015. Eligible residential buildings (six or more detached individual units and three or more floors) that are registered HOAs received up to 75% of renovation costs as a grant. Despite the high levels of capital grant support, demand by HOAs to participate in the program was very low. From 2007 to 2011, 50 multifamily buildings (representing 1,093 households and under 81,000 square meters) were retrofitted. A similar BGN^a 10 million (about €5.1 million) scheme supports retrofits in social housing for vulnerable minority and disadvantaged groups through 100% grant financing.

^a BGN: currency code for the Bulgarian lev, official currency of Bulgaria (\$1=BGN1.62).

Source: World Bank. 2018. *Bulgaria - National Program for Energy Efficiency in Residential Buildings Program Design Report for the Second Phase*. Washington, DC: World Bank.

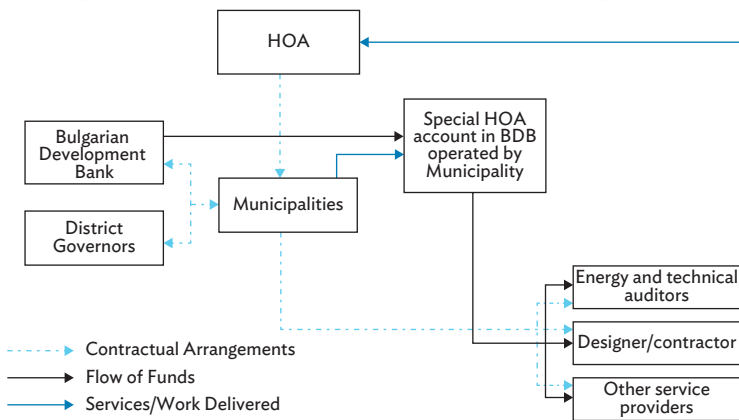
In February 2015, MRDPW launched the National Program for Energy Efficiency of Multifamily Buildings to support the rehabilitation of MABs through energy efficiency measures and structural renovations. The program's objectives were to (i) improve the energy efficiency of multifamily residential buildings and reduce energy expenditures, (ii) extend the lifetime of buildings, and (iii) contribute to a reduction in local and global air pollution. The initial budget of the program in 2015 was BGN1 billion (€500 million), and in 2017 it had expanded with an additional BGN1 billion. The program offered 100% grant support to registered homeowners associations (HOAs) in Bulgaria that were built prior to 1990. The overall cost of the program was financed by the state budget through loans from IFIs.⁴⁰

⁴⁰ Financing was secured from the Council of Europe Development Bank, KfW Development Bank, and the Industrial and Commercial Bank of China.

To apply for the program, homeowners needed to form and register an HOA in accordance with the Condominium Ownership Management Act (which requires the agreement of no less than 67% of the building apartment owners). Once their application was submitted (95% of homeowners had to agree to participate in the program) and accepted, registered HOAs signed a contract with their respective municipalities authorizing them to manage the overall renovation process. HOAs were provided with 100% grant support to finance measures and related services⁴¹ on a first-come, first-served basis. The Bulgarian Development Bank acted as a paying agent and accepted applications from HOAs through the municipalities. Municipalities undertook all procurement and oversight and submitted approved invoices for payment by BDB. Figure 17 shows the mechanism structure.

The program achieved substantial results in demonstrating the benefits of housing renovations for energy efficiency and in improving the enabling environment for the implementation of energy efficiency investments in Bulgaria's residential sector (e.g., conducting energy audits, preparing technical designs, building capacity in the construction sector,

Figure 17: Flow of Funds and Contractual Arrangements



HOA = homeowners association.

Source: World Bank. 2018. *Bulgaria - National Program for Energy Efficiency in Residential Buildings Program Design Report for the Second Phase*. Washington, DC: World Bank.

⁴¹ This includes the up-front energy and structural audits (including issuance of the technical passport), preparation of technical designs and bills of quantities, construction supervision and building performance certification.

monitoring energy savings, issuing residential building certificates). It also helped demonstrate that HOAs can become a useful vehicle to improve and maintain the conditions of MABs. Residents experienced increases in indoor comfort levels, reduced energy bills, and a substantial increase in satisfaction with their buildings.

The program has allocated almost all its BGN2 billion budget to renovate 2,022 buildings and correspond to Class C (European Union energy performance level for buildings) or better. About 5,300 applications were received by the BDB, of which 2,022 financing contracts were signed.

Overall satisfaction with the program was very high, indicating the program was relevant to the needs of MABs and their HOAs. The following lessons learned were identified:

- (i) Demonstration programs based on 100% grant support should be integrated in a long-term vision and strategy to renovate the full housing stock needs introducing more sustainable financing schemes (e.g., better targeting and declining levels of grants, HOA or commercial bank cofinancing) and diversified funding sources.
- (ii) The long-term strategy must be formulated and communicated to the public to avoid the public's expectation of having a 100% grant financing option beyond the demonstration program, which is neither feasible nor sustainable.
- (iii) Sufficient technical support and supervision on the national level should be ensured, such as increased training for stakeholders, standardized audits and designs, centralized program coordination unit, and period evaluations to identify deficiencies and share lessons and plans to address structural deficiencies and seismic safety. This is even more relevant in decentralized programs, where numerous municipalities participate with diverse technical and human capacities.
- (iv) Even when providing 100% pure grant financing, the program should imposed responsibilities on its beneficiaries (e.g., ensuring proper operations and maintenance of the renovated MABs, potential increases in property taxes, tariff reforms including consumption-based billing, opening of HOA bank accounts for future collections and borrowings, etc.).
- (v) Soft measures to support implementation facilitate a smooth deployment of the program, e.g., sample terms of reference for audits and designs, program monitoring and evaluation including energy monitoring, post-renovation audits and energy performance certificate confirmation, outreach on program

procedures and impacts, training of auditors, designers, construction firms, other technical assistance.

- (vi) Policy support is needed to develop a long-term program plan to address the full building stock; strengthening of HOA legislation to improve ability to borrow, sign contracts, open bank accounts, etc.; increase obligations of HOAs to pay monthly fees to ensure proper maintenance and future capital repairs post-renovation; provide incentives to HOAs for measures to support air quality improvements, housing policies, and climate change; enhance building codes and building material standards; and require property price reappraisals after renovation.

South Africa's Standard Offer Demand-Side Management Program

The Standard Offer Program (SOP) of South Africa was created in 2009 to identify and approve energy efficiency and utility DSM projects and allowed the electric utility (Eskom) to purchase energy savings from energy users and ESCOs using a predetermined and pre-published price. This approach streamlined evaluation of project proposals and disbursement of the incentives or subsidies, thus reducing the burden on Eskom staff, and facilitating a larger pipeline of projects. The greater transparency, shorter processing times, and reduced transaction risk of the SOP also facilitated mobilization of commercial financing, essential to achieving a substantial scaling up of energy efficiency and DSM investment.⁴²

This program offers payments for delivered savings from energy efficiency projects at a fixed rate for the Eskom peak period (16 hours per day from 6 a.m. to 10 p.m. on weekdays). The typical technologies implemented under this program include efficient lighting, LEDs, hot-water systems, solar systems, and industrial process optimization. Renewables and cogeneration are not considered part of this program. A standard amount is paid per kWh saved, based on the technology.

Project developers—ESCOs or customers of Eskom or of municipal electricity providers in the commercial and industrial sectors—with electricity-consuming sites within the borders of South Africa are eligible to provide proposals to Eskom.

⁴² World Bank. 2011. *Implementing Energy Efficiency and Demand Side Management: South Africa's Standard Offer Model*. Washington, DC.

Project developers must reduce a minimum average demand of 250 kW per quarterly period for 12 quarters over a 36-month sustainability term. The minimum energy savings applicable is 260,000 kWh/quarter. Compensation will be provided to the project developer for the actual demand reduction based on M&V quarterly performance reports, subject to terms and conditions of the contract. The project developer must provide and install the required M&V equipment, and maintain its accuracy at own cost, for the duration of the contract. The rebate is structured as a 2-part (cents/kWh) block rate. Performance at 80% or above per quarter is paid at the high rate, and performance below 80% is paid at the low rate. Should the project not achieve a minimum of 80% performance for two consecutive quarters, the contract is terminated, and no further rebate funding is applicable for the remaining quarters.⁴³

Major lessons learned from Eskom's implementation for the SOP are the following:

- (i) The Eskom programs have been well received by energy users and ESCOs, and the number of projects implemented increased substantially.
- (ii) Eskom faced many challenges in developing the right incentive structure for the various programs and the technologies and products covered by these programs.
- (iii) Successful implementation of the SOP requires a sound, multifunctional management and implementation approach https://youtu.be/3qBjL_HGvco.
- (iv) Business processes, systems, and controls for the programs addressing the commercial and residential markets need to be streamlined and automated https://youtu.be/3qBjL_HGvco.
- (v) Staff and advisers need to be trained on the complexities of the SOP incentives.
- (vi) The projects are developed by a small number of large ESCOs unless the capacity of the smaller ESCOs for project preparation is strengthened.
- (vii) The fixed incentives offered under the SOP appear to be more attractive to project developers than the tendering process.

⁴³ Eskom. 2010. *Energy efficiency program: scope and evaluation criteria specification*. Eskom.

Box 6: Energy Efficiency Financing Programs: Key Lessons Learned

On the overall, the experience from the deployment of the energy efficiency financing mechanisms, discussed in the section, and the existence of clear policies and effective regulations provides a strong signal for the energy efficiency market stakeholders to invest. The role of local financial institutions and market intermediaries like energy services companies (ESCOs) are important to scale up implementation of energy efficiency in developing and emerging markets in a sustainable manner. While the choice of appropriate financing mechanisms along the energy efficiency ladder is sector- and country-specific to a large extent; global experience and lessons learned could be helpful in adapting and replicating the financing mechanisms and implementation practices. When it comes to financing mechanisms, the value addition of limited public or donor funds are attained when these funds are able to: (i) leverage, mobilize, and unlock private capital to flow into the energy efficiency implementation domain; and (ii) ensure the sustainability of market transformation, that is, large-scale market-driven energy efficiency at the transaction level to continue to get implemented until after the public or donor funds stop.

At the transaction level, the potential for scaling up the ESCO model can be strengthened using standardization of energy savings performance contracting or energy service agreement contractual arrangements (such as through technical assistance that should always accompany financing mechanisms), business models, and lowering transaction costs through super ESCOs. Along with financing, however, robust energy efficiency institutional frameworks and governance systems, strong policies and regulations, communication and stakeholder awareness, and technical capacity development are critical for market transformation. The lessons learned from experiences and impacts of the development, design, and deployment of different financing mechanisms and structures and their implementation modalities and associated institutional arrangements shows the path for delivering demand-side energy efficiency transactions at scale.

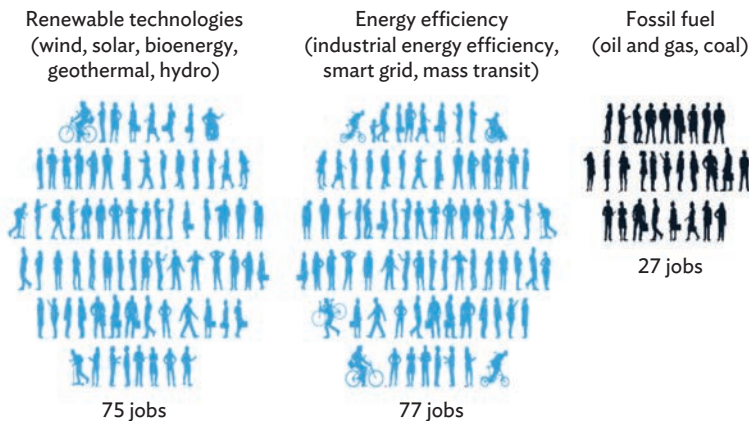
Source: Energy Sector Management Assistance Program (ESMAP). 2011. [Implementing Energy Efficiency and Demand Side Management. South Africa's Standard Offer Model.](#)

Energy Efficiency and Jobs: Post-COVID-19 Recovery Context

In addition to the energy security and climate change mitigation benefits, another co-benefit that had emerged in favor of energy efficiency is its ability to produce new net jobs, which has become even a more important factor to consider as the world recovers from the disruption caused by the COVID-19 pandemic. Over 250 million jobs have been lost worldwide during last 1 year. However, as Figure 18 shows, investments create over three times more direct and indirect jobs compared to equivalent investments in fossil fuels.

Even before the pandemic, energy efficiency created up to 6 million direct jobs in major economies (the United States, Europe, Canada, the People's Republic of China, Brazil, Australia) in 2019 (NASEO and EFI 2019). In the United States, 2.38 million people are employed in the design, installation, and manufacture of products and services in 2019. Similarly, it is estimated that there are 1–3 million jobs in Europe; around 730,000 in the People's Republic of China; 472,000 in Canada; 60,000–236,000 in Australia; and 33,000–62,000 in Brazil. Several factors—including the scale of national deployment, magnitude of industrial policies, changes in the geographic footprint of supply chains and in trade patterns, and industry

Figure 18: Energy Efficiency and Jobs



Source: McKinsey. 2020. *How a post-pandemic stimulus can both create jobs and help the climate. Public & Social Sector and Sustainable Practices*. McKinsey and Company.

consolidation trends—shape how and where jobs are created. Recent IRENA estimates suggest that, under Transforming Energy Scenario (IRENA 2021), there can be 30 million renewable energy jobs by 2030 and 42 million by 2050; energy efficiency could employ 21.3 million people, doubling the current-day situation. These new jobs are expected to exceed the jobs lost fossil fuels and nuclear energy, hence generating net job gains overall.

Post-COVID-19, widespread support for green, resilient, and inclusive recovery could accelerate the transition to a green economy in many countries, including Asia, and could bring about significant employment benefits. Building energy efficiency retrofits—for example, of existing homes, schools, hospitals, or municipal facilities—could create a substantial number of jobs in the coming years because they are among the most labor-intensive of clean energy measures. As investments can also be mobilized quickly, they are one of the most attractive investments in the energy sector for governments seeking to protect existing jobs or generate new jobs during the recession. With every \$1 million spent on buildings efficiency likely to create 6 to 15 jobs on average, spending commitments to date are estimated to create around 3.4 million job-years.

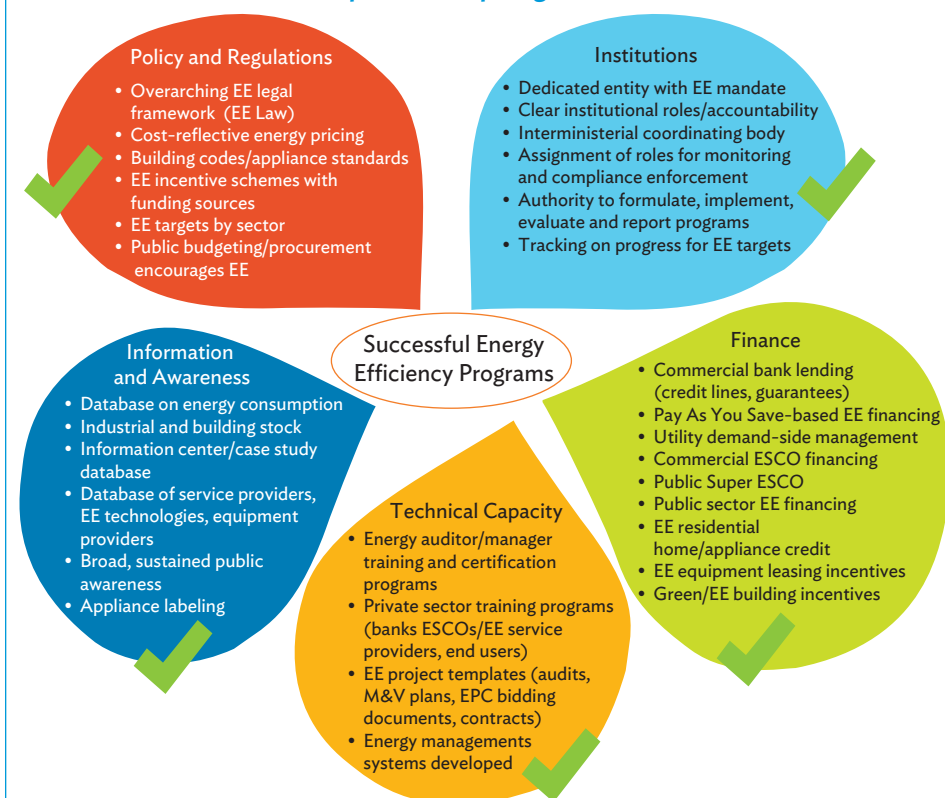
Stimulus packages and recovery efforts throughout the world have announced emphasis on energy efficiency and clean energy in general. The IEA Sustainable Recovery Plan projects that \$160 billion of public and private spending on appliance efficiency over 3 years could protect or create 1.8 million job-years. Although government stimulus packages are still being developed, announcements to the end of October 2020 indicate that spending is being directed to sectors with a high potential to create jobs. Building efficiency measures (including new efficient buildings and retrofits) are receiving the bulk of announced efficiency spending.

The clean energy transition is happening even more rapidly and disruptively across the world given the pressure to step up climate change mitigation actions and the need for “green recovery” post-COVID-19 pandemic, as revealed in stimulus packages of many countries. The pandemic-induced financial and policy decisions will shape the clean energy transition agenda and the overall economy for the next decade to come.

Scaling Up Energy Efficiency Investments in Asia

To implement demand-side energy efficiency at scale across the various end-use sectors in the global effort toward decarbonization of the energy sector aligned with SDG7 goals of doubling of energy efficiency improvements compared to past rates, the investments in the coming decades will need to grow multiple times than the volume of investments in the sector in the past. The amount of available public finance, which has competing priorities for meeting the needs of other development agenda (such as transport, health, etc.) is limited. Even together with development

Figure 19: Energy Efficiency Market Transformation Requires Multipronged Efforts



EE = energy efficiency, ESCO = energy service company, ESPC = Energy Savings Performance Contract, M&V = measurement and verification.

Source: J. Singh. Live Wire 2016/53. [Why Energy Efficiency Matters and How to Scale It Up](#). Washington, DC: World Bank

and climate finance, the total available amount of public finance is far smaller than the scale of financing that will be needed to convert significant untapped potential into investments, leading to energy savings and climate change mitigation. It is essential for energy efficiency financing mechanisms to leverage private capital using limited public funds through innovative financing mechanisms.

The provision of financing alone, however, will not lead to large-scale market transformation in developing countries, including in Asia, which faces multiple barriers and market failure. Multipronged efforts are required beyond financing to make investments happen at scale. Global experience in countries where the sector development has been successful with measured improvements in terms of reduction in energy intensities, shows that all five pillars of energy efficiency market transformation, shown in Figure 19, needs to be in place. They are: (i) policy and regulations and their implementation and enforcement; (ii) institutional frameworks and governance systems; (iii) information and awareness among all stakeholders (ranging from consumers to utilities to ESCOs to financiers, etc.); (iv) technical capacity across the value chain; and (v) financing. Hence the strategies for addressing the barriers to scaling up the implementation of energy efficiency in Asia anchors around these five pillars and their interactions with each other.

While the private sector is required to fill the financing gap, there is the need to create an enabling environment to encourage private sector participation. The role of the private sector must be expanded and will require the strengthening of the ecosystem anchored around the five pillars of energy efficiency market transformation while diversifying sources of private financing in Asia.

Conclusions

Most energy efficiency measures are economically viable and financially attractive on a life-cycle cost basis—with reasonable payback periods and high returns. However, the higher up-front incremental cost of most energy-efficient equipment and appliances becomes one of the major constraints for the energy end user like a building owner or an industry or an MSME or a municipality to invest in and adopt energy-efficient lighting and cooling systems, or efficient motors and compressors, or energy-efficient urban water and sewage pumping systems, respectively. As a result, energy efficiency potential on the demand side continues to remain largely untapped in many developing countries including in Asia, despite its enormous co-benefits like jobs, over and above their cost-effectiveness and ability to contribute to global climate change mitigation.

Multiple barriers in energy efficiency markets lead to market failures and need to be addressed through a combination of policies, regulations, institutions, awareness generation, and technical capacity building along with finance to ensure that the potential gets converted into investments at scale. Even though most demand-side energy efficiency projects are commercially and financially viable on a life-cycle basis, the initial incremental up-front cost of energy-efficient appliances, equipment and measures, and their higher transaction costs requires the need for using innovative financing mechanisms.

Demand-side energy efficiency market is heterogenous and there is no “one-size-fits-all” solution. The experience with different types of financing mechanisms to scale up investments in Asian and other countries shows common key elements and can potentially be replicated. The choice of a particular combination of macro-level finance supply option and the appropriate micro- or transaction-level finance demand options is manifested through various energy efficiency financing mechanisms along the energy efficiency ladder. Based on the market maturity, end-use sector, financial sector readiness, and other factors, a particular financing mechanism can be selected to deliver the results. In general, while the nascent and less-developed markets rely more on public financing resources and institutions, including utilities, as markets mature, energy efficiency gets more commercially financed and through private sector actors like ESCOs.

Public revolving energy efficiency funds, utility DSM based in pay as you save (PAYS), and on-bill financing mechanisms are usually suitable for nascent markets. However, the success of these programs requires a deep analysis of the local context and a tailored design of the financing mechanism to be implemented in a manner that gradually unlocks more private capital to flow into the energy efficiency markets. Grants are key at these stages along with the development and enforcement of policy, regulatory, and institutional frameworks, to provide technical capacity, information, and awareness among all stakeholders, and to strengthen the country readiness. As markets evolve, the design of energy efficiency investment programs should be geared toward the large-scale development of more sustainable market-driven options like private ESCOs, which can be initially also supported by super ESCOs, risk guarantees, credit lines, venture capital, etc. Public sector financing (along with development and climate financing) can help leverage and unlock private ESCO participation and mobilize commercial capital. The lessons learned from experiences and impacts of the development, design, and deployment of different financing mechanisms and structures and their implementation modalities and associated institutional arrangements shows the path for delivering demand-side energy efficiency financing, transactions, and savings at scale.

References

- Ablaza, A., Y. Liu, and M. F. Llado. 2020. *Off-Balance Sheet Equity: The Engine for Energy Efficiency Capital Mobilization*. ADBI Working Paper 1183. Tokyo: Asian Development Bank Institute.
- Eskom. 2010. *Energy efficiency program: scope and evaluation criteria specification*. Eskom.
- Grüning, C., C. Menzel, T. Panofen, and L. S. Shuford. 2012. *Case Study: The Thai Energy Efficiency Revolving Fund*. Frankfurt School of Finance & Management GmbH.
- Hofer K., D. Limaye, and J. Singh. 2016. Live Wire 2016/54. *Fostering the Development of ESCO Markets for Energy Efficiency*. Washington, DC: World Bank.
- Hwang, I. 2018. ESCO Program in Korea. Presentation at the Energy Transition in Asia: South–South Knowledge Exchange Workshop on Energy Efficiency. 24–28 January. Singapore.
- International Energy Agency; International Renewable Energy Agency; United Nations Statistics Division; World Bank; World Health Organization. 2020. *Tracking SDG 7: The Energy Progress Report 2020*. World Bank, Washington, DC.
- International Energy Agency (IEA) 2019. *Energy Efficiency 2019*. Paris.
- . 2018. *Energy Efficiency 2018: Analysis and Outlooks to 2040*. Paris.
- . 2017. *Energy Efficiency 2017*. Paris.
- . 2013. *Energy Efficiency Market Report 2013*. Paris: IEA/Organization for Economic Co-operation and Development.
- Lukas, A. 2018. Live Wire 2018/88. *Financing Energy Efficiency, Part 1: Revolving Funds*. Washington, DC: World Bank.
- McKinsey. 2020. *How a post-pandemic stimulus can both create jobs and help the climate*. Public & Social Sector and Sustainable Practices. McKinsey and Company.
- Regulatory Indicators for Sustainable Energy – RISE. Energy Sector Management Assistance Program (ESMAP). World Bank.

- Sarkar, A. and S. Sundararajan. 2020a. [Transforming India's energy efficiency market by unlocking the potential of private ESCOs](#). *World Bank blog*. 2 December.
- Sarkar, A. and S. Sundararajan. 2020b. India Partial Risk Sharing Facility for Energy Efficiency Operation. Webinar on Unlocking ESCO Market Transformation in India. 14 May.
- Sarkar, A. and S. Moin. 2018a. Live Wire 2018/92. [Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs](#). Washington, DC: World Bank.
- Sarkar, A. 2018b. Overview of ESCO Delivery Models. Presentation at the Energy Transition in Asia: South–South Knowledge Exchange Workshop on Energy Efficiency. 24–28 January. Singapore.
- Sarkar A., J. Sinton, and J. de Wit. 2014. Live Wire 2014/11. [Designing Credit Lines for Energy Efficiency](#). Washington, DC: World Bank.
- Singh, J. Live Wire 2016/53. [Why Energy Efficiency Matters and How to Scale It Up](#). Washington, DC: World Bank.
- Singh, J., D. Limaye, B. Henderson, and X. Shi. 2009. [Public Procurement of Energy Efficiency Services: Lessons from International Experience](#). Washington, DC: World Bank.
- World Bank. 2011. [Implementing Energy Efficiency and Demand Side Management: South Africa's Standard Offer Model](#). Washington, DC.
- World Bank. 2021. Case Study 1: Armenia Renewable Resources and Energy Efficiency Fund (R2E2). *Informal Note* (prepared by Tamara Babayan). Washington, DC: World Bank.
- . 2018. *Bulgaria - National Program for Energy Efficiency in Residential Buildings Program Design Report for the Second Phase*. Washington, DC: World Bank.
- Wang X., R. Stern, D. Limaye, W. Mostert, and Y. Zang. 2013. [Case study: South Africa Eskom Standard Offer Program for Energy Efficiency and Demand Side Management](#). Washington, DC: World Bank.
- Wu Y., J. Singh, and D. K. Tucker. 2018. Live Wire 2018/91. [Financing Energy Efficiency, Part 2: Credit Lines](#). Washington, DC: World Bank.

PART 6

Clean Energy in South Asia: Policies and Strategies



Jiwan Acharya, Len George, and Maria Fritzie Vergel

Introduction

India is among the world's fastest-growing economies, with average annual gross domestic product (GDP) increasing by 6.4% between 2015 and 2019.¹ It aims to become a \$5 trillion economy by 2024–2025. The rapid progress is driving population growth, rapid urbanization, and expanding the middle class. While two-thirds of the population still live in rural areas, population in cities are growing at around 2.3% per year.² Moreover, the growing middle class is expected to increase consumerism, electricity consumption, and vehicle proliferation. Aggressive economic development and unprecedented urbanization are expected to create enormous demand for energy and potentially strain existing energy systems and infrastructure.

The Government of India manages the pressure on the energy sector within a long-term sustainable development framework and commitment to reducing greenhouse gas emissions. In 2008, India announced its voluntary target to reduce its GDP emission intensity by 20%–25% of its 2005 levels by 2020 at the Fifteenth Meeting of the Conference of the Parties in Copenhagen. It laid out eight cross-cutting missions or programs under its 2008 National Action Plan on Climate Change (NAPCC), covering renewable energy, energy efficiency, water, and green living spaces. These missions aimed to create 20 gigawatt-hours (GW) of affordable solar power capacity by 2022 and initiatives for efficiency in energy-intensive industries, including certification and trading in energy certificates. Over time, this evolved into a target to install 175 GW of renewable electricity capacity by 2022 and 450 GW by 2030, as well as reducing energy intensity by 33%–35% by 2030 compared to 2005 levels.³

¹ ADB. 2019. *Asian Development Outlook Update: Fostering Growth and Inclusion in Asia's Cities*. Manila.

² World Bank. *World Bank Indicators* (accessed 18 August 2020).

³ Press Information Bureau. 2020. NITI Aayog, MNRE and Invest India Organized the Global Symposium 'India PV Edge 2020.' 6 October.

Achieving the NAPCC's ambitious goals and ensuring power supply reliability requires innovative policies and approaches to create an enabling environment for private sector participation. This paper explores two approaches that the government has initiated for large-scale deployment of solar power generation and widespread adoption of energy efficiency measures.

Policy Mechanisms on Solar Energy

India ranks fifth globally for largest installed renewable energy power generation capacities. It has set one of the world's largest and most ambitious renewable energy expansion targets of 175 GW by 2022 and 450 megawatts (MW) by 2030.⁴ Renewable energy capacities increased by 77% from 75.5 GW in 2013 to 136.9 GW in 2020. Renewables' contribution to the generation mix increased from 30% in 2013 to 36% in 2020. Among the renewables, hydropower has the largest installed capacity at 50.5 GW, followed by wind (38.6 GW) and solar (37.4 GW). Since 2017, the addition of new solar power generation capacities outpaced other sources (Figure 1).⁵ The capacity factors of the intermittent renewables, however, are lower compared to coal, gas, and nuclear power plants, resulting in a lower share of total electricity generation. From 2010 to 2020, renewables' share of electricity generation stayed under 22%, despite increasing consumption.⁶

The government established the Ministry of New and Renewable Energy (MNRE) to be the focal agency for developing renewable energy supply in order to meet the country's energy security objectives (footnote 4). The ministry works to achieve this goal by creating an enabling policy environment for public and private sector involvement in renewables, and by being a center of renewable energy knowledge and its dissemination.

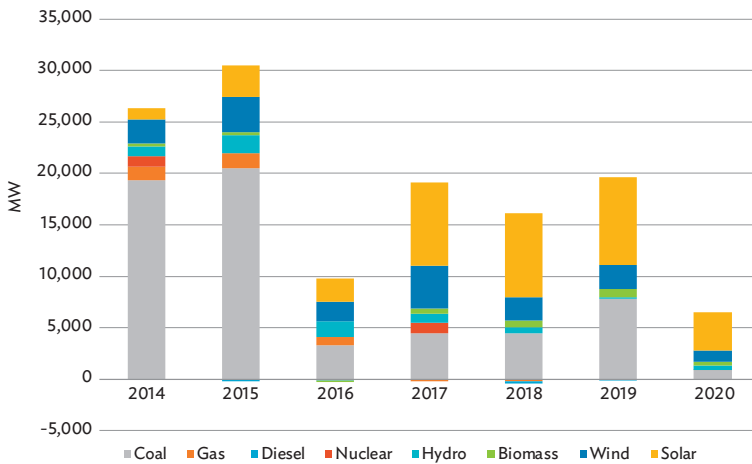
The MNRE oversees the implementation of the Jawaharlal Nehru National Solar Mission (NSM), one of the eight missions of the NAPCC launched in January 2010 to accelerate solar energy development. The NAPCC set an initial target to produce 20 GW of solar power by 2022, but this was accomplished 4 years in advance. In 2015, the NSM increased its target to 100 GW by 2022. Several policies and strategies were put in

⁴ Ministry of New and Renewable Energy, Government of India.

⁵ Central Electricity Authority. 2020. *All India Installed Capacity (in MW) of Power Stations as of 31 December 2020*. New Delhi.

⁶ International Energy Agency (IEA). *Data and Statistics: Electricity Generation by Sources, India 1990–2019* (accessed 9 March 2021).

Figure 1: Incremental Installed Power Generation Capacities by Type of Energy, 2014–2020 (MW)



MW = megawatt.

Sources: Central Electricity Authority. 2020. *All India Installed Capacity (in MW) of Power Stations New Delhi*; International Energy Agency. 2020. *India 2020 Energy Policy Review*. Paris.

place to achieve the targets, which are examined below, including the Renewable Purchase Obligation (RPO) scheme, reverse auctions, Green Energy Corridor Project, Grid-Connected Solar Rooftop Scheme, and solar parks. MNRE established the Solar Energy Corporation of India (SECI) as a state-owned enterprise to facilitate the implementation of the NSM and its schemes. MNRE is also responsible for expanding the share of other renewable energy technologies.

Renewable Purchase Obligation

The RPO scheme requires distribution companies, energy producers, and specific consumers to obtain a share of their electricity from renewable sources. In 2018, the Government of India set a national uniform RPO target of 21% including up to half from solar and half from other renewable sources.⁷ Renewable energy certificates can be traded to meet RPO shortfalls. The certificates addressed the mismatch between the availability

⁷ IEA. 2020. *India 2020 Energy Policy Review*. Paris.

of renewable energy resources and RPO requirements. RPO compliance is being monitored nationally to address the issue of low compliance with only four states exceeding their RPO for 2019–2020.

Reverse Auctions

There was a positive response and interest in the state feed-in tariff mechanism from the first set of solar power project developers. MNRE adopted a competitive bidding process for the procurement of power generated by grid-connected solar photovoltaic (PV) power plants that helped translate the strong interest from project developers to projects, to factor in the potential periodic reductions in capital cost, and to provide a channel for innovation in project sourcing, structuring, financing, and implementation in a fair and transparent manner. The reverse auctions promoted interest in distribution companies and consumers to find the power supplier with the lowest cost. Solar reverse auctions witnessed declining solar tariff bids from an average ₹12.12 per kilowatt-hour (kWh) in the first batch of auctions in 2010⁸ to ₹20 per kWh in March 2021.⁹ While various factors contribute to reducing rates, such as falling technology costs and improved PV efficiencies, competitive auctions have been acknowledged as a significant contributing factor.¹⁰ Wind power is also tendered through reverse auctions, but the response has not been as aggressive. In 2019, project developers offered bids only to 920 MW out of the 3 GW wind capacities tendered. The lesser uptake in wind energy reflects some of the challenges in adding capacity, including similar challenges with lack of transmission infrastructure as well as some unique subsector aspects, such as a relatively limited number of promising sites for wind power, a smaller number of developers, and the transition from well-established business models to reverse auctions.¹¹

⁸ Energy Sector Management Assistance Program (ESMAP). 2013. *Paving the Way for a Transformational Future*. Washington, DC.

⁹ India RE Navigator. [Auction Results](#).

¹⁰ K. Chawla, M. Aggarwal, and A. Dutt. 2020. Analyzing the Falling Solar and Wind Tariffs: Evidence from India. *ADB Institute Working Paper No. 1078*. Tokyo: Asian Development Bank Institute.

¹¹ REVE. 2020. [India Announces 4 Gigawatts of Solar, Wind Energy](#). 22 March.

Green Energy Corridor Project

MNRE initiated the Green Energy Corridor Project in coordination with the central and state transmission utilities to ensure that the upgrading of the transmission network occurs in consonance with the development of more renewable energy power plants to meet national requirements. The project expands the transmission network that will channel electricity generated from renewable-rich regions to high consumption centers and ensure reliable power supply to 80 million people.¹² The project was implemented by Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Tamil Nadu with abundant renewable energy resources. ADB and other cofinanciers supported the green energy corridor through multiple interventions at the state and national level, including through a combination of a \$500 million sovereign guaranteed loan and nonsovereign lending.¹³

Grid-Connected Solar Rooftop Scheme

Rooftop solar is expected to contribute 40 GW to the NSM's 100-GW target. The Grid-Connected Solar Rooftop Scheme was established to promote the use of small grid-tied solar PV systems that can supply power to both the grid and the connected load (end-user net-metering schemes). It contributes to enhancing power supply reliability through decentralized generation. The scheme provides financial assistance to rooftop installations by the residential sector and incentives to distribution companies. For households, 20%–40% of their cost (based on MNRE-prescribed benchmark costs) is shouldered by the program. For distribution companies, performance-based incentives are given on additional rooftop capacities installed above the base level across all sectors. The incentives for distribution companies are limited to the first additional 18 GW.¹⁴ The program has been supported by agencies including ADB, the World Bank, and bilateral partners through different banks and financing intermediaries.¹⁵

¹² A. Dutta. 2017. Work Begins on India's First Green Energy Corridor Project. *The Economic Times*. 22 May.

¹³ ADB. 2019. India: Green Energy Corridor and Grid Strengthening Project. *Project Data Sheet*. Manila.

¹⁴ MNRE. 2019. Launch of Phase-II of Grid Connected Rooftop Solar Programme for Achieving Cumulative Capacity of 40,000 MW from Rooftop Solar Projects by the Year 2022. New Delhi.

¹⁵ ADB. 2021. *India: Solar Rooftop Investment Program – Tranche 1*.

Solar Parks

Of NSM's 100-GW target, 60 GW will come from large-scale grid-connected solar power plants. MNRE initiated a solar parks scheme to address the challenges associated with developing scattered solar power projects and to support scaled development. Project development is often associated with land acquisition challenges, grid interconnection issues, and transmission losses.¹⁶

Solar parks address these challenges by providing a ready “plug-and-play” platform to construct and operate solar power plants. Under MNRE's scheme, a solar park hosts several individual solar power projects with an aggregate total of at least 500 MW. Smaller parks with limited available nonagricultural land or challenging site locations are also eligible under the program. The solar park takes on significant early project development activities as it offers a well-characterized and pre-developed site for independent solar power producers. A key feature is providing a transmission link that connects all projects to the grid and ensures the evacuation of solar power generation, addressing interconnection risks. Enhanced grids allow solar power generated in the solar parks to evacuate to other states that need supply. Other infrastructure necessary for the operation of solar power plants is provided, such as offices, access roads, security, water supply, and other administrative arrangements. This bundled approach addresses the challenges and mitigates risks associated with developing and operating individual power plants and drives economies of scale.¹⁷

State governments and their designated agencies can develop solar parks in various ways. For example, they may choose to develop the park through a subsidiary, enter into a joint venture with SECI or a private company, or assign SECI to develop the park on behalf of the state. The solar park project developer (SPPD) must plan, finance, execute, operate, and maintain the solar park, and ensure that solar power generation is exported to the grid.

The SPPD raises funds to finance the development of the solar parks from available government funds or incentives, or secures a loan where MNRE grants can be treated as the SPPD's contribution. SPPDs may recover the expenses after the MNRE subsidy through the sale or lease charges of land from the solar projects and service fees. The solar park

¹⁶ MNRE. 2014. *Implementation of a Scheme for Development of Solar Parks and Ultra Mega Solar Projects in the Country Commencing from 2014–2015 and Onwards*. New Delhi.

¹⁷ Institute for Energy Economics and Financial Analysis. 2020. *India's Utility-Scale Solar Park a Global Success*.

operators generate a reasonable amount of profit to ensure their financial strength for long-term sustainable operations (footnote 15).

A tariff-based competitive bidding tender is issued to select independent solar power producers to be housed in the park, choosing the lowest bidders. Reverse auctions in solar parks have seen the lowest solar tariff bids in India and globally. Winning bidders enter into a power purchase agreement with the distribution company. Many state-owned distribution companies are financially stressed, posing off-taker risks. SECI and the National Thermal Power Corporation (NTPC) sign power purchase agreements with the solar park and the distribution company to improve the quality of contracts with independent power producers to manage this risk. SECI and NTPC are central government-supported entities with more robust financial standings than most state-owned distribution utilities (footnote 16).

Off-Grid Solar

NSM's off-grid component involves developing decentralized grid-connected solar or other renewable energy-based power projects, installing solar-powered agricultural pumps and streetlights, and providing solar study lamps for school children.

Financing Solar Energy in India

India's ambitious solar targets require the mobilization of private sector investments through an enabling policy and financing environment. To unlock private capital, the government used public financing sources to prepare and invest in the required infrastructure that would catalyze private solar power producers and encourage public-private partnerships (PPPs). The catalyzing mechanism has evolved to be more competitive-based with a preference for reverse auctions and generation-based incentive mechanisms rather than feed-in-tariffs.¹⁸

MNRE has dedicated agencies to implement schemes and administer financial support to state governments and other solar power stakeholders. The Indian Renewable Energy Development Agency is the primary agency administering financial assistance to renewable energy and energy efficiency projects. This government nonbanking financing institution,

¹⁸ G. K. Sarangi. 2018. *Green Energy Finance in India: Challenges and Solutions*. ADB Institute Working Paper Series. No. 863. August. Tokyo: ADBI Institute.

established under MNRE, extends loans to renewable energy project developers at low interest rates through various mechanisms such as direct lending or lines of credit.

SECI was established to facilitate the implementation of the NSM and administer the Viability Gap Financing Scheme for grid-connected solar projects and the solar parks scheme. Funds are sourced from international agencies and banks, and from the National Clean Energy and Environment Fund. The Clean Technology Fund (CTF) has been tapped to finance clean energy schemes through India’s partner multinational development banks (Table 1). An aggregate of \$3.45 billion from the CTF and its multilateral development bank partners has been allocated for solar power development.¹⁹

Table 1: Clean Technology Fund Contribution to Solar Projects in India
(\$ million)

CTF Project	Partner MDBs	CTF Value	Cofinanced by CTF Partners MDBs	Total Cost
Rajasthan Renewable Energy Transmission Investment Program (2013)	ADB	200	300	800
Solar Rooftop Investment Program guaranteed by India Solar Transmission Project (2015)	ADB	175	330	505
	IBRD	125	470	1,095
India Solar Park Transmission (2016)	ADB	50	175	450
Shared Infrastructure for Solar Parks (2016)	IBRD	25	75	200
Innovation in solar power and hybrid technologies (2017)	IBRD	40	150	400

ADB = Asian Development Bank, CTF = Clean Technology Fund, IBRD = International Bank for Reconstruction and Development, MDB = multilateral development bank.

Source: CIF. 2021. *Supporting Just Transitions in India*.

¹⁹ Climate Investment Funds. 2021. *Supporting Just Transitions in India*.

Financing the Development of Solar Parks

The general provisions of MNRE's Central Financial Assistance for the development of solar parks are:

- (i) Up to ₹2.5 million for the preparation of a solar park's Detailed Project Report;²⁰
- (ii) Up to ₹2 million per MW or 30% of the solar park's project cost, including grid-connectivity costs, whichever is lower; and
- (iii) ₹2 million per MW for the development of the external transmission systems, where 60% is for the SPPD's development of internal infrastructure of the solar park, and 40% goes to the central or state transmission utility, or 30% of their project costs, whichever is lower.²¹

SECI, on behalf of MNRE, manages and releases the grants as milestones are reached. SECI receives a handling fee of 1% for fund management.

The interconnection of plots to pooling stations is the responsibility of the independent power producer. The SPPD sets up the pooling stations and the interconnection to the main grid. Responsibility for setting up a substation near the solar park to the central transmission network lies with the central or state transmission utility. Financing for the power evacuation network may come from an MNRE grant or be loaned from multilateral/bilateral agencies. If the cost is too high, separate funding may be sought from the National Clean Energy and Environment Fund, the Green Energy Corridor Project, or other sources (footnote 15).

Viability Gap Funding

Viability Gap Funding (VGF) is a one-time or deferred grant to bridge the viability gap of infrastructure projects under PPPs. It was set up in recognition of some infrastructure projects not always being financially viable because of long gestation periods and small financial returns.²² To access VGF, a project must be implemented and operated by a

²⁰ A Detailed Project Report is equivalent to a feasibility study. It analyzes the technical and economic feasibility of a project, including its social and environmental impacts.

²¹ MNRE. *Development of Solar Parks and Ultra Mega Solar Power Projects*.

²² Government of India. 2005. *Scheme for Support to Public Private Partnerships in Infrastructure*.

private company, which is selected through open competitive bidding. The grant can cover up to 20% of the total project cost for economic infrastructure projects, or up to 30% of financing for social infrastructure projects such as wastewater treatment, water supply, and solid waste management projects.²³

A dedicated VGF for solar projects under NSM was set up, covering 5 GW of projects. The grant can be up to ₹10 million per MW for the open category²⁴ and ₹12.5 million per MW for projects in the domestic content requirement category.²⁵ In 2018, a 1-GW subset of the existing 5 GW VGF was allocated for the North Eastern States project.²⁶

Recognizing government entities' potential contribution to achieve long-term energy security goals, a special VGF was allocated for government (not PPPs) power producers. It falls under the Central Public Sector Undertaking Scheme, which covers 12 GW of solar power projects to be developed from fiscal year (FY) 2020 till FY2023. This VGF extends a maximum permissible grant of ₹7 million per MW.²⁷ The government producer may undertake the development of the solar projects or contract it out to an engineering, procurements, and construction company.

National Clean Energy and Environment Fund

The National Clean Energy and Environment Fund, established in 2009 as the National Clean Energy Fund, supports clean and renewable energy projects and promotes innovation and research in the sector. The fund comes from a tax on coal produced in India initially set at ₹50 per metric ton and increased to ₹400 per metric ton in FY2017. From 2010 till 2018, a total of ₹864.4 billion was collected. This supports MNRE's renewable energy programs and other development projects, such as grid upgrades, off-grid decentralized renewable power, and research and development programs.²⁸

²³ G. Noronho. 2020. [Finance Ministry Notifies Updated Viability Gap Funding Scheme](#). *The Economic Times*. 10 December.

²⁴ Open category has no restrictions on where equipment is sourced.

²⁵ Domestic Content Requirement is a scheme that mandates use of both solar PV cells and modules manufactured domestically.

²⁶ MNRE. 2019. *Implementation of a Subset of existing 5000 MW Viability Gap Funding Scheme for Setting Up of 1000 MW Grid-Connected Solar PV Power Projects in North Eastern States including Sikkim under Jawaharlal Nehru National Solar Mission*. New Delhi.

²⁷ MNRE. 2019. *Implementation of Central Public Sector Undertaking Scheme Phase-II for Setting Up to 12000 MW Grid-Connected Solar Photovoltaic Power Projects by the Government Producers with Viability Gap Funding Support for Self-Use or Use of Government*. New Delhi.

²⁸ Department of Expenditure. 2018. *National Clean Energy & Environment Fund*.

The Indian Renewable Energy Development Agency also taps into the fund to provide subsidized debt at a 5% interest rate to renewable energy projects through select banks.

The success of Gujarat's Charanka and Rajasthan's Bhadla solar parks (Box 1) helped make the case for a national scheme for solar parks under NSM 2014. In 2014, NSM set an initial target of building 25 solar parks with a total capacity of 20 GW by 2019. But the ongoing success of these and other parks validated building solar parks as an effective strategy. As a result, NSM's target was increased to 50 solar parks with an aggregate capacity of 40 GW by FY2022. As of September 2020, 38 solar parks had been approved across 15 states, with an aggregate capacity of 25.1 GW. The increased capacity targets will contribute to achieving the country's energy security goals.

Box 1: Charanka and Bhadla Solar Park

Gujarat State receives solar radiation of 5.8–6.0 kilowatt-hour (kWh) per square meter per day and has vast tracts of barren land. The state government realized the high potential of solar energy and released the Gujarat Solar Power Policy in 2009, ahead of the National Solar Mission (NSM). The objective of the policy was primarily to promote solar energy through private sector participation. It initiated private-public partnerships for developing a solar park under a feed-in-tariff scheme.

Charanka Solar Park, Gujarat's first solar park, was inaugurated in 2012. The Gujarat Power Corporation Limited, a state government-owned company, led its development. Among its responsibilities were land acquisition and the provision of common park infrastructure such as water, sanitation, security and roads. The Asian Development Bank (ADB) supported Charanka Solar Park with a \$100 million loan, while the state government's contribution was nearly \$37 million.^a The funds were on-lent to the Gujarat Energy Transmission Company, which constructed the transmission infrastructure for evacuating solar power generated in the park. Gujarat Urja Vikas Nigam Limited, the state government agency designated for interstate transmission and distribution, arranged for the surplus power

continued on next page

Box 1 *continued*

generated in Gujarat to be exported to neighboring power deficit states and energy-intensive industrial zones.

The feed-in tariff rate was set at ₹13 per kWh for the first 12 years and then ₹5 per kWh for the next 13 years. Private developers were attracted to the front-loaded fixed tariff to support debt service and the transparency and investor-friendly policy mechanisms laid out in the Gujarat Solar Power Policy.^b The installed solar capacity within the park has reached 600 megawatts (MW), commissioned by 31 developers. A further expansion to the park is being considered.^c

Rajasthan State is similar to Gujarat, with high solar radiation levels (5.72 kWh per square meter per day) and a vast, barren landscape. In 2011, Rajasthan implemented a solar policy to meet its renewable purchase obligation requirements. Its initial target was to install 1.0–1.2 gigawatts (GW) of solar capacities by 2022.^d In 2014, it updated its solar policy to align with NSM's Solar Park Scheme and to contribute to NSM's 100 GW target, expanding its target to 30 GW by FY2025, where 24 GW will be installations in solar parks. Other capacities will come from distributed generation (4 GW), solar rooftop (1 GW), and solar pumps (1 GW).^e Rajasthan is one of the top solar-producing states in India.

The Rajasthan Renewable Energy Corporation is the state's implementing agency for developing solar parks. Rajasthan has six solar parks with a total capacity of 4.3 GW.^f Two parks were developed solely by the corporation through its subsidiary, Rajasthan Solar Park Development. The rest were developed as joint ventures with private entities. The state can invest up to 50% (including the cost of land) into the joint venture.^g

The Bhadla Solar Park is the largest in Rajasthan, with a total capacity of 2.2 GW (see table below). It was developed in four phases by different solar power park developers. It covers 5,783 hectares of land in Bhadla, a sandy, arid region in Jodhpur district. The average temperature is between 46 and 48 degrees Celsius, with frequent hot winds and sandstorms. The closest neighboring village is 50 kilometers away, and the nearest urban area is 80 kilometers away. Vast government-owned, unused land here was seen as ideal for the development of solar parks.^h

continued on next page

Box 1 continued

Box 1 Table: Estimated Investments for Bhadla Solar Park

Phase	Solar Park Development	Area (hectares)	Number of Projects	Total Capacity (MW)	Investment for Solar Park (₹ million)
I	Rajasthan Solar Park Development Company	186	7	65	4,500
II	Rajasthan Solar Park Development Company	1,797	10	680	34,000
III	Saurya Urja Company of Rajasthan (joint venture of the Government of Rajasthan and Infrastructure Leasing and Financial Services Energy)	247	10	1,000	40,000
IV	Adani Renewable Energy Company (joint venture of the Government of Rajasthan and Adani Renewable Energy Park)	1,330	10	500	20,000
Total		3,560	37	2,245	98,500

₹ = Indian rupees, MW = megawatt.

Source: Energy Department, Government of Rajasthan. 2018. Rajasthan—The Solar Destination & Development of Bhadla Solar Park. 5 June.

Bhadla Phase 1 was commissioned in 2015 with seven solar projects and a combined capacity of 65 MW. Phase II was six projects by independent power producers of 70 MW each, and 260 MW projects by the National Thermal Power Corporation, the largest state-owned power generation company under its self-owned projects program. Bhadla Phases III and IV host 10 solar power projects each. The solar power producers were selected through reverse auctions. An auction under Phase III resulted in one of the lowest ever solar bids globally at ₹2.44 per kWh for 800 MW, in 2017. The total estimated investment for Bhadla Solar Park was ₹98.5 billion. The park is eligible for up to ₹28.2 billion based on the Central Financial Assistance grant provisions for solar parks.

continued on next page

Box 1 *continued*

ADB and the Clean Technology Fund supported Rajasthan State in developing the Bhadla Solar Park through the Rajasthan Renewable Energy Transmission Investment Program. The \$500 million program financed the transmission network that will evacuate solar generation from the park and wind power produced from resource-rich regions in the western part of the state. Given the unprecedented magnitude of the solar park, adequate capacity building was necessary to be able to manage the significant solar capacity addition to the grid and planning for dispatch. The program included a \$2 million technical assistance component that (i) developed the solar park master plan, (ii) implemented community development initiatives, (iii) enhanced the institutional capacity of the transmission utility and the Rajasthan Renewable Energy Corporation, and (iv) studied the system for the renewable energy integration road map.ⁱ The program will eventually help add at least 4,300 GW of renewable energy capacity to the grid. The additional capacity will generate 7,761 GWh per year, which will lead to an estimated 5.4 million tons of reduced carbon dioxide emissions per year. In addition to financing investments, the program also supported improvements in the financial sustainability of the state-owned transmission company, including through tariff adjustments and financial covenants.

^a ADB. 2019. *Completion Report: India Gujarat Solar Power Transmission Project*. Manila.

^b K. Yenneti. 2016. Industry Perceptions on Feed in Tariff (FIT) based Solar Power Policies—A Case of Gujarat, India. *Renewable and Sustainable Energy Reviews*. 57 (2016) 988–998.

^c DNA. 2018. *Solar Power Capacity at Charanka Solar Park to Touch 790 MW*. 21 April.

^d International Energy Agency. 2012. *Rajasthan Solar Policy*. 18 July.

^e Energy Department, Government of Rajasthan. 2019. *Solar Energy Policy, 2019*. Jaipur.

^f SECI. 2020. *Statewise Solar Parks*.

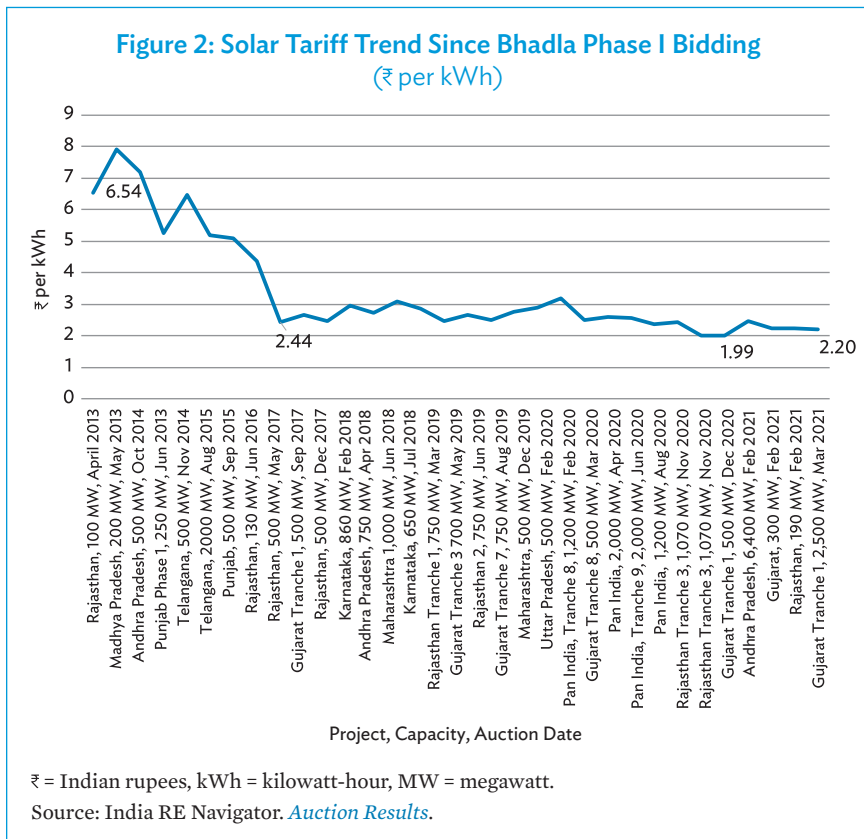
^g Government of Rajasthan, Energy Department, 2014. *Rajasthan Solar Energy Policy, 2014*. Jaipur.

^h ADB. 2018. *Rajasthan Renewable Energy Transmission Investment Program Fact Sheet*. Manila.

ⁱ Government of Rajasthan, Energy Department, 2014. *Rajasthan Solar Energy Policy, 2014*. Jaipur.

Source: ADB.

The solar parks saw tariffs fall over time due to competitive reverse auctions (Figure 2). The falling solar bids in India have been attributed to the up-front planning and structuring of the solar parks, the financial credibility of the off-takers' assurances, and an assured connection to the state and national electricity transmission network that the solar park business model facilitates. These reduced risks for large solar projects, which helped bring down costs. Other factors such as technology advancements, increased efficiency, and access to low-cost capital are also significant determinants of costs (footnote 10).²⁹



²⁹ A. George. 2020. *Why SECI Auction Paints Optimistic Picture for Indian Solar Sector*. 25 November.

Community Development in Bhadla

Incorporating a Community Development Action Plan (CDAP) into the development of solar parks is crucial to ensure that communities are protected and share in progress. This is a plan that engages all relevant stakeholders, such as the park developer, solar projects, and distribution companies, to participate in community building. The CDAP is a needs-based plan that designs activities that promote inclusive growth in capability and livelihood. It is gender-sensitive, prioritizing the needs and interests of women and girls. It is vital to sustain meaningful engagement with communities to identify synergistic opportunities in terms of land use and to contribute to greater gender positive transformation.

Rajasthan State requires that all solar parks develop and implement a CDAP. While Bhadla is largely an uninhabited region, care was taken to ensure that the nearest communities were not negatively affected by the solar park. The park employed around 1,000 people including engineers, construction works, and technicians. About 40% of these employees came from surrounding villages. Income-generating and alternative livelihood opportunities for women in Bhadla were cultivated through capacity building as part of the park's development. Some 415 women benefited from microenterprise development training on goat rearing, 150 women were trained in embroidery and handicrafts, and 75 received training in basic accounting, finance management, and vocational skills.³⁰ Incubation centers were created to support emerging microenterprises, facilitating access to financing and administration support. Health camps were conducted for 200 women and adolescent girls, and schools were also established to enhance community access to social services, especially for women.³¹

Bhadla's CDAP also includes a strategy to improve community infrastructure and energy services. Distribution companies provided off-grid lighting systems. New mini-grid systems were constructed in several villages, while existing ones were rehabilitated.³² Access to drinking water is an essential component of the CDAP for this water-poor region. Bhadla Solar Park uses sweeping systems to clean panels instead of water; this maintenance procedure has generated jobs with minimal skill requirement.

³⁰ Energy Department, Government of Rajasthan. 2018. *Rajasthan—The Solar Destination & Development of Bhadla Solar Park*.

³¹ ADB. 2018. *Rajasthan Renewable Energy Transmission Investment Program Fact Sheet*. Manila.

³² Energy Department, Government of Rajasthan. 2016. *Private Sector Partnership for Inclusive Solar Park Development in Rajasthan*. 12 April.

Lessons Learned from Solar Parks

The solar park model leverages public sector investment in parks and transmission lines with larger private investments to deploy large-scale renewable energy in a cost-effective and scalable manner. The solar park provides a “plug-and-play” platform for solar PV projects that reduces project-level risks, mitigates development delays, and ensures interconnection to the grid. Addressing these risks enhances private sector confidence and leads to greater participation. Further, reduced risks permit solar power producers to scale up, attract a more established class of investors with better access to global supply chains, and offers more competitive tariffs.

The NSM’s scheme mitigates counterparty risks for solar investments by having a central government agency or utility, such as SECI or NTPC, as off-takers. State distribution companies are known to have weaker financial standing and may have overdue payments to generation companies. Central government entities are in a better financial position than the distribution companies and their involvement reduces off-taker risks for developers.

The enhancement of the transmission network should be coordinated with the solar PV project’s development timeline to ensure timely grid connection. The solar park model can be customized to cater to needs, such as incorporating energy storage or hosting other renewable energy technologies, like wind power. Simulation studies are important to understand the solar park’s impact on the grid and identify appropriate strategies to facilitate integration.

Over time, increasing private sector interest has been demonstrated for solar park development and transmission connectivity. The experience in Rajasthan has helped in the development of solar park approaches with public sector facilities including transmission systems and park development by the public sector and private sector investment in solar PV generation in multiple countries, including ADB-funded projects in Cambodia and Uzbekistan.³³

Energy Efficiency Policies

The Government of India has taken significant efforts to promote demand-side energy efficiency through various policy measures under the Energy

³³ ADB. 2019. *ADB to Help Build 100-MW Solar Park in Cambodia*. News release. 24 May.

Conservation Act of 2001. The Act's primary goals were to reduce the energy intensity of the Indian economy, manage the pressure on energy demand, and support sustainable development. It provides the regulatory mandate for standards and labeling, energy conservation building codes, and energy consumption guides for energy-intensive industries.

Through the Bureau of Energy Efficiency (BEE), the Ministry of Power implemented several initiatives targeting the residential, commercial, and agriculture sectors, as well as small and medium-sized enterprises and energy-intensive industries. The programs aimed to contribute to energy security and support India's Conference of the Parties 21 commitment to bring down its energy intensity by 33% to 35% in 2030 from its 2005 levels. In 2020, BEE reported that energy intensity had already been reduced by 20% from 2005 levels. For FY2019, total energy savings reached 23.73 megatons of oil equivalent, including 113.16 trillion watt-hours of electricity savings. These efforts have also contributed to 151.74 million metric tons of reduced carbon dioxide emissions.³⁴

The initiatives covered:

- (i) **Standards and labeling:** The program covers 19 appliances to enable consumers to make informed choices related to energy and cost savings.
- (ii) **An energy conservation building code:** This code sets the minimum energy standards for new commercial buildings with a connected load of 100 kW. A voluntary star labeling program was initiated for office buildings, hospitals, and malls to promote energy efficiency.
- (iii) **Demand-side management:** This focuses on the agriculture sector, electricity distribution companies, urban local bodies, and small and medium-sized enterprises. It involved demonstration projects, audits, and capacity building on energy efficiency.
- (iv) **Strengthening institutional capacity of states:** This involves enhancing state-designated agencies' capabilities and resources to implement the Energy Conservation Act and establish the State Energy Conservation Fund.
- (v) **School education program:** Energy clubs were formed in schools and energy efficiency concepts were included in science lessons and in textbooks.

³⁴ Ministry of Power. 2020. *The Energy Efficiency Initiatives by BEE Leads to Savings Worth Rs.89,122 Cr. In 2018–19*. News release. 6 May.

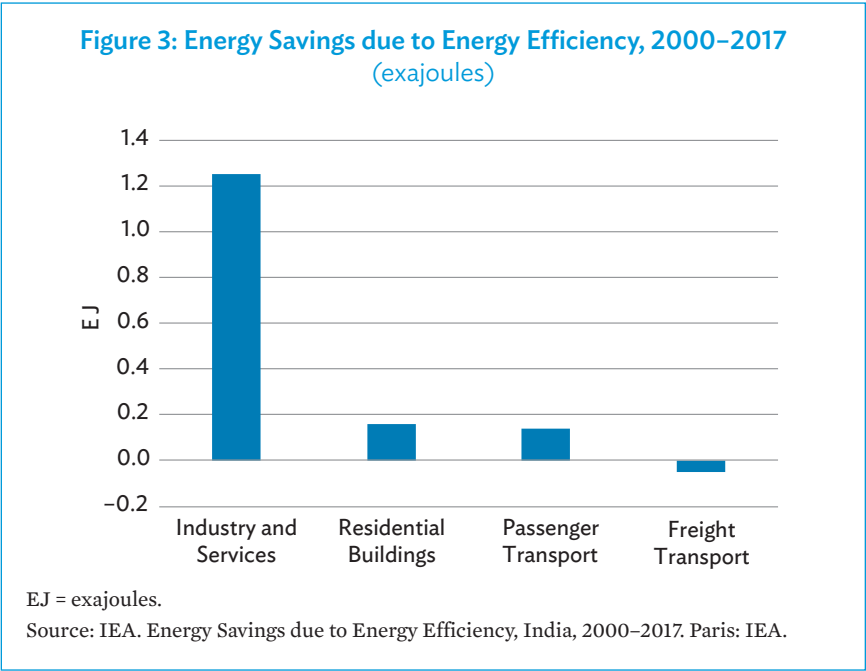
- (vi) **Human resource development:** Theory and practice-oriented training on energy efficiency and support to access energy audit instruments were offered to appropriate staff.
- (vii) **National mission for enhanced energy efficiency:** The mission is one of the eight created under the NAPCC. It aims to open and strengthen markets for energy efficiency by creating a conducive, regulatory, and policy regime, and has designed innovative and sustainable business models for the energy efficiency sector. It has four primary initiatives targeting energy-intensive industries:
 - (a) **Perform, achieve, and trade scheme:** This is a market-based mechanism to enhance the cost-effectiveness of energy efficiency improvements in energy-intensive facilities through the certification of energy savings that can be traded.
 - (b) **Market transformation for energy efficiency:** This aims to accelerate the shift to more energy-efficient appliances in select sectors through innovative measures to make the products more affordable.
 - (c) **Energy efficiency financing platform:** The platform facilitates financing of demand-side management (DSM) programs. A memorandum of understanding was signed with financial institutions to develop the energy efficiency market.
 - (d) **Framework for energy-efficient economic development:** This framework allows for the development of fiscal instruments for energy efficiency. Two funds have been created: the Partial Risk Guarantee Fund for Energy Efficiency and the Venture Capital Fund for Energy Efficiency. The support under the fund is limited to improvements in government buildings and projects for municipalities.³⁵

The Perform, Achieve, and Trade Scheme has been the most significant contributor to energy savings. The evaluation of the scheme's first cycle (2012–2015) showed that all sectors exceeded their targets except for the thermal power generation sector. The majority of the designated consumers implemented relatively low-cost measures, such as adjustment in the process control system and installation of variable speed drives on electric motors. These improvements were financed through companies' internal funds.

³⁵ Ministry of Power. *Energy Efficiency*.

The scheme established the trading of energy saving certificates as an incentive to reach or exceed the mandatory targets. Consumers that exceeded their targets were awarded certificates equivalent to 1 ton of oil equivalent of surpassed energy savings. The certificates may be sold to consumers who failed to achieve their target, with the price determined by supply and demand via the Indian Energy Exchange, a centralized trading platform. The certificates can also be banked in order to meet future targets as the scheme expands and imposes higher targets.³⁶

Most savings due to the scheme have been in the industry and services sectors. There remain significant energy-saving opportunities for the residential and transport sectors (Figure 3).



³⁶ IEA. 2019. *Perform, Achieve, Trade (PAT) Scheme*. 5 June.

Barriers to Energy Efficiency

While India's energy efficiency initiatives are aggressive, rapid adoption is hampered by a number of challenges,³⁷ including the following:

- (i) Electricity is still subsidized to some extent, whereas energy efficiency programs are voluntary. The Perform, Achieve, and Trade Scheme is the only mandatory energy efficiency program for energy-intensive industries.
- (ii) There is a lack of institutional capacity for implementing energy efficiency projects, combined with limited awareness and knowledge of energy efficiency technologies and their benefits.
- (iii) Some energy-efficient technologies have high up-front costs and may not compare favorably to other investments that will increase production rather than reduce costs.
- (iv) Investment returns derive from energy savings, but those returns can be difficult to quantify because they are often measured by energy cost savings rather than by revenues.
- (v) Accessing financing for energy efficiency activities has been a critical challenge for its widespread adoption. Commercial lenders associate new technologies and new business models, such as with energy efficiency projects, as high-risk activities. Specifically, the challenges are:
 - (a) Low awareness, lack of information, and limited understanding of energy efficiency on the side of the banking industry;
 - (b) Small project size, relatively high transaction costs and administrative hurdles for financiers;
 - (c) High perceived technical and commercial risk, particularly with respect to enforcement of contracts; and
 - (d) Lack of standardized methods and processes for measuring energy savings, and limited understanding of protocols for assuring performance guarantees.

³⁷ ADB. 2019. India: Demand-Side Energy Efficiency Sector Project. *Project Data Sheet*. Manila.

DSM companies or energy service companies address many of the technical and financial challenges in implementing energy efficiency projects. They often provide end-to-end services, including designing the project, financing or facilitating the financing of the project and implementing it, then monitoring and verifying service levels. They provide energy savings guarantees, and manage most technical risks to ensure viability. There are various business models and the most common involves generating revenue based on energy savings.

Financing Energy Efficiency Projects

The Government of India launched two schemes to encourage local financial institutions to finance energy efficiency projects: the Partial Risk Guarantee Fund for Energy Efficiency and the Venture Capital Fund for Energy Efficiency. The Partial Risk Sharing Facility is another guarantee fund, initiated by the World Bank with the BEE, and this augments the Partial Risk Guarantee Fund. An Energy Efficiency Financing Platform was created to facilitate interaction among DSM companies and potential financing sources.

The **Venture Capital Fund for Energy Efficiency** extends equity support to energy efficiency projects in government buildings, private commercial or multistorey residential buildings, and municipalities. The government allocated ₹2.1 billion for the fund, which provides risk capital support to energy efficiency investments in technologies and services. The fund can also be used for “last-mile” equity support for public and private sector projects.³⁸

The fund (i) invests in the form of equity; (ii) provides last-mile equity support to eligible energy efficiency projects, limited to a maximum of 15% of total equity required, through a special purpose vehicle or ₹20 million, whichever is less; and (iii) lasts for 10 years from the date of commencement.³⁹

The **Partial Risk Guarantee Fund for Energy Efficiency** is a risk-sharing mechanism that provides banks and nonbanking financial companies with partial risk coverage in lending to energy efficiency projects. The government has approved ₹3.12 billion for the fund, which

³⁸ A. Sheik et al. 2016. Apprising Energy Efficiency Projects and Relevance to ESCOs. *Advances in Economics and Business*. 4 (8): 414–423.

³⁹ IEA. 2019. *Venture Capital Fund for Energy Efficiency (VCFEE)*. 26 September.

can guarantee up to 50% of the loan. In case of nonperforming energy efficiency accounts, the fund shall (i) cover the first loss subject to a maximum of 10% of the total guaranteed amount, and (ii) cover the remaining default outstanding principal amount disbursed on an equally ranked basis up to the maximum guaranteed amount.⁴⁰

The World Bank and BEE also launched the **Partial Risk Sharing Facility** in 2015, supported by \$25 million of contingent finance from the CTF and an \$18 million grant from the Global Environment Facility. The \$37 million facility is managed by the Small Industrial Development Bank of India.⁴¹ The facility guarantee covers up to 75% of the principal or ₹150 million, whichever is lower, for up to 5 years. Ten financial institutions have become part of the facility platform and have supported 28 energy efficiency projects. These projects' cumulative investments reached \$53 million, which is 3.4 times greater than the public contingent funds of only \$15.8 million in loan guarantees (footnote 40). The facility includes a \$6 million technical assistance program for banks and DSM companies.⁴²

All these mechanisms address financing barriers faced by DSM companies. Guarantee instruments de-risk energy efficiency investments and leverage limited public funds by unlocking commercial debt financing.

Other factors still hamper the adoption of energy efficiency measures such as the skepticism of energy users about DSM companies. The lack of trust in the ecosystem stems from a lack of standardized technology-specific solutions, tight contractual frameworks, and questionable legal enforcements. Another critical gap is the absence of a credible market maker or “champion” that can enable and transform the industry by facilitating interactions with relevant stakeholders, and that will showcase success stories.⁴³

⁴⁰ USAID. 2017. Guidelines for Finance Energy Efficiency Projects in India. *USAID PACE-D Technical Assistance Report*. New Delhi.

⁴¹ A. Sarkar and S. Sundararajan. 2020. *Transforming India's Energy Efficiency Market by Unlocking the Potential of Private ESCOs*. 2 December.

⁴² World Bank. 2015. *Government of India and World Bank Sign Agreement for \$43 million Partial Risk Sharing Facility for Energy Efficiency Project*. News release. 31 March.

⁴³ S. Kumar et al. 2017. *Transforming the Energy Services Sector in India: Towards a Billion Dollar ESCO Market*. New Delhi: Shakti Sustainable Energy Foundation and Alliance for an Energy-Efficient Economy.

Energy Efficiency Services Limited

Energy Efficiency Services Limited (EESL) was established in 2009 to provide a comprehensive package of project design, implementation, and investments for energy efficiency projects. It was established as a joint venture of four public sector undertakings under the Ministry of Power: the NTPC, the Power Grid Corporation of India Limited, the Power Finance Corporation, and the Rural Electrification Corporation.

EESL assists the central and state governments in opening markets for energy efficiency, and was initially focused on the public sector. It aims to demonstrate that the energy services company model can effectively deploy energy efficiency projects at a scale that will save energy, reduce peak demand, and lead to positive environmental effects.

EESL uses the pay-as-you-save business model, which takes the up-front investment risk by procuring efficient equipment and executing the project at no cost to the energy user. It uses a deemed savings contract that manages challenges in calculating accurate energy savings. It addresses difficulties in setting up accurate baselines, collecting sufficient energy consumption data, or using equipment that may not always perform up to standard.⁴⁴ EESL aggregates the procurement of equipment to take advantage of economies of scale. It enters into a lease-type agreement with its customers, with the “lease rental” capturing fees linked to future guaranteed energy savings and warranties for failures. Typically, the ownership of the equipment is transferred to the energy user at the end of the lease term.

The Government of India and its development partners, including ADB, Agence Française de Développement, KfW, and the World Bank, provided EESL with more than ₹60 billion of capital (debt and equity) by the end of FY2020 to implement its programs.

ADB’s assistance package to EESL includes a total of \$465 million in loans, grants, and technical assistance. The first \$200 million committed was a loan to finance EESL’s high-priority areas, including supporting municipalities to deploy more efficient light-emitting diode (LED) streetlights and lights, efficient electric fans, and efficient water pumps for agricultural use.⁴⁵ EESL received an additional \$13 million grant through

⁴⁴ P. Makumbe et al. *LED Public Lighting: Super-ESCO Delivery Model Case Study*. ESMAP.

⁴⁵ ADB. 2016. *Report and Recommendation of the President to the Board of Directors: Proposed Loan Energy Efficiency Services Limited Demand Side Energy Efficiency Sector Project*. Manila.

the Global Environment Facility to promote emerging technologies such as trigeneration, efficient motors and air conditioners, smart meters, and grids. It also allowed EESL to try new business models to promote these devices, and establish an energy efficiency revolving fund.⁴⁶

In 2019, ADB approved another \$250 million loan, guaranteed by the government, to enable EESL to focus on services that traditional DSM companies do not implement. The activities include supporting distributed solar PV systems, electric vehicles, and electric vehicle charging stations. The loan is part of a \$592 million project, of which the CTF provides \$48 million, and EESL contributes \$296 million. ADB extended \$2 million in technical assistance to support EESL in implementing the project, including developing a gender action plan and piloting new technologies.⁴⁷

EESL's Projects

Unnat Jyoti by Affordable LEDs for All

Unnat Jyoti by Affordable LEDs for All (UJALA) was launched in 2015 to overcome the high-cost barrier of replacing incandescent lamps with LED lights for domestic users. It promotes efficient lighting by enhancing households' awareness of energy cost-saving opportunities and offering LEDs at a price significantly lower than market rates. EESL collaborated with electricity distribution utilities to offer LEDs under easy payment terms, such as monthly or bimonthly installments, charged through electricity bills, or through up-front payments.

Aggregating the demand for LEDs resulted in significant economies of scale that have allowed EESL to purchase LED bulbs at one-eighth of their retail market price and offer them to households at about 40% of the market price.⁴⁸ The initiative has already distributed 361 million LEDs, saving around 47 billion kWh per year and avoiding about 38 million tons of carbon dioxide annually. The electricity cost savings for end users is estimated at ₹190 billion per year.⁴⁹

⁴⁶ ADB. 2018. [ADB, EESL Sign \\$13 Million Grant to Promote End-Use Energy Efficiency](#). News release, 11 November.

⁴⁷ ADB. 2019. [ADB Provides \\$250 Million to Expand Energy Efficiency Investments in India](#). News release, 27 November.

⁴⁸ Government of India. [UJALA 2019](#). EESL. 2020. Presentation on EESL's Initiatives. 28 January.

⁴⁹ Ministry of Power. 2020. [National Ujala Dashboard](#) (accessed 15 September 2020).

The UJALA's benefits go beyond energy savings and environmental impacts. The scheme has triggered large-scale investment in LED bulbs' manufacturing and created employment. The success of the UJALA scheme has been replicated for other equipment, including fans and tube lights. EESL has distributed more than 2.34 million energy-efficient fans and 72 million LED tube lights, resulting in estimated energy savings of 530 million kWh per year. As of 2020, an estimated 9,730 MW of peak demand has been avoided from adopting the energy-efficient LEDs, tubelights, and fans.⁵⁰

Street Lighting National Programme

The **Street Lighting National Programme** complements the UJALA by replacing conventional street lights with smart LED lights. Under the program, EESL covers the up-front cost of the light replacement, and municipalities pay a single monthly charge that covers EESL's capital, maintenance, and financing costs. The agreement is typically over a 7-year period. Under this model, EESL guarantees the minimum energy savings (typically 50%) and provides maintenance services and free replacements for failed LEDs.

As of 2020, EESL had installed more than 10.4 million LED street lights, resulting in an estimated 7 billion kWh of energy savings annually with an avoided peak demand of 1,172 MW. Some 1,508 urban local bodies are participating in the program, and by the end of 2020 work had been completed for 966 of them.⁵¹ EESL is expanding the SNLP to rural areas.

Energy-Efficient Pump Programme

EESL is implementing agriculture DSM through the **Energy-Efficient Pump Programme**. It distributes BEE five-star energy-efficient agricultural pumps that are expected to generate a minimum of 30% reduction in electricity consumption. The pumps are equipped with smart control panels that can be remotely operated.⁵² The business model is similar to the lighting programs where EESL advances the cost of equipment and will be paid back over time based on guaranteed deemed savings. Activities are focused on agricultural states, including Andhra Pradesh, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, and Uttar Pradesh. Around 73,600 pumps have already been deployed (footnote 52).

⁵⁰ Ministry of Power. 2020. [National Tubelight Dashboard](#) (accessed 15 September 2020).

⁵¹ EESL. 2020. *Presentation on EESL's Initiatives*. 28 January.

⁵² EESL. *Agriculture Demand-Side Management*.

Smart Metering

A **smart metering** program aims to replace approximately 6 million conventional electromechanical and electronic electricity meters with electronic smart meters that allow bi-directional communications. Smart meters provide a direct means through which electricity distributors can address the pervasive issue of nontechnical losses within their networks. EESL's business model for its proposed smart meter program relies on electricity distributors leasing smart meters from EESL and paying EESL an annuity over a fixed 8-year period. The fee covers the capital, financing, and operating costs of the meters and related infrastructure. The capital cost includes the meters and meter boxes, software customization, installation and integration, consumer indexing, and relevant training to distribution companies. Operating costs cover software, deployed meters, recurring fees of the GPRS (General Packet Radio Services) cellular network, cloud hosting charges, and project management charges.

Distributed Solar Photovoltaic

EESL's **distributed solar PV** program aims to install 160 MW of solar PV panels and associated equipment in 33/11 kilovolt substations in rural areas. It will help distribution companies reduce technical losses, improve power quality in the low-voltage electricity distribution network, and reduce the need for new centralized electricity generation plants. Under this innovative business model, EESL owns the solar PV "generator" and sells electricity to the distribution company at a fixed unit rate and for a fixed term, thereby lowering distribution companies' overall generation costs.

Electric Vehicles

EESL also aims to develop India's **electric vehicle** (EV) sector. Compared to internal combustion engine-powered vehicles, the major benefit of EVs is a reduction in emissions: greenhouse gasses, particulate matter, and other combustion-related pollutants. The goals of this initiative are to (i) encourage the development of a domestic EV manufacturing industry, charging infrastructure companies, and fleet operators; (ii) achieve necessary efficiencies of scale to drive down costs of EVs; and (iii) grow associated technical competencies to support the long-term growth of the EV industry.

Under its business model, EESL will purchase 10,000 EVs and 2,125 EV charging stations. It will lease the EVs to government agencies using a mix of dry lease (i.e., EV and/or charging station leased only, with some servicing included) and wet lease (i.e., including driver, all repairs and

maintenance, fleet management) arrangements. EESL will engage service providers to provide drivers, repair and maintenance services, and fleet management, taking advantage of economies of scale for wet-lease customers.

EESL also implements a number of other energy conservation and clean energy programs not covered by ADB's loan. These include an energy efficiency program targeting lighting and air-conditioning systems initially in public sector buildings, solar street lighting in areas not grid-connected, and a solar study lamp program. For most of these programs, EESL employs a similar business model, where EESL advances the up-front cost of equipment, guarantees the performance through service level agreements, and matches repayments to deemed energy savings.

Lessons Learned by EESL

Strong policies, such as the Perform, Achieve, and Trade Scheme, enhance the adoption of energy efficiency projects. Potential energy savings are often weak drivers for companies to adopt energy-saving measures, especially in regions where electricity is subsidized. Companies would most likely invest in operations or business expansion rather than in energy reduction measures. A firm policy forces companies to understand their energy consumption and shift to more efficient technologies and practices.

There are significant opportunities for energy savings in the residential sector. Simple energy efficiency measures, such as shifting to more efficient LEDs and appliances, generate significant energy savings and shaving of peak demand when delivered at scale.

With adequate financing, a pay-as-you-save business model can overcome barriers associated with energy efficiency projects. Advancing up-front investments and recouping the costs through guaranteed energy savings gives end users a more convenient mechanism to implement energy efficiency projects. The DSM company takes on the performance risks by building its technical capability, providing operation and maintenance services, and ensuring the equipment's quality. These strategies increase the likelihood that energy-saving projections are met. It should be noted, however, that EESL has typically used deemed savings contracts, meaning that if targeted savings were not achieved, customers had no contractual recourse to EESL.

EESL achieved economies of scale by stimulating demand for energy-efficient technologies and by aggregating the procurement of energy-efficient technologies. The low costs allowed EESL to offer equipment at

more affordable rates to end users and can also contribute to the growth of nascent energy-efficient technology supply businesses.

EESL provides a good example of how a well-funded, public sector DSM company can deploy energy-efficient technologies at scale and open markets for energy efficiency projects by identifying, designing, financing, and implementing projects for end users. The trust gained through successful implementation of the public sector model may open opportunities for private DSM companies (although to date no significant growth in private DSM companies is evident).

Implementation of energy efficiency projects across all sectors enhances awareness of energy efficiency and energy conservation. When end users benefit from lower electricity bills, it enhances their desire to implement more energy-efficient strategies to generate more savings.

Conclusion

The Government of India has undertaken a two-pronged, sustainable approach to cater to the rapidly increasing energy demand of its expanding economy. On the generation side, the government promotes a greater use of renewable energy in the energy mix. On the demand side, it leads efforts to manage energy consumption without compromising economic development.

The government initiated a solar park scheme to accelerate the implementation of solar power generation projects by providing an infrastructure-ready platform. Public investments in solar parks and transmission grids reduce individual private sector solar project development costs, timelines, and risks, leading to a reduction in tariffs to customers. The model overcomes interconnection risks by planning and developing transmission infrastructure in advance. An enhanced transmission grid enables the evacuation of large volumes of renewable energy generation and facilitates interstate connections and market development. Similarly, EESL facilitated the implementation of the government's numerous energy efficiency policies and programs. Its business model overcomes both technical and financial barriers to implement energy efficiency activities at scale. EESL advanced financing for energy efficiency projects and addresses concerns about performance risks by linking fees to guaranteed energy savings. Both the solar park scheme and the EESL program use limited public investments to reduce risk and catalyze larger private investments in renewable generation and energy efficiency.

Investments can be fully recovered in both schemes. The solar park scheme charges land use and services fees to project developers, while EESL is paid based on deemed energy savings. These schemes do not need subsidies to succeed and over time, the private sector has been visible through interventions both as SPPDs and in electricity transmission.

The benefits of solar parks and EESL go beyond climate impacts and energy security. Since both facilitate large-scale deployment of clean technologies—solar PV components and energy-efficient devices—they contribute to the growth of the industries that manufacture these technologies. Developing local manufacturing for these components creates jobs.

Communities can be engaged to participate in sustainable development. In the case of the solar park, a community development action plan defines needs-based activities that support communities by creating jobs, introducing livelihood options, building skills and knowledge, and opening opportunities for women entrepreneurs. EESL has successfully tapped the vast and disaggregated residential sector to adopt more efficient lighting through a business model with distribution utilities. Cheaper electricity bills increase users' awareness of energy efficiency and conservation, and encourage users to consider other efficiency initiatives.

References

Asian Development Bank (ADB). 2016. *Report and Recommendation of the President to the Board of Directors: Proposed Loan Energy Efficiency Services Limited Demand Side Energy Efficiency Sector Project*. Manila.

———. 2018a. [ADB, EESL Sign \\$13 Million Grant to Promote End-Use Energy Efficiency](#). News release. 11 November.

———. 2018b. *Rajasthan Renewable Energy Transmission Investment Program Fact Sheet*. Manila.

———. 2019a. [ADB Provides \\$250 Million to Expand Energy Efficiency Investments in India](#). News release. 27 November.

———. 2019b. [ADB to Help Build 100-MW Solar Park in Cambodia](#). News release. 24 May.

———. 2019c. *Asian Development Outlook: Fostering Growth and Inclusion in Asia's Cities*. Manila.

———. 2019d. *Completion Report: India Gujarat Solar Power Transmission Project*. Manila.

———. 2019e. India: Demand-Side Energy Efficiency Sector Project. *Project Data Sheet*. Manila.

———. 2019f. India: Green Energy Corridor and Grid Strengthening Project. *Project Data Sheet*. Manila.

———. 2021. [India: Solar Rooftop Investment – Tranche 1](#).

Bureau of Energy Efficiency. [Venture Capital Fund for Energy Efficiency](#).

BloombergNEF. 2020. [India's Stunning Solar Bid Rides in 12 Boosters](#). 26 November.

Central Electricity Authority. 2020. *All India Installed Capacity (in MW) of Power Stations as of 31 December 2020*. New Delhi.

Chawla, K., M. Aggarwal, and A. Dutt. 2020. Analyzing the Falling Solar and Wind Tariffs: Evidence from India. *ADB Institute Working Paper No. 1078*. Tokyo: ADBI.

Climate Investment Funds. 2021. *Supporting Just Transitions in India*.

Department of Expenditure. 2018. *National Clean Energy & Environment Fund*.

DNA. 2018. *Solar Power Capacity at Charanka Solar Park to Touch 790 MW*. 21 April.

Dutta, A. 2017. Work Begins on India's First Green Energy Corridor Project. *The Economic Times*. 22 May. EESL. 2020. *Presentation on EESL's Initiatives*. 28 January.

Energy Department, Government of Rajasthan. *Agriculture Demand Side Management*.

———. 2014. *Rajasthan Solar Energy Policy, 2014*. Jaipur.

———. 2016. *Private Sector Partnership for Inclusive Solar Park Development in Rajasthan*. 12 April.

———. 2018. *Rajasthan—The Solar Destination & Development of Bhadla Solar Park*.

———. 2019. *Solar Energy Policy, 2019*. Jaipur.

ESMAP. 2013. *Paving the Way for a Transformational Future*. Washington, DC.

George, A. 2020. *Why SECI Auction Paints Optimistic Picture for Indian Solar Sector*. 25 November.

Government of India. *UJALA 2019*.

———. 2005. *Scheme for Support to Public Private Partnerships in Infrastructure*.

India RE Navigator. *Auction Results*.

Institute for Energy Economics and Financial Analysis. 2020. *India's Utility-Scale Solar Park a Global Success*.

International Energy Agency. *Data and Statistics: Electricity Generation by Sources, India 1990–2019*.

———. *Energy Savings due to Energy Efficiency, India, 2000–2017*. Paris: IEA.

———. 2012. *Rajasthan Solar Policy*. 18 July.

———. 2019a. *Perform, Achieve, Trade (PAT) Scheme*. 5 June.

———. 2019b. *Venture Capital Fund for Energy Efficiency (VCFEE)*. 26 September.

———. 2020. *India 2020 Energy Policy Review*. Paris.

Kumar, S., N. Kumar, K. Cherail, A. Sett, N. Yadav, and A. Goenka. 2017. *Transforming the Energy Services Sector in India: Towards a Billion Dollar ESCO Market*. New Delhi: Shakti Sustainable Energy Foundation and Alliance for an Energy-Efficient Economy.

Makumbe, P., D. Weyl, A. Eil, and J. Li. *LED Public Lighting: Super-ESCO Delivery Model Case Study*. ESMAP.

Ministry of New and Renewable Energy (MNRE).

———. *Development of Solar Parks and Ultra Mega Solar Power Projects*.

———. 2014. *Implementation of a Scheme for Development of Solar Parks and Ultra Mega Solar Projects in the Country Commencing from 2014–2015 and Onwards*. New Delhi.

———. 2019a. *Implementation of Central Public Sector Undertaking Scheme Phase-II for Setting Up to 12000 MW Grid-Connected Solar Photovoltaic Power Projects by the Government Producers with Viability Gap Funding Support for Self-Use or Use of Government*. New Delhi.

———. 2019b. *Implementation of a Subset of Existing 5000 MW Viability Gap Funding Scheme for Setting Up of 1000 MW Grid-Connected Solar PV Power Projects in North Eastern States including Sikkim under Jawaharlal Nehru National Solar Mission*. New Delhi.

———. 2019c. *Launch of Phase-II of Grid Connected Rooftop Solar Programme for Achieving Cumulative Capacity of 40,000 MW from Rooftop Solar Projects by the year 2022*. New Delhi.

Ministry of Power. 2020a. *The Energy Efficiency Initiatives by BEE Leads to Savings Worth Rs.89,122 Cr. In 2018–19*. News release. 6 May.

———. 2020b. *National Tubelight Dashboard*.

———. 2020c. *National Ujala Dashboard*.

———. *Energy Efficiency*.

Mishra, T. 2020. *Renewable Purchase Obligation Compliance Remains Low in most States*. Hindu Business Line. 7 July.

Noronho, G. 2020. Finance Ministry Notifies Updated Viability Gap Funding Scheme. *The Economic Times*. 10 December.

Press Information Bureau. 2020. *NITI Aayog, MNRE and Invest India Organized the Global Symposium ‘India PV Edge 2020.’* News release. 6 October.

REVE. 2020. *India Announces 4 Gigawatts of Solar, Wind Energy*. 22 March.

Sarangi, G. K. 2018. Green Energy Finance in India: Challenges and Solutions. *ADB Institute Working Paper*. Tokyo: ADBI.

Sarkar, A. and S. Sundararajan. 2020. *Transforming India’s Energy Efficiency Market by Unlocking the Potential of Private ESCOs*. 2 December.

SECI. 2020. *Statewise Solar Parks*.

Sheik, A., D. Joshi, M. Joshi, and R. Ravi. 2016. Apprising Energy Efficiency Projects and Relevance to ESCOs. *Advances in Economics and Business*. 4 (8) 414–423.

United States Agency for International Development (USAID). 2017. Guidelines for Finance Energy Efficiency Projects in India. *USAID PACE-D Technical Assistance Report*. New Delhi.

World Bank. *World Bank Indicators*.

———. 2015. *Government of India and World Bank Sign Agreement for \$43 million Partial Risk Sharing Facility for Energy Efficiency Project*. News release. 31 March.

Yenneti, K. 2016. Industry Perceptions on Feed in Tariff (FIT) based Solar Power Policies—A Case of Gujarat, India. *Renewable and Sustainable Energy Reviews*. 57 (2016) 988–998.

Hongwei Zhang, Anthony Jude, Keshan Samarasinghe, and Siddique Zobair

Introduction

Bangladesh is one of the fastest-growing economies in Asia and the Pacific. The country has made impressive economic and social gains despite growing population pressure and increasing disaster impacts. The Government of Bangladesh committed to ensure access to affordable and reliable electricity supply for all its citizens by 2021. In 2015, Bangladesh attained the status of a lower middle-income economy and articulated its goal of becoming an upper middle-income country by 2031, and a high-income country by 2041.¹ One of the key challenges in achieving that vision is to have a reliable power system, since electricity plays a vital role in sustainable economic growth, poverty eradication, infrastructure development, and strengthening energy security.²

Renewable energy, in particular, is important for Bangladesh's energy security, sustainable development, and response to climate change. The country is heavily dependent on imported fossil fuels, with its domestic natural gas reserves depleting due to a lack of success in finding new gas fields. The government has set a goal for renewable energy development as part of its fuel diversification and climate change program. *Solar Energy Road Map 2041*, drafted by the Sustainable and Renewable Energy Development Authority (SREDA) is pending approval of the Power Division, Ministry of Power, Energy and Mineral Resources (MPEMR). Once approved, it will be integrated into Bangladesh's updated *Power System Master Plan*. The government has also facilitated both public and

¹ As defined by the World Bank, lower middle-income economies are those with a gross national income (GNI) per capita between \$1,036 and \$4,045; upper middle-income economies are those with a GNI per capita between \$4,046 and \$12,535; and high-income economies are those with a GNI per capita of \$12,536 and above.

² Z. H. Kiri Hanks, M. Yasmin, and M. Biswas. 2018. *IFI Energy Investments in Bangladesh: A Way Forward to SDG 7*. Dhaka.

private sector investments in renewable energy and energy efficiency development projects.

Bangladesh ranks seventh among countries most impacted by climate change over the last 2 decades, according to the Climate Risk Index.³ The government is committed to reducing greenhouse gas emissions by 5% from the business-as-usual case by 2030 under the Paris Agreement. In this context, SREDA was established in 2014 with a mandate to promote, develop, and coordinate renewable energy activities to ensure energy security and sustainability and has conducted several assessments on solar, wind, and biomass energy as well as municipal waste since then. Progress has been made in coordination among stakeholders in addressing barriers to development of renewable energy. The government together with SREDA and private sector have initiated several solar and wind energy development projects to strengthen the renewable energy sector with the support of multilateral development banks such as the Asian Development Bank (ADB) and the World Bank.

While *Renewable Energy Policy 2008* and *Power System Master Plan 2016* have been instrumental in supporting renewable energy development, it is important to review the development of the renewable energy sector over the past decade, given improvements in technologies, lower costs, and financial models. As the renewable energy market has become increasingly competitive, many technologies have emerged, such as floating solar photovoltaic (PV) energy, rooftop solar systems, smart grids, solar PV pumps, wind, and battery energy storage systems. This chapter examines how renewable energy, particularly solar PV, has performed in Bangladesh and suggests new strategies to achieve a low-carbon energy trajectory through solar power financing.

Overview of Energy Development

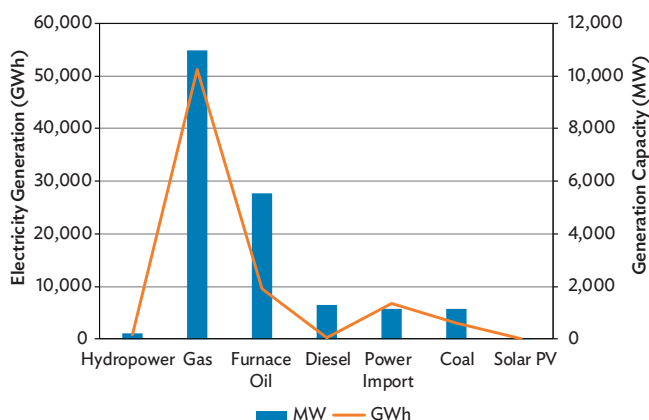
Bangladesh's installed electricity generation capacity improved from 5,500 megawatts (MW) in 2009 to 25,227 MW including captive power generation and renewable energy as of June 2021.⁴ About 5,273 MW of new generating capacities were added from July 2018 to June 2020. In the past, unreliable energy supply was a major constraint to economic growth, given frequent load shedding and underutilization of industrial capacity. The deficit between electricity supply and demand was approximately

³ D. Eckstein, V. Künzel, and L. Schäfer. 2021. *Global Climate Risk Index 2021*. Berlin.

⁴ Government of the People's Republic of Bangladesh, Power Division. 2021. *National Database of Power Generation*. Dhaka.

1,500 to 2,000 MW from 2009 to 2012.⁵ Recognizing the importance to the economy of having reliable power supply, the government prioritized support for power generation and managed to meet electricity demand by 2018.⁶ This catalyzed inclusive economic growth by creating jobs in small and medium-sized enterprises, the services sector, and for the self-employed.⁷ Such efforts led to more generation capacities being added to the system in the last few years. However, most new power plants are gas and furnace oil-fired plants. The coronavirus disease pandemic disrupted construction of power plants, curtailed industrial production, and drove down electricity demand. Figure 1 shows the installed generation capacity and net electricity generation (on-grid) as of June 2020, when installed on-grid solar capacity was only 38.4 MW and total electricity generation from renewable energy is about 62 gigawatt-hours (GWh), excluding major hydropower. SREDA's recent data shows that Bangladesh had 142 MW of on-grid solar PV capacity as of March 2021.⁸

Figure 1: On-Grid Power Plant Capacity and Electricity Generation, June 2020



GWh = gigawatt-hours, MW = megawatt, PV = photovoltaic.

Source: Bangladesh Power Development Board (BPDB). 2020. *Annual Report 2019–2020*. Dhaka.

⁵ ADB. 2016. *Country Partnership Strategy, Bangladesh 2016–2020*. Manila.

⁶ Bangladesh Power Development Board. 2020. *Annual Report 2019–2020*. Dhaka.

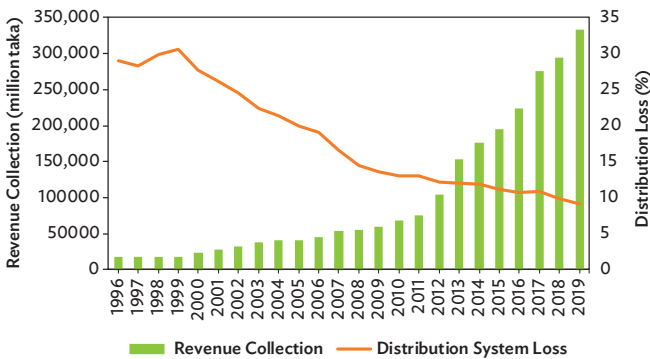
⁷ Government of the People's Republic of Bangladesh, Sustainable and Renewable Energy Development Authority (SREDA). 2015. *Scaling Up Renewable Energy in Low Income Countries: Investment Plan for Bangladesh*. Dhaka.

⁸ Sustainable and Renewable Energy Development Authority. 2021. *National Database of Renewable Energy*. Dhaka.

Bangladesh’s power sector is highly dependent on gas-fired power plants since natural gas is an indigenous resource. While domestic gas resources have depleted, consumption has been growing over recent decades. To meet increasing demand, the government began importing liquefied natural gas in 2018. As Bangladesh’s dependence on imported natural gas increases, it is important to conduct an analysis on the risks of supply disruptions, supply chain challenges, system flexibility, and the resilience of the electricity sector.

Bangladesh’s electricity access grew significantly from 47% of its population in 2008 to 98% by the end of 2020, an increase that drove up electricity sales and power utilities’ revenue. The government aims to achieve 100% electrification by end of 2021. Moreover, distribution system losses were reduced (Figure 2). Despite this success, per capita electricity consumption in 2020 was just 378 kilowatt-hours (kWh) from 375 kWh during the previous year, far below that of other countries in South Asia.⁹

Figure 2: Sustainability of Electricity Distribution, 1996–2019

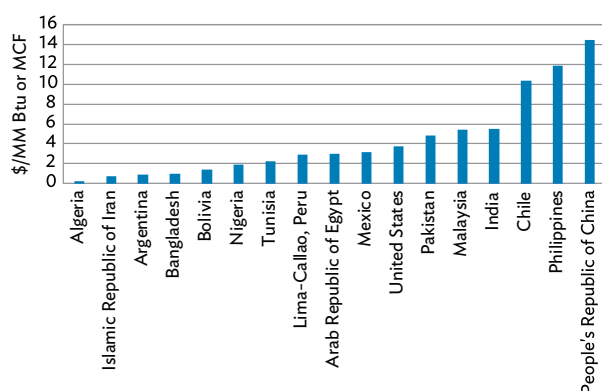


Source: BPDB. 2020. *Annual Report 2019–2020*. Dhaka.

Electricity tariffs in Bangladesh remain low, with domestic gas prices way below market price. In Bangladesh, 1,000 cubic feet (mcf) of natural gas cost only \$1.03 for consumers in 2015, while India charged \$5.50 per mcf and the People’s Republic of China charged \$14.50 per mcf (Figure 3).¹⁰ Power plants and fertilizer plants, which consume nearly half of the country’s total gas supply, were unaffected by a 2015 tariff restructuring. In

⁹ Bangladesh Power Development Board. 2020. *Annual Report 2019–2020*. Dhaka.

¹⁰ World Bank Group. 2016. *Fossil Fuel Subsidy and Pricing Policies: Recent Developing Country Experience*. Washington, DC.

Figure 3: Natural Gas Prices in Selected Cities/Countries, March 2015

Btu = British thermal unit, MCF = thousand cubic feet, MM = millions.

Source: The World Bank Group. 2016. *Fossil Fuel Subsidy and Pricing Policies: Recent Developing Country Experience*. Washington, DC.

July 2019, domestic natural gas prices increased by 32.8%, the largest hike within a year in the country's history. Similarly, tariffs for gas-fired power plants increased by 40.8% to \$1.57 per mcf.

Bangladesh has addressed its power shortages in recent years and, as of late 2020, its supply was in surplus. Peak load was around 13,000 MW in summer and 8,860 MW during winter. However, the quality of power supply remains an issue for most of the population¹¹ due to insufficient transmission capacity and the poor quality of the distribution network.¹² Power disruptions contribute to an estimated annual loss of production exceeding 0.5% of the country's gross domestic product.¹³ Improving transmission and distribution networks requires long-term interventions to strengthen energy security through sector reforms and boosting investment.¹⁴ In recent years, ADB together with the government has initiated several projects focusing on energy security and promoting green growth by introducing new financing instruments to support cleaner technologies in the energy sector.¹⁵

¹¹ Asian Development Bank Institute. 2018. *Green Finance in Bangladesh: Policies, Institutions, and Challenges*. Tokyo.

¹² M. A. Haque. 2020. *Bangladesh Power Sector*. Dhaka.

¹³ Private Infrastructure Development Group. 2019. *Study of Bangladesh Bond Market*. London.

¹⁴ Infrastructure Development Company Limited (IDCOL). 2019. *Reimagining Clean Energy Financing*. Dhaka.

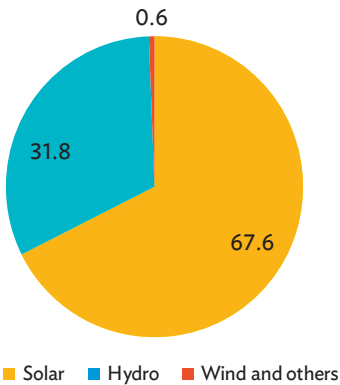
¹⁵ Bangladesh Central Bank. 2016. *Are We Greening the Economy? Recent Trends of Green Financing in Bangladesh*. Dhaka.

Progress of Renewable Energy Development and the Role of Solar Energy

Performance of Renewable Energy Development

The government has made a concerted effort over the last decade to promote renewable energy by enacting policies for off-grid energy solutions, including solar home systems (SHS), as well as on-grid energy generation, such as ground-mounted solar PV systems, rooftop solar PV systems, wind energy, and biomass energy. Bangladesh has more than 6,000 GWh of annual renewable energy generation potential.¹⁶ Most existing renewable energy investments have been in off-grid technologies such as SHS (5.6 million have been installed), solar mini- and micro-grids, and solar PV irrigation pumps. Figure 4 shows installed renewable energy generation capacity of about 730.53 MW, representing just 3.1% of Bangladesh’s total electricity generation capacity as of June 2020, including a 230 MW hydropower plant in Kaptai.

Figure 4: Share of Different Technologies in Renewable Energy Generation in 2020 (%)

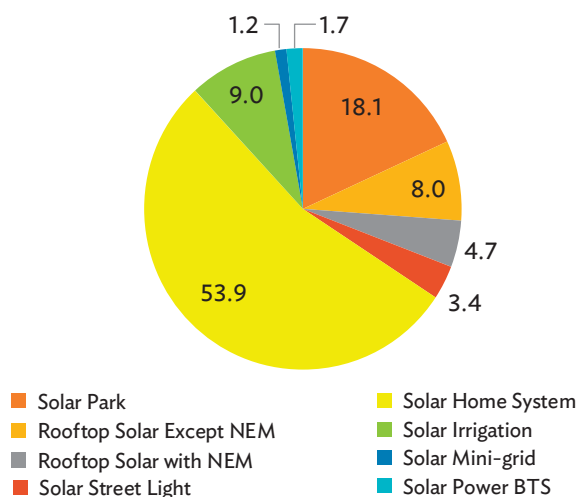


Source: SREDA. 2021. *National Database of Renewable Energy*, Dhaka.

¹⁶ World Bank Group. 2018. *Bangladesh Scaling-Up Renewable Energy Project*. Dhaka.

The shares of different solar energy generation projects are presented in Figure 5. In 2013, the government declared that it aimed to add 500 MW of solar generation capacity annually, including solar parks and solar PV irrigation pumps (footnote 11). This target has been integrated into the country's long-term generation plan.

Figure 5: Share of Different Solar Energy Generation Projects in 2020 (%)



BTS = battery storage, NEM = net electricity meter.

Source: SREDA. 2021. *National Database of Renewable Energy*, Dhaka.

Bangladesh could harness a large volume of solar energy by replacing traditional diesel pumps with efficient solar PV pump systems in irrigation. The government's draft *Solar Irrigation Pump Road Map* estimates that a 2,000 MW peak of solar PV could be added to the power system through solar irrigation pumps by 2030, with estimated annual export electricity capacity of 1,300 GWh.¹⁷ In addition, the country has water bodies with a surface area totaling about 3,000 square kilometers (km²), where a technical potential of 1,600 MW floating solar power plants could be deployed by using just 2% of the water surface area according to an ADB ongoing study. While the capital cost of floating solar PV systems is

¹⁷ ADB. 2020. *Road Map to Scale-up Solar Irrigation in Bangladesh (2021–2030)*. Draft. October. Dhaka.

1.2–1.3 times higher than using ground-mounted solar PV, floating systems do not take up scarce land resources. The government had set a target of adding 3,100 MW of renewable energy to the country's overall energy mix by 2021 (footnote 7), but could not fully achieve it due to several barriers.

Barriers to Renewable Energy Development

Land scarcity has been a major hindrance to developing utility-scale solar PV power plants in Bangladesh, as existing policy prohibits the use of agricultural land for large solar power plants. A lack of feasibility studies and technical data on projects (footnote 11), as well as an inadequate comprehensive legal and regulatory framework, are also contributing to the slow growth of renewable energy. In particular, the following are barriers to growth: (i) no guaranteed payments for transmission congestion; (ii) no separate renewable energy independent power producer (IPP) unit to help with processing applications; (iii) a lack of proper land ownership documentation, which prevents the takeover of suitable land for power generation and evacuation facilities; (iv) inadequate coordination among respective agencies to actively develop and implement regulatory and legal frameworks; and (v) an absence of a national policy oversight body to support SREDA in achieving national renewable energy targets.

Policies and Regulation for Solar Power Development

National Energy Policy

The *National Energy Policy* was introduced in 1996 and updated in 2005. The policy stressed the need for developing indigenous energy sources, sustainable utility operations, and environmentally friendly energy development programs, as well as promoting public and private sector participation in the development and management of the energy sector and ensuring energy security.

Private Sector Power Generation Policy

The *Private Sector Power Generation Policy* was introduced in 1996 to attract private sector investments in the power sector to meet growing energy demand. The revised 2004 policy set clearer guidelines on procurement, implementation, and monitoring of private sector

infrastructure projects. While the policy granted exemptions for corporate tax, customs duties, and value-added tax (VAT) for capital machine importation and import permits for spare parts for fossil fuel projects, only limited exemptions were offered for renewable energy projects.

Remote Area Power Supply System Guideline

In 2007, the *Remote Area Power Supply System Guideline* was launched to promote private sector investments in both on-grid and off-grid power generation and distribution systems in rural areas. This policy was supposed to attract renewable energy investments in solar PV projects and mini-grid projects, but few projects have been developed under it (footnote 7).

Renewable Energy Policy

In 2008, the government introduced its *Renewable Energy Policy*, which set a new direction in addressing fuel price volatility due to the demand–supply gap, reducing carbon emissions, and strengthening energy security. The policy set a target for renewable energy to comprise a 5% share of total energy generation by 2015, and 10% by 2021, and aimed to facilitate both public and private sector investments in renewable energy projects in rural and urban areas. In addition, the SREDA Act, passed in 2012, brought SREDA into operation in May 2014. The act catalyzed renewable energy sector development, including solar PV power projects, by encouraging private sector investments through innovative financing and business models. The *Renewable Energy Policy* emphasized having a mutual agreement signed between public or private sector investors, and a utility company or consumer, for feeding electricity to the grid from a renewable energy plant with a generation capacity of less than 5 MW. The investor may use the existing electricity transmission and distribution system through an agreement with the utility company and must pay a wheeling charge, decided by the Bangladesh Energy Regulatory Commission (BERC) in consultation with the MPEMR, to the Bangladesh Power Development Board (BPDB).

Financial Incentives

Key fiscal incentives were introduced to promote private sector investments in conventional power plants under the *Private Sector Power Generation Policy Act of 1996*. They included income tax exemptions for a period of 15 years, and exemption from customs duties, VAT, and import permits for 10% of the total value of a power plant for a period of 12 years.

Incentives granted to foreign investors included a tax exemption on royalties, technical know-how, technical assistance, interest on foreign loans, and capital gains from a transfer of shares by the investing party.¹⁸

Under the Renewable Energy Policy 2008, additional financial incentives were granted to renewable energy investors such as a 15% VAT charge exemption for all renewable energy equipment and related raw materials of renewable energy projects, and corporate income tax exemptions for a period of 5 years.¹⁹ The tax exemption period is however expected to be extended periodically after conducting financial impact assessments. The policy recommended that the government assist private investors in locating and acquiring land for renewable energy projects. Moreover, an incentivized tariff that is 10% higher than the highest purchase price of electricity by BPDB may be granted to renewable energy projects. The government could further assist investors by streamlining the application processes for projects, and guiding them with tariff determination, proposal submission, and processing.

The Government's Vision for Solar Power Development

Solar Rooftops

In 2009, the government embarked on an initiative to install rooftop solar on buildings. Under the initiative, the following has been installed: a 21.6 kilowatt-peak (kWp) rooftop solar system at the Prime Minister's Office, a 32.75 kWp system at the Bangladesh Water Development Board, a 37.5 kWp system at MPEMR, and a 50 kWp system at the Secretariat Office (footnote 7). About 66 MW of rooftop solar PV systems were installed in the country as of June 2021, including net metering. However, some of the early rooftop solar systems on government buildings stopped operations due to poor maintenance, lack of spare parts, and poor inspection and monitoring systems. The government factored in these past experiences while adopting new measures for new rooftop projects.

Installing grid-connected rooftop solar PV systems is a common practice in the region to enable excess power to be fed to the grid. However, a large majority of rooftop solar PV systems in Bangladesh operate off-grid. In 2014, one study identified 4.92 km² of roof space available for solar PV installation in Dhaka, among which significant solar PV installation capacities on

¹⁸ Sustainable Renewable Energy Development Authority. 2020. *National Solar Energy Road Map [Draft], 2021–2041*. Dhaka.

¹⁹ Government of the People's Republic of Bangladesh, MPEMR. 2008. *Renewable Energy Policy of Bangladesh*. Dhaka.

the roofs of schools (41 MW), railway stations (30 MW), and commercial and industrial buildings (10 MW) (footnote 7). The potential could in fact be much higher, as many new buildings have been erected since then. An assessment carried out by the Bangladesh Solar and Renewable Energy Association (BSREA) in 2017 found that the garment industry in Dhaka alone has the capacity to install 450 MW of rooftop solar systems. The government introduced a guideline for a net-metering system in 2018 to harness rooftop solar potential, optimize the use of energy from rooftop solar systems, and attract commercial investments. While industrial consumers and distribution utilities participated and established some commercial cases, the residential sector has been left out of this program for the moment.

Solar Parks

SREDA published its *Guidelines for the Implementation of Solar Power Development Program* in 2013. Projects implemented under these guidelines are governed by existing laws and policies, such as the *Private Sector Power Generation Policy* and *Renewable Energy Policy*. The government is contemplating a scheme to support potential solar park investors in securing funds from the capital market where shares of solar energy projects would be issued after approval of the Bangladesh Security and Exchange Commission at project completion. Several private solar PV projects proposed by IPPs have been approved by the government. As of March 2021, a total capacity of 980.77 MW solar park projects were under construction in Bangladesh. The unit generation cost of \$0.07–\$0.16 per kWh is higher than the \$0.035 per kWh cost in India, owing to higher costs of land development and land leasing in Bangladesh. Larger solar parks through auctions could bring down the tariff. The government was able to secure its lowest tariff through competitive bidding for a 55 MW solar PV plant in Rangunia. The off-take price is \$0.0748 per kWh and the land was provided by BPDB.²⁰ Auction could be an option for Bangladesh to promote renewable energy going forward.

Solar Mini-Grids

Solar PV mini-grids have mainly been implemented in remote areas where grid extension is unlikely to happen within the next 15–20 years. The government set a maximum solar PV installation capacity of 25 MW for stand-alone mini-grids. BPDB has installed a 650 kWp solar mini-grid system in Sullah, Sunamganj. Infrastructure Development Company Limited (IDCOL) has provided loans to solar mini-grid operators blended

²⁰ P. Largue. 2021. *Metito Consortium Wins Contract for Bangladeshi Solar*. Dhaka: Power Engineering International.

with 50% grants. The government's grid extension program however has squeezed out the mini-grid market, as mini-grid operators can only start exporting electricity to the grid 5 years after a project's completion. To protect initial mini-grid investments, Power Division of MPEMR has set up a committee to develop an exit plan for existing mini-grids with a grid integration tariff, which means a unified electricity tariff would be adopted to cover both on-grid and off-grid areas. To do this, the government would buy electricity from existing solar mini-grids and distribute it to customers at the BERC-declared retail electricity tariff.

Land Policy

Bangladesh is a densely populated, land-scarce country and has a land policy that forbids the use of agricultural land for nonagricultural purpose, making acquiring suitable land for the construction of solar PV plants very challenging. Only uncultivable land, land in low-lying, flood-prone areas, or land unsuitable for habitation or commercial purposes can be used for solar energy development, all of which tend to be in remote areas. As a workaround, agro-PV systems could be installed on agricultural land, where farmers can continue planting below PV panels, and lease land to project developers during project implementation. Currently, private solar power projects with approximately 900 MW total capacity have been signed with the government. Most developers however have not been able to start their projects due to land constraints and an inability to reach financial closure.²¹ Resolving land issues is time consuming and costly for developers, and early resolution would help accelerate project implementation. A requirement of a solar energy road map was identified to fulfill the government's vision for solar power development in the country as well as to provide a total solution for land issues. As discussed in Box 1, the draft *Solar Energy Road Map 2041* has identified that the country has potential to absorb 12 GW out of 30 GW total solar PV generation capacity into the power system by using only 4% of the riverbanks and reclaimed lands, and also to generate another 12 GW by using industrial and other buildings under the 100 Economic Zones Development Plan as a solution for the land constraints.

²¹ ADB. 2018. *People's Republic of Bangladesh: Capacity Development for Renewable Energy Investment Programming and Implementation*. Manila.

Box 1: Draft Solar Energy Road Map 2041

The Sustainable and Renewable Energy Development Authority's (SREDA's) draft Solar Energy Road Map aims for Bangladesh to generate 30 gigawatts (GW) of solar power by 2041. The main objectives of the draft road map are to increase the share of renewable energy in Bangladesh's overall energy production, ensure energy security and sustainability, reduce greenhouse gas emissions, attract private sector investments, and achieve national renewable energy targets. The road map proposes three possible scenarios that might be in place by 2041: (i) a business-as-usual scenario producing 6 GW, (ii) a medium-deployment scenario producing 20 GW, and (iii) a high-deployment scenario producing 30 GW. The high-deployment scenario is recommended for Bangladesh because the global weighted-average installed cost of utility scale, grid-tied solar photovoltaic (PV) systems was around \$90 per kilowatts in 2020, more than 80% reduction since 2010.^a Under this scenario, energy generation from solar PV would be around 46,000 gigawatt-hours (GWh) per year, and solar PV would meet nearly 20% of total electricity demand by 2041.

The government's proactive support in procuring land is important in achieving the high-deployment scenario. The Bangladesh Delta Plan 2100 identified more than 3,800 square kilometers of riverbanks and reclaimed land; around 40% of the targeted 30 GW capacity could be reached if only 4% of the reclaimed land was allocated to solar power projects, coupled with necessary transmission infrastructure development. This would bring down the levelized cost of electricity to less than \$0.05 per kWh through competitive bidding, as seen in India and Southeast Asian countries. As Bangladesh plans to develop 100 economic zones by 2035, industrial and other private and public buildings could be used to install rooftop solar PV panels with up to approximately 12 GW of power generation capacity, representing 40% of the 30 GW target.

Absorbing more solar energy into the generation system is challenging as solar power is a variable energy source. The draft road map recommends formulating policies for smart grid implementation. A large-scale battery energy storage system for smoothing voltage fluctuations and enabling peak shifting may be considered to ensure economic viability. The government may also consider upgrading grid operation practices and enhancing transmission system flexibility.

^a IDCOL. 2019. Reimagining Clean Energy Financing. Dhaka.

Source: Government of the People's Republic of Bangladesh, SREDA.

Net Metering

The government launched net metering guidelines in 2018 to incentivize rooftop solar PV projects; these were updated in *Guidelines for the Grid Integration of Solar Irrigation 2020*. Net metering helps reduce losses and loads on distribution and transmission networks. As of June 2021, a total of 1,380 net-metered rooftop solar PV systems were installed throughout the country, with a cumulative capacity of around 24.7 MW. Tariffs for commercial and industrial users are higher than for residential consumers. For example, the tariff for industrial users is \$0.09–\$0.12 per kWh, depending on voltage level and time of use. This explains why many garment factories in Bangladesh have opted to install rooftop solar systems using the operating expenses model. Under this model, a private sector company installs and maintains a rooftop system, selling the power to the factory via a net-metering system. A 40 MW peak rooftop solar system is being developed in an export processing zone under this model. Thanks to the net-metering scheme, garment factories are meeting commitments to the RE100 initiative which is a global initiative of businesses committed to using 100% renewable electricity by 2050. Solar irrigation pumps meanwhile can be operated under a net-metering scheme where farmers both meet their irrigation needs and export excess generated electricity to the grid. As of early 2021, about 44 MW off-grid solar PV irrigation system is in operation. The Solar Irrigation Pump Road Map has recommended hybridization of electric pumps under net-metering scheme.

Floating Solar

ADB is assisting the government in promoting floating solar photovoltaic (FSPV) systems being installed on the country's vast water bodies on a pilot basis, which if successful, could be used widely to help meet the government's renewable energy targets. Studies have been conducted on multiple potential sites and being reviewed by the government before proceeding. FSPV is an innovative way to scale up renewable energy generation in a densely populated, land-scarce country like Bangladesh. FSPV technology enhances energy yields from solar PV due to the cooling effect of the water body surrounding it. FSPV also improves water security in hotter climates by reducing water losses through evaporation. The shade of a floating solar PV can also help reduce the growth of algae in fresh water, thereby improving water quality and reducing water treatment cost. In addition, installing FSPV helps save land for agriculture, industrial, and residential uses, while reducing deforestation.

Like utility-scale PV plants, the electrical system of FSPV has a 25-year lifespan. At the FSPV project design stage, it is important to assess floating and anchoring systems, system stability, weather conditions, and geotechnical properties of the water and/or land being used. The FSPV platform arrangement and the angle of the solar PV module depends on wind load. Inverter and transformer stations are installed on several floating platforms to minimize the cabling distance between PV modules and the inverter and transformer or can be located on land depending on the project site. Hence, developing a pilot project would provide Bangladesh a better understanding of the need to undertake bathymetric, hydrographic, geophysical, and geotechnical data gathering, as well as assessing the likely impacts of FSPVs on water bodies and aquatic life.

The three most common floating platforms used to mount solar PV are modular pontoons, modular rafts, and floating membranes. High density polyethylene is the main raw material used to manufacture floating platforms; a recycled version could be an alternative source for pontoons in Bangladesh, where the local recycling sector would invest further to recover more plastic waste.

In Bangladesh, communities live around water bodies and many people's livelihoods heavily depend on fishing. Careful attention needs to be given to minimize the surface area of water bodies covered by FSPV systems, and compensatory plans for communities resulting from any social and environmental impacts would need to be developed.

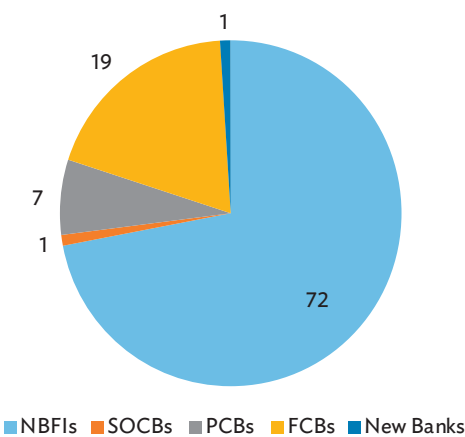
Site assessments conducted under an ADB technical assistance show the potential of developing sites into a pilot project (footnote 21). A FSPV resource mapping is being developed for the country for both public and private investors' consideration. The initial assessment shows that Bangladesh has great FSPV potential, with the highest Global Horizontal Irradiation value at about 4.98 kWh per square meter, and the lowest value at 4.27 kWh per square meter.²² Designing and implementing a pilot FSPV project would enable the government to better understand FSPV systems and help formulate clear guidelines and policies to scale up FSPV systems across the country. These guidelines and policies will also help in streamlining the approval process of obtaining environmental clearances, local communities and concerned local authorities acceptance prior to implementation.

²² Asian Development Bank. 2021. Assessment of Investment Opportunities and Challenges for Floating Solar PV in Bangladesh. ADB consultant's report. Manila.

Financial Intervention for Solar Photovoltaic Development

As of 2015, just under three-quarters of the renewable energy financing market share in Bangladesh belonged to nonbank financial institutions, followed by foreign commercial banks with 19%, private commercial banks with 7%, and then state-owned commercial banks with just 1% of the total (Figure 6).²³ A considerable number of financial institution branches and ATMs have been electrified with solar PV systems. Also, they have been involved in green banking activities to promote sustainable energy in the agriculture sector, such as offering concessional loans and giving grants to implement solar pump systems for irrigation and fish farming. The *Renewable Energy Policy* supports both existing and new renewable energy projects to access carbon funds and participate in carbon emission trading. The government set up both commercial lending and microcredit facilities, with support from the

Figure 6: Market Share of Financial Institutions
in the Renewable Energy Market, 2015
(%)



FCB = foreign commercial bank, NBFi = nonbank financial institution, PCB = private commercial bank, SOCB = state-owned commercial bank.
Source: Bangladesh Institute of Bank Management, 2015.

²³ S. M. A. Habib and P. Shah. 2016. Development of Renewable Energy Financing in Bangladesh in Response to the Central Bank’s Policy Initiatives. *Energy Production and Management*.

clean development mechanism and carbon funds and specialized financial institutions, for rural and remote communities to purchase renewable energy systems to have access to electricity.

Infrastructure Development Company Limited

Infrastructure Development Company Limited (IDCOL) is a leading diversified financial institution providing financial assistance to promote renewable energy and energy efficiency in Bangladesh. It plays a major role in renewable energy sector development by supporting the SHS program (Box 2) financed by development partners with a combination of grants, concessional loans, and equity.

Box 2: IDCOL Solar Home System Program

Bangladesh's Infrastructure Development Company Limited (IDCOL) initiated an off-grid solar home systems (SHS) program in 2003 when only 40.3% of the population had access to grid power supply, to support the government's goal of supplying electricity to all citizens by 2021. Though the initial investment cost was high owing to the high price of solar photovoltaic (PV), coupled with battery storage, operating costs were lower than most other renewable energy sources. The SHS consisted of three capacities: 20-watt peak (Wp), 50 Wp, and 85 Wp. IDCOL's SHS program installed more than 2 million SHS by the end of March 2013, with a total capacity of 150 MW in 2015.

IDCOL received support from the World Bank and the Global Environment Facility to start the program. Later, the Asian Development Bank (ADB) provided financing of \$78 million to strengthen the program by installing another 330,000 SHS. While ADB, Islamic Development Bank, and the World Bank supported this program, several other multilateral and bilateral organizations including Germany's Deutsche Gesellschaft für International Zusammenarbeit and KfW, as well as Global Partnership for Results-Based Approaches, Japan International Cooperation Agency (JICA), United States Agency for International Development, and the United Kingdom's Department for International Development provided financing to subsidize the cost of SHS for the households.^a Each household made a down payment equal to 10%–15% of the subsidized price. The rest of the financing was arranged by a loan with a 2–3-year tenor, depending on the size of the system and financial capacity of the customer, at 16% interest rate. IDCOL borrowed 70%–80% from development banks with the total cost at 6%–9% interest rate, with a 5–7-year tenor.

continued on next page

Box 2 *continued*

As of December 2020, IDCOL's program oversaw some 4.49 million off-grid SHS installed with aggregated capacity of 187.12 MW. The program facilitated electricity access to an estimated 18 million people who had previously relied on kerosene lamps to light their houses. The SHS program significantly improved the quality of life of those it impacted, as solar PV systems with batteries can be used to light up a house, operate a small TV and radio, and charge mobile phones. Moreover, around 75,000 people were directly or indirectly involved with the program to provide manpower.

^a S. Islam. 2020. *Bangladesh Net Metering Requirement May Deter Solar Pump Owners*. Dhaka: PV Magazine.

Source: World Bank Group.

Solar mini- and micro-grids, first commissioned in Bangladesh in 2010 on Sandwip Island, are the most economical way to bring electricity access to remote areas. As of December 2020, IDCOL had financed 27 mini- and micro-grids plus two nano-grids in operation in different parts of the country, with an accumulated capacity of 5.657 MW.²⁴ Power grid extensions to these micro-grid areas have led to households stopping their debt servicing, so the government is looking at buying back SHS from those households who want to give them up.

IDCOL has initiated several financial packages for households to access renewable energy, such as loan schemes to access solar mini-grids and solar irrigation pumps, and for rooftop solar systems. Though the financing terms and conditions of the schemes are similar, with each for instance having a 10-year loan tenor and a 6% interest rate with a 1–2-year grace period, the financing models are different. Solar mini-grid and solar irrigation pump financing has been a combination of grants, concessionary loans, and equity, expecting to lower financing costs and increasing adoption of these technologies by rural consumers, whereas rooftop solar financing has only been provided in the form of loans and equity (footnote 14).

²⁴ Government of the People's Republic of Bangladesh, SREDA. 2020. *National Renewable Energy Data Base*. Dhaka.

Refinance Schemes from Bangladesh Central Bank

In 2009, Bangladesh Central Bank (Bangladesh Bank) allocated approximately \$25 million to encourage banks and financial institutions to provide loans in supporting solar energy and other renewable energy projects. Under this scheme, banks and financial institutions provide loans at a maximum of 10% interest rate to borrowers for investing in solar panels and solar PV assembling plants with maximum loan tenors of 3 and 5 years, respectively. As of end of 2020, 16 banks had signed agreements with Bangladesh Bank under this refinancing scheme. Bangladesh Bank has also introduced a longer-term refinancing scheme called the Green Transformation Fund, with \$200 million being allocated to finance export-oriented manufacturers who incorporate sustainable renewable energy and energy-efficient investments in their manufacturing process that enables labeling of their products as green.

Bangladesh Bank introduced a refinancing scheme with ADB assistance to enhance the capacity of financial institutions to specifically improve electrification in rural areas with SHS. Under the scheme, \$3 million was earmarked to refinance and implement about 6,000 SHS in 2015 (footnote 23). \$7.75 million was used to build a solar PV module assembly plant that employed 100 people, while \$900,000 was used to refinance 12 solar PV irrigation pumps covering 2 km² of agricultural land (footnote 11). In January 2021, Bangladesh Bank established a \$125 million revolving fund to finance the import or manufacture of renewable energy-related equipment. The new financing scheme will help factories upgrade, acquire clean technology, and increase environmentally friendly production to achieve the Sustainable Development Goals.²⁵

Multilateral Development Bank Financing

In 2019, ADB approved a private sector loan to develop a 35 MW grid-connected solar power plant in Manikgonj District. This project is expected to generate 52.2 GWh of electricity annually to the national grid,²⁶ showcasing the economic viability of a medium-scale solar power plant in Bangladesh that could be replicated through private sector financing in other parts of the country.

²⁵ S. Islam. 2021. *Bangladesh Forms \$125 Million Fund for Sustainable Technology*. Dhaka: PV Magazine.

²⁶ ADB. 2019. *Spectra Solar Power Project*. Manila.

A solar irrigation pump program is being supported by ADB through the Bangladesh Rural Electrification Board for 2,000 solar pump systems. As of early 2021, 705 contracts have been signed for the supply and installation of irrigation pumps and implementation is underway. In Bangladesh, approximately 1.34 million diesel irrigation pumps are currently used, and 1 million tons of diesel are consumed annually. Solar pump systems have been introduced to reduce dependency on fossil fuels, improve reliable water and electricity supply with clean energy, and minimize noise, air, water, and soil pollution with diesel spills. One solar pump system with a capacity of 11 kWp is estimated to replace three to four diesel pumps. By December 2020, out of 1,969 installed solar pumps, a significant number of those were installed by the private sector with financial support from IDCOL, while the rest were financed and installed by the government through the Barendra Multi-Purpose Development Authority and Bangladesh Agriculture Development Corporation. IDCOL expects to install 50,000 of these 11 kWp pump systems by 2025. ADB has provided financial and technical assistance in developing a road map to scale-up solar PV irrigation pump installation (Box 3).²⁷

Box 3: Draft Road Map to Scale-up Solar Irrigation Pumps in Bangladesh

A feasibility study carried out under an Asian Development Bank (ADB) technical assistance assessed the benefits for Bangladesh of replacing traditional diesel pumps with solar irrigation pumps (SIP). Based on this study, the government initiated replacement of 2,000 diesel pumps with solar irrigation photovoltaic (PV) pumps, supported by ADB and Green Climate Fund, expecting to further scale-ups after establishing a country-wide road map. This road map estimated that about 425,000 diesel pumps consuming approximately \$900 million worth of fuel per year could be replaced by SIP.

SIP offers several advantages over conventional diesel pumps, including the following:

- (i) They are perfect match for irrigation since water is needed mostly when solar irradiation is strong;
- (ii) They offer reliable supply, using clean energy, and do not pollute water and soil with diesel spills;

continued on next page

²⁷ ADB. 2019. TA-9267 – Road Map to Scale-up Solar PV Pumping in Bangladesh (2021–2030). Draft. Manila.

Box 3 *continued*

- (iii) They professionalize irrigation and encourage more efficient use of groundwater;
- (iv) They use mature technology, are easy to install, operate autonomously, and have similar lifetimes to diesel pumps;
- (v) Some 60% of the renewable electricity produced could be exported to the national grid;
- (vi) They offer the possibility of storing energy in the form of water in elevated tanks or reservoirs; and
- (vii) Their use means farmers do not need to travel long distances to obtain diesel fuel.

The draft SIP road map envisages that solar PV systems will be installed on agricultural land (these are so-called agro-PV) so that farmers can cultivate crops as well as produce electricity, replacing existing diesel irrigation pumps by 2030. The program also advocates SIP replacing diesel pumps or the hybridization of electric pumps.

The draft road map indicates that 2,000 MWp of solar PV could be added through SIP by 2030, with an estimated annual export capacity to the grid of about 1,300 GWh, which will help not only in minimizing the financial burden on Bangladesh's public accounts through avoided diesel subsidies but also support poverty reduction and improve farmers' quality of life. The total cost of implementing the draft road map is estimated at \$1.59 billion, of which \$1.06 billion is expected from public financing. At least \$250 million could be made available through a national public SIP fund with the rest from loans and grants from climate financiers and multilateral development banks.

The government issued guidelines for integrating solar irrigation pumps to the grid in July 2020 to help maximize the use of energy generated from the system. Generally, the utilization factor of solar PV irrigation pumps varies from 50%–60% for irrigation, with the system remaining idle during non-irrigation periods, thus wasting generated energy. If SIPs are connected to the grid and excess electricity sold, farmers can earn additional revenue during the non-agriculture to off-farming season. Hence, grid integration makes the use of the pumps more economically viable.

Source: Asian Development Bank.

Net Metering Business Model

Net metering is potentially the next promising program to boost rooftop solar PV implementation. The government issued a net metering guideline at the end of 2018 and revised it in 2020. Net metering is one of the best business models for attracting customers and private sector investment in rooftop solar PV systems, as customers generate revenue by selling excess power to the grid. One of the best examples is the nation's first grid-tied 25 kW solar pump system in the southwestern Kushtia District, which exported 6,956 kWh to the grid within 9 months of installation and each household earned roughly \$50 monthly from it.²⁸ Similarly, customers would be incentivized to invest more in small- and medium-sized rooftop solar systems if concessional loans could be provided by banks and other financial institutions to cover the initial capital cost of the solar PV system.

Green Banking

Bangladesh Bank issued a circular under the Green Banking Policy and a comprehensive Green Banking Policy Guideline in 2009 and 2011 respectively, requesting commercial banks as well as nonbank financial institutions to promote green financing by channeling investments beneficial to environment and sustainability, creating climate change risk funds, using green strategic planning, setting up green branches, and disclosing and reporting green banking activities (footnote 11). Financial institutions were encouraged to support solar PV, biogas plants, and other renewables. In 2014, Bangladesh Bank instructed all banks and nonbanking financial institutions to earmark 5% of total credit, amounting to \$6.45 billion for direct green finance investment. Though 70% of financial institutions in the country declared their engagement in supporting green finance (footnote 23); only \$70 million, or 0.44%, was utilized for renewable energy projects during the financial year 2016.²⁹

²⁸ S. Islam. 2020. *Bangladesh Net Metering Requirement May Deter Solar Pump Owners*. Dhaka: PV Magazine.

²⁹ UK Aid Direct. 2017. *Financing Green Growth in Bangladesh: Challenges & Opportunities*. London.

Challenges Ahead and Options

Several legal and regulatory, financial, and technical barriers must be addressed to accelerate Bangladesh's renewable energy sector development, particularly solar power generation. It is important for multilateral development banks to identify the country's knowledge gaps and provide knowledge-based inputs to overcome these barriers through supporting institutional reforms and capacity development.

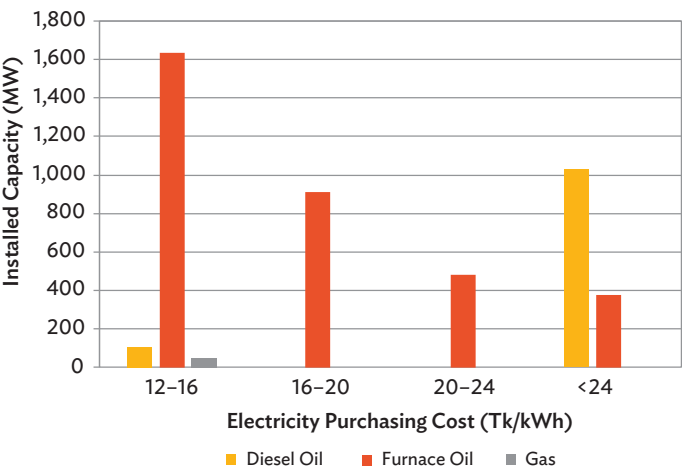
Fuel Diversification Policy

Fuel diversification can only be achieved through a proper regulatory framework. Due to a lack of a comprehensive legal and regulatory framework to create incentives for renewable energy investors, the share of renewable energy in the country's overall energy mix was lower than expected over the past decade.³⁰ Following the BERC Act 2003, several draft feed-in-tariff schemes were considered to support the renewable energy industry, but these were not approved. In the meantime, the falling cost of renewable energy equipment, particularly for solar PV, and the emergence of a renewable energy auction mechanism, resulted in many regional countries phasing out feed-in-tariffs and shifting to a reverse auction mechanism. Hence, the government may now consider reviewing and evaluating the performance of existing policies and improving its regulatory framework in order to achieve fuel diversification targets and develop a sustainable energy sector. The BPDB in fiscal year 2020 made a net loss of about \$1.15 million, due to the high cost of electricity purchased from diesel- and oil-fired power plants. BPDB purchased 6,541.4 GWh of expensive power (defined as the unit cost being greater than \$0.142 per kWh)³¹ from power plants with capacity of 4,591 MW in the fiscal year 2020 (Figure 7). Given this, the government is considering the promotion of clean energy and purchase low-cost energy. In this context, the government could introduce a capacity charge and implement a guideline on priority dispatch of power from renewable energy plants to minimize BPDB's financial losses.

³⁰ USAID. 2020. *System-Friendly Competitive Renewable Energy Procurement in Bangladesh*. Washington, DC.

³¹ Based on the January 2020 exchange rate of \$1 = Tk84.50.

Figure 7: Generation Capacity of Power Plants with Expensive Purchasing Costs, July 2019–June 2020



kWh = kilowatt-hour, MW = megawatt, Tk = taka.
Source: Annual Report 2019–2020, BPDB, Bangladesh.

Financial Institutions

The slow growth of green finance is partially attributed to the high start-up investment required and long payback period of renewable energy projects, plus a lack of clear policy and regulatory provisions to prioritize investments in the renewable energy sector. Commercial banks dominate infrastructure financing in Bangladesh. However, the commercial banking sector has no or limited knowledge and experience in financing renewable energy projects, particularly in large utility-scale solar PV power plants. They lack expertise in (i) assessing technical risks, (ii) conducting environmental and social impact analysis, (iii) developing long-term lending models, and (iv) monitoring project implementation and performance. Moreover, the capital market in Bangladesh is not big enough to cater to large infrastructure financing, with limited institutional investors engaged (footnote 16). ADB may, along with other development partners, share knowledge to commercial banks through training, workshops, and awareness campaigns, and provide support in establishing and maintaining a comprehensive database of all renewable energy projects, including the status of project implementation work, technical performance information, and future investment plans. This will help the banking sector build greater confidence in financing grid-tied renewable energy projects from their own resources.

Small and Medium-Sized Enterprises

Most renewable energy enterprises in Bangladesh are small. While these small and medium-sized enterprises (SMEs) play an important role in renewable energy development, they have limited resources and face challenges accessing low-cost finance. Some SMEs have partnered with international companies to form joint ventures to take up individual power purchase agreements. The revenue generated from most small enterprise-owned projects is often lower than the expected outcome at the feasibility stage. It is important to help strengthen the technical capacity of SMEs in carrying out detailed feasibility studies at the project's initial phase. Providing cheap financing to SMEs is vital and conducive to promoting both grid-connected rooftop solar and smart grid projects in commercial areas, and off-grid solar PV projects in rural areas where transmission and distribution network are not available.³²

Climate Change

Bangladesh is vulnerable to climate change given its geographical location. Much of the land used to develop utility-scale solar PV plants is at risk of flooding due to seasonal variations in water levels. Hence, renewable energy projects must incorporate disaster resilience in their project design. Solar PV plant designs must ensure they are resistant to Category 4 hurricanes (the second-highest hurricane classification category) and at least 1.5 meters above ground. Given the higher up-front investment required for projects constructed in disaster-resilient areas, the government may consider acquiring land and strengthening the capacity of implementing agencies to meet the relevant social and environmental safeguard requirements for proper management of the projects.

Performance Monitoring and Evaluation

Implementation of micro-grid projects are affected by grid extensions, as customers tend to draw electricity from the main grid instead of the micro-grid when available, jeopardizing the expected financial return of investors. Inadequate maintenance services and the installation of low-quality equipment are other challenges (footnote 23). Some solar PV pumping systems provided through grants have not been maintained properly due to lack of allocated budget for replacement PV panels and inverters. Properly

³² S. I. Khan. 2014. *An Innovative Financing Mechanism: Creating Access to Renewable Energy for Rural People of Bangladesh*. Dhaka.

addressing these issues will help attract private sector investment and boost community readiness for microfinancing clean energy. Financial and technical support is needed for more integrated electrification pathways such as support for SHS and grid extension.

Institutional Reforms and Capacity Development

At present, developers are required to acquire more than 40 permits and approvals from different organizations to initiate a renewable energy project in Bangladesh; this approval process could be streamlined to cut transaction costs and reduce investor frustration, thereby supporting the growth of renewable energy use. This could be done, for instance, by (i) training public sector staff to build their expertise; (ii) developing standardized transaction documents, such as power purchasing and implementation agreements, and making them available online; and (iii) allowing enough lead time for bidders to collect necessary data for bid preparation and project development. Data availability on renewable energy resources is vital for investors to carry out due diligence and make financial decisions on the projects.

Auctions to Achieve Low Tariffs

Several countries have implemented renewable energy projects by using the auction model to mobilize public and private funds, improve local capacities, and strengthen the private sector. The government might consider developing land for utility-scale solar PV park and auctioning the sites to private developers for a period of 20 to 30 years. A low electricity generation cost can be expected from solar PV parks if the government facilitates the evacuation of power within sites to the nearest appropriate substation. This will help make the bidding process more competitive and enable early financial closure of the project. Recently, solar auctions in Cambodia, India, Malaysia, Poland, and Portugal were held with low electricity tariffs as the outcome. The auction business model could be piloted for renewable energy and then improved before scaling up.

Conclusions

Bangladesh's energy sector is dependent on natural gas for power generation and coal. Indigenous natural gas reserves are fast depleting, with expensive imported fossil fuels filling the gap. Renewable energy can help supplement the power supply and reduce dependence on fossil fuels, supporting fuel diversification. Updating the *Renewable Energy Policy 2008* to reflect latest developments and practices would help Bangladesh refine its renewable energy targets, while finance and regulatory reforms aligned with national and international climate commitments would support the government's efforts in increasing renewable energy investment.

Bangladesh has big potential in deploying solar PV technology. While land scarcity is a key barrier impeding utility-scale solar PV power plant deployment, floating solar plants could address this. With large volumes of intermittent energy such as solar and wind on the grid, there is an urgent need to reinforce the national grid for accommodating renewable energy.

The government may consider strengthening energy policy interventions by creating an investor-friendly environment with clearer policies on VAT exemptions and duty concessions on imported solar PV modules, inverters, and other accessories, the introduction of a capacity charge, and a guideline on priority dispatch of power from renewable energy plants. Appropriate risk sharing between the government and private sector investors would help minimize costs and further accelerate renewable energy development.

Strong policy measures are needed to:

- (i) identify or designate land or water bodies for renewable energy projects and facilitating transmission for power evacuation;
- (ii) incorporate smart-grid technologies on the transmission distribution network to enable larger volumes of renewable energy supply into the system;
- (iii) introduce a competitive and transparent bidding process;
- (iv) facilitate access to low-cost financing;
- (v) introduce gas pricing that reflects the real cost of imported gas to make renewable energy projects more attractive to power utilities and investors;
- (vi) strengthen the existing net-metering billing mechanism for rooftop solar PV system and solar PV irrigation pumps;

- (vii) develop renewable energy auction models, coupled with standardized and high-quality tender documents; and
- (viii) create a renewable energy independent power purchasing unit within BPDB to help reduce transaction costs and risks for developers.

The government may also consider seeking funds from the Green Climate Fund to help implement the draft *Solar Energy Road Map 2041* and the draft *Solar Irrigation Pump Road Map 2021–2030*. Simultaneously, channeling these funds via commercial banks is suggested to mobilize domestic resources in filling the funding gap in green finance. Strengthening capacity and sharing knowledge with the banking sector in terms of renewable energy technology, project risk analysis and project monitoring are essential to close their skill gaps in green finance and green technology. ADB, along with other development partners, could provide knowledge solutions on these matters and share experiences and best practices from other regional countries to support institutional reforms and capacity development. ADB can share its partial risk guarantee mechanisms to buy down project risks. A collective effort from all the responsible stakeholders would develop a green and more secure energy sector in Bangladesh.

References

- Asian Development Bank. 2016. *Country Partnership Strategy, Bangladesh 2016–2020*. Manila, Philippines.
- . 2018. *People’s Republic of Bangladesh: Capacity Development for Renewable Energy Investment Programming and Implementation*. Manila, Philippines.
- . 2019. *Spectra Solar Power Project*. Manila, Philippines.
- . 2019. *TA-9267 - Roadmap to Scale-Up Solar PV pumping in Bangladesh (2021–2030)*. Manila, Philippines.
- . 2021. *Road Map to Scale-Up Solar Irrigation in Bangladesh (2021–2030)*. Manila, Philippines.
- . 2021. *Assessment of Investment Opportunities and Challenges for Floating Solar PV in Bangladesh - ADB consultant’s Report*. Manila, Philippines.
- Asian Development Bank Institute. 2018. *Green Finance in Bangladesh: Policies, Institutions, and Challenges*. Tokyo, Japan.
- Bangladesh Bank. 2016. *Are We Greening the Economy? Recent Trends of Green Financing in Bangladesh*. Dhaka, Bangladesh.
- Bangladesh Power Development Board. 2016. *Annual Report 2018–19*. Dhaka, Bangladesh.
- . 2020. *Annual Report 2019–2020*. Dhaka, Bangladesh.
- Eckstein, D. et al. 2021. *Global Climate Risk Index 2021*. Berlin, Germany.
- Government of the People’s Republic of Bangladesh, Power Division. 2021. *National Database of Power Generation*. Dhaka, Bangladesh.
- Habib, A. and P. Shah. 2016. *Development of Renewable Energy Financing in Bangladesh in Response to the Central Bank’s Policy Initiatives: Energy Production and Management*.

Hanks, K. et al. 2016. *IFI Energy Investments in Bangladesh: A Way Forward to SDG 7*. Bangladesh.

Haque, A. 2020. *Bangladesh Power Sector*. Dhaka, Bangladesh.

Infrastructure Development Company Limited. 2019. *Reimagining Clean Energy Financing*. Dhaka, Bangladesh.

Islam, S. 2020. Bangladesh Net Metering Requirement May Deter Solar Pump Owners. Dhaka, Bangladesh: PV Magazine.

Islam, S. 2021. *Bangladesh Forms \$125 million Fund for Sustainable Technology*. Dhaka, Bangladesh: PV Magazine.

Islam, S. 2021. Bond Market to Finance 230 MW Solar Projects in Bangladesh. Dhaka, Bangladesh: PV Magazine.

Khan, S. I. 2014. *An Innovative Financing Mechanism: Creating Access to Renewable Energy for Rural People of Bangladesh*. Dhaka, Bangladesh.

Largue, P. 2021. *Metito Consortium Wins Contract for Bangladeshi Solar*. Dhaka, Bangladesh: Power Engineering International.

Ministry of Power, Energy and Mineral Resources. 2008. *Renewable Energy Policy of Bangladesh*. Dhaka, Bangladesh.

Ministry of Power Energy and Mineral Resources. 2013. *Guidelines for the Implementation of Solar Power Development Program - 2013*. Dhaka, Bangladesh.

Private Infrastructure Development Group. 2019. *Study of Bangladesh Bond Market*. London, UK.

Sustainable and Renewable Energy Development Authority. 2015. *Scaling up Renewable Energy in Low Income Countries - Investment Plan for Bangladesh*. Dhaka, Bangladesh.

Sustainable and Renewable Energy Development Authority. 2020. *National Renewable Energy Data Base*. Dhaka, Bangladesh.

Sustainable Renewable Energy Development Authority. 2020. *National Solar Energy Road Map [Draft], 2021–2041*. Dhaka, Bangladesh.

UK Aid Direct. 2017. *Financing Green Growth in Bangladesh : Challenges & Opportunities*. London, UK.

USAID. 2020. *System-Friendly Competitive Renewable Energy Procurement in Bangladesh*. Washington, DC.

World Bank Group. 2016. *Fossil Fuel Subsidy and Pricing Policies: Recent Developing Country Experience*. Washington, DC.

World Bank Group. 2018. *Bangladesh scaling-up renewable energy project*. Dhaka, Bangladesh.

*Priyantha Wijayatunga, Ranishka Wimalasena,
and Keshan Samarasinghe*

Introduction

Sri Lanka has a long and an exemplary track record of using renewable energy for day-to-day energy requirements of its people dating back to more than 2,500 years. Like many other countries, some of the examples include the use of solar energy for open sun drying of various materials such as crops and fruits, and sustainable use of wood fuel for industrial applications and domestic cooking. One unique example is the use of wind furnace for processing steel needed for the manufacture of famous Damascus swords dating back to the 5th century B.C. In recent years, the emphasis has been on greater use of renewable energy for power generation.

Sri Lanka has an estimated 2,000 megawatts (MW) of hydropower potential (including large- and medium-scale plants) of which majority has already been developed.¹ Estimates suggest that the small hydropower (generation capacity up to 10 MW) potential alone can be about 500 MW.² Similarly, the wind resource assessment conducted by the National Renewable Energy Laboratory concluded a technical potential of wind power in Sri Lanka to be about 5,000 MW in the best wind sites, while it can be as high as about 24,000 MW if both excellent and good wind sites are considered.³ It is estimated that the country can gain a utilizable wind power potential of 5,600 MW.⁴ Sri Lanka's solar power potential is significantly high considering that it enjoys a high daily solar insolation in the range of 4–6 kilowatt-hours (kWh) per square meter most days

¹ P. Wijayatunga. 2009. Energy Status and Future Outlook: Sri Lanka and Maldives. *SLEMA*.

² Government of Sri Lanka, Public Utilities Commission of Sri Lanka. 2011. *National Policy for off Grid Hydro Power Generation*. Colombo.

³ National Renewable Energy Laboratory. 2003. *Wind and Solar Resource Assessment of Sri Lanka and Maldives*. Golden, Colorado.

⁴ Asian Development Bank. 2019. *Sri Lanka Energy Sector Assessment, Strategy, and Road Map*. Manila.

during the year (footnote 1). A study conducted by ADB and the United Nations Development Program in 2016 has indicated that Sri Lanka has the potential to develop 16,000 MW of solar power, and the country would be in a position to meet the entire electricity demand in the country by 2050 with renewable energy using currently available technologies.⁵

This paper examines the chronological evolution of the policies, strategies and regulations, financing, and institutional framework that enabled the development of renewable energy sources for power generation with emphasis on nonconventional renewable energy (NCRE), which excludes large hydropower (exceeding 10 MW) development in the context of Sri Lanka.

Early Years of Development

Development of renewable energy for power generation in Sri Lanka dates back to the early 20th century when micro- and mini-hydropower plants were established in the central hills to power plantation-based tea processing factories.⁶ The number of such small hydro plants was 500 at its peak during this period.⁷ While initially there was indifference toward developing large hydropower—which took almost 25 years since the first proposal in 1924⁸—with the commissioning of the Lakshapana hydropower plant (HPP) of 25 MW in 1950, renewable energy development continued, with great emphasis on large hydropower. This trend continued with the expansion of Lakshapana into a complex of HPPs totaling 354.5 MW and the construction of the Mahaweli HPP complex of 660 MW in 1980s. These contributed to the Sri Lankan power system being completely dominated by renewable energy, including large hydro, to almost 100% in 1990 in energy terms. Later, Samanalawewa HPP of 120 MW, Kukele HPP of 70 MW, and Upper Kotmale HPP of 150 MW were added.⁹

⁵ Asian Development Bank and United Nations Development Programme. 2017. *100% Electricity Generation Through Renewable Energy by 2050: Assessment of Sri Lanka Power Sector*. Manila.

⁶ S. Fernando. 2002. An Assessment of the Small Hydro Potential in Sri Lanka. *Energy for Sustainable Development*. vol. VI.

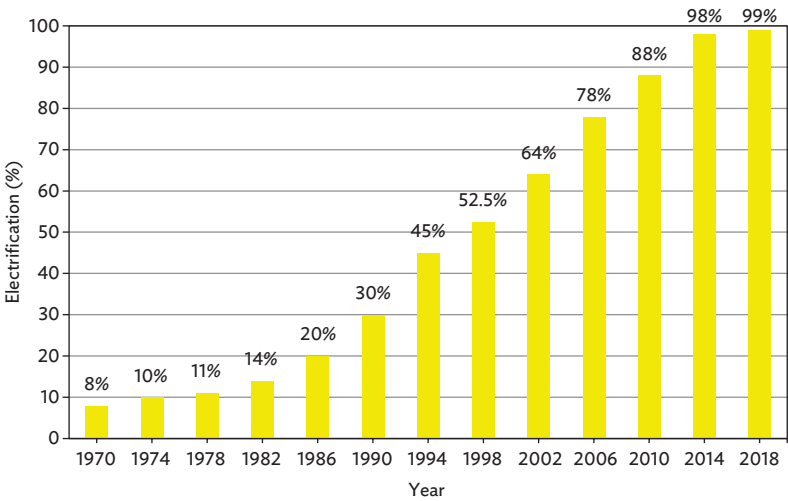
⁷ K. Dhanapala and P. Wijayatunga. 1999. *Best Practices of Micro-Hydro Development*. Colombo.

⁸ D. J. Wimalasurendra. 1918. *Economics of Hydro Power Utilization in Ceylon*. Colombo: Engineering Association of Ceylon.

⁹ Government of Sri Lanka, Sri Lanka Sustainable Energy Authority. 2017. *Sri Lanka Energy Balance 2017*. Colombo.

Even by 1990, countrywide household electrification rate was as low as 29%. Hence, during this period, Sri Lanka started its efforts to increase electricity access with rural electrification programs. While these programs were mainly based on national grid extension, parallel efforts were made to electrify rural areas with solar home systems, village micro-hydro, and small wind plants. Government-sponsored but private sector-led solar home system programs started in 1980 with the establishment of a dedicated “Energy Unit” within the Ceylon Electricity Board (CEB), the electricity utility. Also, the village micro-hydro program was mostly led by institutions like the Intermediate Technology Development Group (ITDG) at the time. Even though not widely deployed, installation of small off-grid wind power systems could also be seen with the support from ITDG in propping up rural electrification programs. The first such wind turbine of 2.5 kilowatts (kW) was installed in 1997 as part of community hybrid power generation system.¹⁰ These efforts helped faster electrification of rural areas, which would have otherwise waited for many years until the grid extension becomes economical.¹¹ By 1995, the electrification rate increased to 45% (Figure 1).¹²

Figure 1: Progress in Countrywide Electrification, 1970–2018



Source: Sri Lanka Sustainable Energy Authority.

¹⁰ M. Narayana. 2007. *Demand and Supply Analysis of Community Type Wind Power System at Gurugoda Village in Sri Lanka*. Kandy.

¹¹ Government of Sri Lanka, Ceylon Electricity Board. 2019. *Long Term Generation Expansion Plan 2020–2039*. Colombo.

¹² Government of Sri Lanka, Sri Lanka Sustainable Energy Authority. 2015. *Sri Lanka Energy Balance 2015*. Colombo.

In the 1980s, these developments were guided by the National Energy Strategy and later by the draft National Energy Policy of 1997 which recognized, among others, reducing dependence on imported energy sources.¹³

Golden Two Decades of Nonconventional Renewable Energy Sources (1995–2015)

The 2 decades from the mid-1990s to 2015 could be considered as the most eventful period of the NCRE development in Sri Lanka. On one hand, demand for electricity, increasing at a rate of about 7%–10% annually during this period of high economic growth and on the other, exhaustion of most of the large hydropower potential, increasing use of thermal power mostly based on liquid petroleum, could be seen since early 1990s. At the same time, with the rapid penetration of the national grid into more geographical areas, the development of mini and micro HPPs, and even the operation of existing ones, curtailed significantly. The result was gradually increasing contribution of fossil fuel-fired plants in the power generation mix since early 1990s. However, this trend and the accompanying increasing average cost of supply resulted in immediate resurgence of small hydropower and later other NCRE-based electricity generation. The electricity supply industry again started encouraging grid-connected small hydropower plants by late 1990s.

Institutional Arrangement

Ministry in charge of energy. Energy being one of the key sectors, successive governments always had dedicated a ministry for this sector under different names and with varying overall scope encompassing one or more sectors out of irrigation, power, and petroleum sectors.

Ceylon Electricity Board. Government-owned CEB had been the sole national power generation company and the transmission operator since its establishment in 1969. Private sector participation was introduced to the thermal power generation in the mid-1980s, but CEB remained as the single institution purchasing this power and pooling it with CEB's own generation

¹³ Government of Sri Lanka, Ministry of Irrigation, Power, and Energy. 1997. *Draft National Energy Policy*. Colombo.

before transmitting it to the distribution utilities.¹⁴ Even with the introduction of private sector-led grid that connected small hydropower by late 1990s, CEB continued with this role. In addition, CEB was vested with the power to issue letters of intent to purchase energy from the prospective small hydropower plants for specific geographical locations.

Sri Lanka Sustainable Energy Authority. With government announcing the opening up of the small hydropower sector to private entrepreneurs in 1992¹⁵ and subsequent policy action (described later in section 3.2) by 2007, this specific subsector expanded exponentially to reach a total small hydropower capacity of 133 MW, providing an energy contribution of 344 gigawatt-hours (GWh) or 3.5% of total power generation. At the same time, the need to incentivize the development of other renewable energy sources also grew. This resulted in government enacting legislation to establish the Sri Lanka Sustainable Energy Authority (SLSEA) in 2007¹⁶ as the central institution for NCRE resource development. The SLSEA board is represented by all relevant stakeholders including private sector interests through various renewable energy associations such as small hydropower association and biomass association. The SLSEA has power to identify and declare resource development areas and to issue licenses to develop these resources.

Public Utilities Commission of Sri Lanka. The Public Utilities Commission of Sri Lanka (PUCSL), which had been already established and operationalized in 2003 as a multisector regulator for the electricity, water, and petroleum sectors, was fully empowered with the regulation of the electricity sector along with the enactment of the Sri Lanka Electricity Bill in 2009. This provided the PUCSL the opportunity to intervene in the licensing and the power purchase tariff-setting processes. However, the argument that the PUCSL is empowered to determine the power purchase tariff from NCRE can be contested considering that it is part of government policy.¹⁷ It is argued that PUCSL's powers are limited to taking these considerations into determining the final consumer tariff, but not to set the generation tariff.

¹⁴ Power distribution had been completely handled both by the CEB and the local councils until the establishment of the Lanka Electricity Company Ltd. (LECO) in 1983. LECO and CEB gradually took over distribution function from all the local councils and currently distribution function is totally handled by these two institutions.

¹⁵ Resource Management Associates (Pvt.) Ltd. 2001. *Study on Grid Connected Small Power Tariff in Sri Lanka*. Colombo.

¹⁶ Government of Sri Lanka. 2007. *Sri Lanka Sustainable Energy Authority Act*. Colombo.

¹⁷ Government of Sri Lanka, Ministry of Power and Energy. 2009. *Energy policy and strategies of Sri Lanka*. Colombo.

Office of the Chief Electrical Inspector. Until the empowerment of the PUCSL to regulate the power sector in 2009, the licensing powers for generation, transmission, and distribution of electricity had been vested with the Office of Chief Electrical Inspector, which came directly under the purview of the subject ministry.

Other state agencies. Other central government and local government agencies are responsible for relevant approvals and licenses such as securing required land, environmental safeguards, and use of water in the streams where the relevant infrastructure facilities are located.

Renewable energy associations. There are several associations of renewable energy-based electricity generators to promote their cause. The Small Hydropower Developers Association, Solar Industry Association, and Biomass Association are among the prominent groupings. In addition, organizations like the Sri Lanka Energy Managers Association, Practical Action, and Energy Forum Sri Lanka have been in the forefront of promoting clean energy in the country.

Policies on Nonconventional Renewable Energy Sources

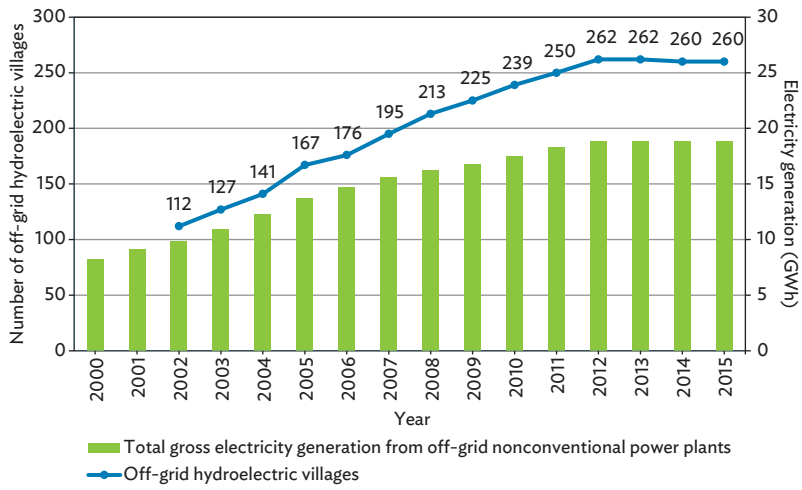
Prior to 2008 the policies governing NCRE, development was more on an ad hoc basis depending on the vision of the government at the time. One such example was the decision of the government and the CEB in 1992 to open grid-connected small hydropower (below 10 MW) sector for private investment. Similarly, the government used to ignore generation licensing requirement for community-owned micro and village hydro plants, which were fast expanding in the remote rural villages (Figure 2).¹⁸ By this time, the unwritten policy of the government was that any hydropower development above 10 MW should be carried out by the CEB.

In 2008, the government adopted the Energy Policy and Strategies of Sri Lanka after almost a decade since the introduction of the much leaner policy directions in 1997.¹⁹ The new policy document clearly identified promotion of indigenous resources in energy supplies as a policy element directly impacting NCRE development. Under this policy element, certain strategies relevant to NCRE had been identified. They are, among others, to (i) provide a level playing field for NCRE development

¹⁸ Government of Sri Lanka, Sri Lanka Sustainable Energy Authority. 2012. *Sri Lanka Energy Balance 2012*. Colombo.

¹⁹ In 1997, the government published "Power Sector Policy Directions," which encompassed the vision of the government in which the only reference to renewable energy was in the context of developing cost-effective renewable energy sources as decentralized generation.

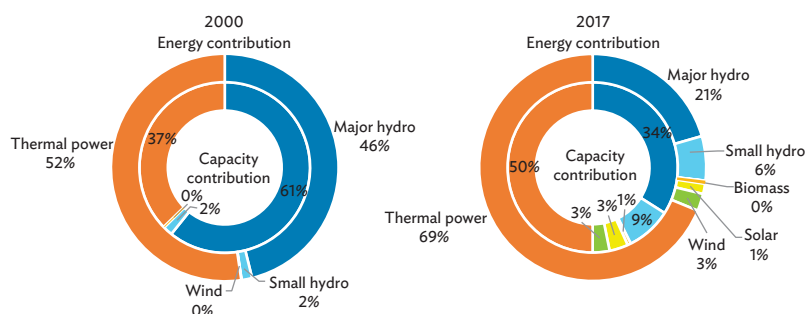
Figure 2: Off-Grid Nonconventional Power Generation



GWh = gigawatt-hour.
Source: Sri Lanka Sustainable Energy Authority.

with due consideration given to economic viability and environmental sustainability; (ii) seek concessionary financing to support hydropower plants not attractive under commercial financing and provide incentives, as appropriate, for development of other NCRE lacking economic viability; (iii) establish a dedicated institution for planning and promotion of NCRE; and (iv) support research and development relating to NCRE. In this policy, the emphasis was largely on the development of small hydropower, wind power, and biomass-based power, and envisaged to reach a target of 10% of generation (in energy terms) to be delivered by NCRE-based plants by 2015. As can be seen in Figure 3, this target was achieved comfortably. By 2017, there were NCRE plants with a total capacity of 656 MW (16%), providing 1,597 GWh of energy (10.6%) annually to the country’s generation system.

With the PUCSL becoming fully empowered to regulate the power sector, in 2009 it took steps to formally exempt all the community-owned village renewable energy-based power generation plants from generation licensing, helping them to come fully within the legal framework.

Figure 3: Power Generation Mix in 2000 and 2017

Source: Sri Lanka Sustainable Energy Authority.

Resource Identification and Allocation

Renewable energy resource allocation and the benefit distribution is always a debatable subject, particularly in the early stages of development of these resources. Assigning the ownership of certain renewable energy resources (like water resources and wind as primary energy to produce electricity) to a particular party who owns the land where such resources are used is not straightforward. These renewable energy resources have multiple users and uses and interact with each other. For instance, the construction of a small hydropower plant in a stream will impact the water users along the stream and other possible hydropower developers in the downstream. Similarly, harvesting wind power in one location may affect the ability to harvest energy from wind in an adjacent land. In certain cases, like the use of water resources, depending on the significance and the boundaries of the waterflows, their ownership may have to be the local population, the entire country, or even a subregion or a region if the water resources are transboundary in nature. Therefore, it is important to provide equal opportunities for anyone to participate in a bid for resource allocation and make arrangements to share benefits among relevant population groups as appropriate. At the same time, it is equally important to reward the first movers who go into more in-depth analysis on resource identification and the feasibility assessments taking the risk of developing them. Without these first movers, these resources may not be transformed into tangible benefits to the nation.

By 1989, the CEB has already developed a master plan for hydropower resource development covering generation capacities above 1 MW.²⁰ In parallel, many prospective developers also had independently identified and explored more deeply the resource locations, including those below 1 MW. While these developments were initially mostly for small hydropower, later they expanded to wind power sites. At the time, the estimated small hydropower development potential was considered to be 400 MW.

Based on these pioneering efforts of the developers, the government and CEB at the time decided to allocate these identified sites up to 10 MW capacity on a first-come, first-served basis. These allocations were limited to only for those sites where the generation plants would be connected to the national grid. Initially, such allocation of the identified resource site for development was for an indefinite period of time. Later, the government decided to issue a permit only for a specific period of time within which the site was expected to be developed. This was mainly to ensure timely development of these sites.

With the establishment of the SLSEA in 2007, the license to use the renewable energy sources, or in other words site allocation for developers, came under the purview of the SLSEA. The SLSEA continued with the principle of first-come, first-served basis for plants between 100 kW and 10 MW, but with clear guidelines on the project development steps and allowed timelines.

Local Communities

Local communities benefited in different ways from the development of the decentralized renewable energy sources such as small hydropower and small-scale wind and solar. These include the direct benefits coming from community-owned off-grid village hydropower schemes, which were part of the rural electrification drive. By 2015 the number of such plants grew to about 260, providing electricity to about 13,000 rural households (or about 65,000 people). These plants had capacities ranging from 5–25 kW and no formal renewable energy resource allocation was required. In most cases, substantial portion of the capital cost was provided as a grant from nongovernment institutions, as well as local and central government. The community itself managed and operated the plant. Similarly, by 2012 there were about 111,000 solar home systems installed by the World Bank-funded Renewable Energy for Rural

²⁰ P. Wijayatunga. 2014. Regulations for Renewable Energy Development: Sri Lanka Experience. *Renewable Energy*.

Economic Development Project alone.²¹ However, as the national grid expanded to these rural areas over the years, while some of these off-grid hydropower plants were grid-connected, many of them were abandoned. Similarly, the number of solar home systems providing electricity in rural areas also gradually declined to almost nothing by 2017, while the solar rooftop systems in grid-electrified areas expanded with the introduction of other incentives such as net metering.

The second significant benefit to the local communities was in the form of infrastructure development. These include access roads and support to local schools and community centers from the private developers of grid-connected power plants located by the side of these local communities. Most of the labor requirements and some construction materials were also sourced from the local community. These interventions, as part of the corporate social responsibility of the companies, immensely helped the developers to secure support from the local communities toward these projects. In some countries, royalties are levied from renewable energy developers, in particular for hydro resource utilization. A portion of the income from the royalties is shared with the local communities and their development. However, Sri Lanka has never used this approach for benefit-sharing in the past.

In contrast, large hydropower development had serious adverse impact on the immediate local communities because of relocation and loss of their traditional livelihoods and agricultural land. However, the development of large hydropower has been always under the government and there have been adequate measures to restore the livelihoods of the affected local communities and to provide housing and others means to compensate adverse impacts from such large development.

Economic Regulation

Safety and technical regulations ensured that the power generation plants conform to the required safety requirements and technical standards. These regulations maintained the consistency and hardly changed over many years. However, economic regulation involves setting and/or reviewing of power purchase tariffs, which are expected to be ultimately passed on to the end-consumer tariffs. These regulations and methodologies tend to change with time depending on the varying policies and the vision for the power sector.

²¹ L. Nadaraja. 2013. *Sri Lanka Lights Up*. Washington, DC.

In the initial years until full empowerment of the PUCSL to regulate the power sector, safety and technical regulation came under the Office of the Chief Electrical Inspector, which issued the license to generate power. Economic regulation was under the ministry in charge of power (at the time it was called Ministry of Power and Energy). In 2009, all these powers on safety, technical, and economic regulation were transferred to the PUCSL (footnote 20).

Unlike in the case of larger power plants, the investment costs of small generation plants less than 10 MW are relatively small and hence needed to bring down the transaction costs associated with such developments. This brought out the need for a standard power purchase agreement (SPPA). With interest in investments in the small hydropower sector gradually growing, in 1997, the CEB introduced an SPPA for all renewable energy-based power plants below 10 MW. The power purchase tariff methodology could change from time to time (however, fixed for a given SPPA at the time of signing) but it is based on the principle of a feed-in-tariff (FIT). At the agreed FIT, the CEB is compelled to purchase all the power generated. The SPPA period lasts for 20 years from the date of signing.

Feed-In Tariff - Shadow Cost

When the decision to proceed with an SPPA arrangement was taken in 1997, two important items that needed immediate attention were (i) the generation capacity ceiling and (ii) the power purchase price. It was thought that a 10 MW capacity ceiling would be most appropriate to recognize such small-scale power generation under a standardized procedure. Considering that the renewable energy development needed to be catalyzed with the private sector investment while not passing the burden to CEB, it was decided that the principle of “avoided cost” be used for the power purchase price or FIT. The avoided cost was determined and announced annually as a 3-year moving average. To determine the avoided cost of generation in the initial stages, the long-term generation planning model of CEB was used and this means it was the long-term avoided cost of capital and operation cost. Later, however, methodology was modified to consider the avoided operational costs in the short term, or the short-run marginal cost based on the annual operation of the generation system. This means, the FIT was dominated by the avoided cost of expensive liquid fuel-based plants at the time (footnote 15).

Feed-In Tariff - Cost Plus

Under the FIT regime based on avoided cost, only those renewable energy systems which could be developed within that cost could manage

to succeed. As a result, Sri Lanka mainly saw the development of small hydropower plants, a subsector which had already matured over the years since the introduction of the SPPA. By 2006, the government realized the need to incentivize the countrywide development of other renewable energy sources if Sri Lanka is to increase its NCRE contribution in the energy sector. This led to the decision to introduce cost-based FIT by technology so that the developer's returns are assured irrespective of avoided cost. Each of the technologies would have a technology-specific FIT based on a representative plant under a typical financing structure of its development. Plants that were already in operation were given the option to shift to this new cost-plus FIT, while all the newly constructed plants were mandated to be under this regime. The cost-plus FIT introduced two options for tariff and the developers can choose any one of the two. One, for a period of 20 years with three tiers: (i) tier 1 initial loan repayment period (1–7 years), (ii) tier 2 covering normal operation (8–15 years), and (iii) tier 3 covering 16–20 years. The other alternative was a flat tariff for 20 years. Originally, this FIT covered three technologies, small hydro, wind, and biomass, which was later expanded to include waste to energy, wave energy, and “other technologies.”

Green Tariff Innovation

The legal framework in Sri Lanka's power sector never allowed direct power sales from the generators to the consumers or power wheeling through the transmission and distribution network. This situation did not change even when the new electricity act came into operation in 2009. This means a consumer does not have a chance to choose where its power comes from. Therefore, unlike in many other countries, the consumers who prefer to consume only green power (usually at a premium price) could not do so unless it is through self-generation. This resulted in a great loss of opportunity for the industries that could have projected and marketed themselves as those rely on only green power.

However, in 2008, the PUCSL developed an agreement that could be entered into by a green power producer and a green power consumer to trace the consumed power back to the producer. This was done by linking the seller and the buyer in the transaction in the form of an incremental payment by the consumer to the generator over and above what it receives from CEB for power supplied to the national grid. The verification process, of such transactions, and the validation of power generated and consumed were to be undertaken by the PUCSL. Annually, the PUCSL could examine that the seller has generated adequate power to supply the contracted amount, while the claimed green consumption of the buyer is within this generated amount. This arrangement allowed circumventing the barriers to direct green power trade.

Net Metering

Sri Lanka introduced net-metering regulations in 2009 for the grid-connected individual prosumers to bank power in the grid for a period of 10 years. While the net power consumption is billed on a monthly basis, at the end of the year the power generation and consumption are reconciled. In 2016, this facility was extended by two additional models, net accounting and net plus. Under the net-accounting model, the announced tariff is paid through an SPPA for the net power generated and fed to the grid. The net-plus model made provisions available to the prosumers to separately meter the generation and consumption allowing the generation to receive the announced tariff through an SPPA, while the consumption is charged at the prevailing customer tariff. The tariff paid for the energy generated under this scheme is currently a flat rate regardless of the time of generation during the day.

The Outcome

During this period, significant development of small hydropower could be seen, and it became a mature technology almost entirely invested in by local entrepreneurs and funded through local banks. Under several interventions by the development partners, some of these loans amounting to about \$100 million were refinanced up to about 80%.²² The total investment in grid-connected small hydropower systems alone was in the range of \$400 million.²³

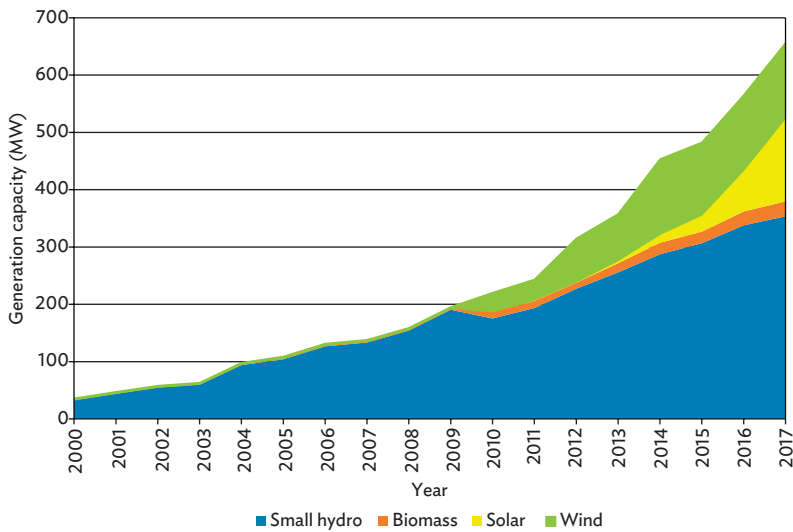
The introduction of cost-plus FIT, which triggered private sector interest in developing other renewable energy technologies such as wind, biomass, and solar power, started materializing under the scheme of the SPPA. Since 2010 with the commissioning of first privately owned wind power plant of 10 MW in Puttalam, subsequently several wind power plants were added to the system and current wind power capacity amounted to 128 MW by 2019. Similarly, with the first medium-scale 10 MW ground-mounted solar power plant installed in Hambantota, a total of 50 MW ground-mounted solar capacity was added by 2019. However, even though the first large-scale commercial biomass power generation plant of 1 MW was commissioned in Walapane, in December 2004 (this was later closed down due to biomass feedstock supply chain issues), interest in biomass power generation decreased gradually due to supply chain challenges.

²² J. Nagendran. Undated. *Financing Small Scale Renewable Energy Development in Sri Lanka*. Colombo.

²³ World Bank. 2004. *Renewable Energy Project Toolkit for World Bank Task Managers: Sri Lanka Renewable Energy Program*. Washington, DC.

This lack of interest is reflected in the total installed capacity, which stood at only 38 MW by 2019. Figure 4 shows this trend of development of all renewable energy sources during 2010–2017. The overall investment in NCRE by 2017 is estimated to be in the range of about \$700 million.

Figure 4: Development of Nonconventional Renewable Energy Sources, 2000–2017



MW = megawatt.

Source: Sri Lanka Sustainable Energy Authority.

Consolidation and Sustainability

The success of the FIT regime, coupled with SPPA and its significant contribution to catalyze renewable energy development as shown by the exponential development of the renewable energy sector since the introduction of FIT in 1998 (Figure 4), along with falling technology costs, drove the government to explore the next stage of renewable energy development—the competitive procurement of renewable energy-based power generation. This would help to pass on the benefit of low-cost renewable energy technologies, such as wind and solar, to the end consumers of electricity without harming the genuine investors.

In 2016, the CEB requested ADB to finance a 100 MW wind power park in Mannar Island in northern Sri Lanka to pilot a centrally dispatchable power plant. This also served to benchmark the technology and price for wind power development in Sri Lanka. This facility is currently under construction. In line with the recommendations provided in the approval of this loan to develop future renewable energy through competitive bidding, CEB in November 2019 called for bids from the private sector to develop wind power on a build–own–operate basis in 1–10 MW blocks totaling 60 MW, without going through the FIT basis. This is likely to bring a significant reduction in the cost of private sector invested wind power to CEB.²⁴

In April 2017, the government called for tenders to install, own, and operate 60 solar photovoltaic (PV) systems of 1 MW each under a 20-year power purchase agreement (PPA). Similarly, in July 2017, CEB called for tenders to install a 10 MW solar PV system in eastern Sri Lanka under 20-year PPA. Both of these tenders were subjected to a price ceiling of about \$0.12 per kWh.²⁵

In late 2019, CEB announced competitive procurement of a total of 150 MW of solar PV systems consisting of about 20 solar projects each ranging from 3–10 MW spread across different parts of the country and a ceiling power purchase price of about \$0.086 per kWh. Also, for the first time, CEB has indicated that 80% of the offered price would be linked to exchange rate fluctuations.²⁶

In March 2020, SLSEA requested for proposals from private developers for the construction of a 10 MW ground-mounted solar system accompanied by 20% storage capacity. The minimum storage expected was 8 megawatt-hours and this facility is to be established in Hambantota, where ground-mounted solar systems have already been installed. These facilities will have a 20-year agreement to sell power to CEB.²⁷

The government has recently shown interest to establish two renewable energy parks, one in Pooneryn and another in Siyambalanduwa. However, the capacity and the mode of development of these parks are yet to be determined. The government has requested development partners to help construct the required park facilities and the power evacuation infrastructure.

²⁴ E. Bellini. 2017. *Sri Lanka Seeks Bids for 60 MW of Large-Scale PV*. 27 April.

²⁵ Based on the exchange rate (as of April 2020) of \$1 = SLRs 190.

²⁶ E. Bellini. 2019. *Tender for Megawatt Scale Solar-Plus-Storage Launched in Sri Lanka*. 27 April.

²⁷ E. Bellini. 2020. *Sri Lanka Launches 150 MW Solar Tender*. 27 April.

The Future

Sri Lanka's commitment in 2016 under the Nationally Determined Contributions was to achieve 60% contribution from renewable energy in the power sector by 2020. This included reducing greenhouse gas emissions in the energy sector (and in the power sector) by 20% from the baseline by 2020. This target was to be achieved through installation of wind (514 MW), solar (115 MW), biomass (105 MW), and mini-hydropower (176 MW) plants, among others.

Later in August 2019, the government published the long-awaited energy policy update consisting of 10 pillars. Of these, pillar 7 is specifically dedicated to enhancing the share of renewable energy in the overall energy mix. The policy states: *“Energy supply from renewable energy resources in the country's energy mix will be increased to reduce pressure on foreign exchange, as a means of engaging the local community in the energy industry, attain sustainability and to promote the use of environmentally friendly energy sources.”* The strategies proposed to under this pillar proposes (i) centrally coordinated expeditious approval process of the renewable energy projects, (ii) attracting investments through a competitive process, (iii) strengthening power evacuation and absorption infrastructure including introduction of smart technologies, (iv) supporting related research and development, and (v) bringing innovative financing models for increased private sector participation. In addition, the two pillars on “Energy Security” and “Self-Reliance” also indirectly promote renewable energy because of the capacity of renewable energy to contribute to the diversification of the energy mix for better energy security, and indigenous nature improving self-reliance in the energy sector.²⁸

The government published its vision for country's development in October 2019. This vision envisages the country's NCRE contribution to be 40% of the overall portfolio by 2030. The renewable energy contribution including conventional hydropower is expected to be 80% of the portfolio by 2030. This target has been revised to 70%. Though not explicitly stated, these numbers seem to be for the power sector and for power generation capacity, in particular (rather than energy contribution, which is quite challenging to achieve by 2030). Specifically, it expects the commissioning of the 100 MW wind park in Mannar and additional 800 MW of solar power in Pooneryn and Siyambalanduwa. The government will continue to encourage solar

²⁸ Government of Sri Lanka, Ministry of Power and Energy. 2019. *Energy Policy and Strategies of Sri Lanka*. Colombo.

rooftop systems for households and small businesses through bank loans backed by concessionary funding sources when available.²⁹

It is worth noting that, like in many other developing countries, Sri Lanka's power sector represents only a small proportion of the total energy sector. A recent study has estimated that the contribution of renewable energy, excluding biomass but including large hydropower, will amount only about 1.9% of the total primary energy supply by 2050. At the same time, final energy consumption attributable to electricity will be only 10%–12% during 2015–2050.³⁰ This means the expected NCRE (power sector) contribution to the total energy mix in the country even in 2050 is likely to be extremely small.

Financing

Large hydropower. Large hydropower development (more than 10 MW capacity) has always been under government ownership, considering factors such as water in the rivers, which is a national resource, and water use for power generation that strongly interacts with irrigation and drinking-water supplies. Also, many of these power plants are part of multipurpose development schemes involving irrigation. Financing of these large hydropower plants therefore are mostly carried out with multilateral and bilateral sovereign financing arrangements. In these investments, Germany, Japan, Sweden, and the United Kingdom were among the key bilateral development partners involved along with ADB and the World Bank. Such financing, either on grant basis or at concessionary rates, is channeled through the government as the borrower to the relevant agencies.

Financing for nonconventional renewable energy sources. NCRE development has been almost entirely confined to the private sector. In the initial stages of development, there was certain level of foreign investments. However, later, investors have been mainly local companies securing debt financing through local banks and microfinancing institutions. In the process there were several schemes supported by multilateral institutions like ADB and the World Bank.

²⁹ G. Rajapaksha. 2019. *Sri Lanka Podujana Peramuna Manifesto*. 27 April.

³⁰ R. Shrestha et al. 2021. *Energy Efficiency in South Asia: Opportunities for Energy Sector Transformation*. Manila: Asian Development Bank.

Financing from Multilateral Banks

World Bank. The World Bank financed the Energy Services Delivery Project and the Renewable Energy for Rural Economic Development Project during 1997–2007, which supported renewable energy projects as a credit-line facility through the local banks and microfinance institutions. This is mainly for debt financing for both grid-connected small hydropower systems and off-grid community-owned micro-hydro plants. The assistance from the credit line for grid-connected systems is used to refinance up to 80% of the subloan to the power plant developers, while the remainder is expected to be covered by the lending banks. Typically, the subloan was expected to be about 60% of the project cost.

In the case of off-grid community-owned micro-hydro plants, a similar approach was taken to lending. The ultimate borrower was the respective consumer societies consisting of the beneficiaries of each of those systems. These loans for off-grid systems were coupled with a grant from the Global Environment Facility (GEF) depending of the capacity of the system. This grant covered the total cost of the feasibility study and portion of the investment cost. The equity contribution from the consumer societies was usually provided as “sweat equity,” in the form of voluntary labor for construction of the power plants. The consumer societies set the charging criteria for electricity use to ensure cost recovery to pay back the loan and to cover operational costs.

This support was expanded to include other NCRE development such as wind power and biomass for both grid-connected and off-grid systems.

The projects also supported countrywide adoption of solar home systems for unconnected households mostly in rural areas. This support was extended through the participating credit institutions that included microfinance institutions in addition to commercial banks and registered solar system providers. These loans were also coupled with a grant GEF.

In certain provinces, these investment grants for community-owned systems and solar home systems were further enhanced by the respective provincial governments as a part of their rural electrification programs.

The support under these two programs also accompanied a strong capacity development component consisting of, among others, setting technical standards for off-grid generators and distribution systems, resource assessments in the identified locations, developing feasibility reports, awareness building, training, and monitoring. These interventions catalyze the exponential increase on NCRE development in the country.

Asian Development Bank. In 2012, ADB provided a \$3 million credit line to pilot rooftop solar schemes in commercial establishments, with an aim of identifying the market appetite for rooftop solar investments. The pilot project provided a grant as a capital subsidy up to 30%. The industry responded positively by installing a capacity of 2 MW, twice the original target under the pilot project. Subsequent to this pilot, as a part of scaling-up process, ADB in 2017 approved the Rooftop Solar Power Generation Project as a \$50 million financial intermediation loan to support the government's Battle for Solar Energy Program. This credit line was made available to enable electricity consumers to install solar PV systems under different schemes of net metering. This credit line at a preferential interest rate is available through 10 local banks. The project, through an attached technical assistance, also supported establishing standards for equipment, development, and implementation of technical guidelines to ensure installation of high-quality solar PV systems. Further, training and monitoring support has been part of the technical assistance. In parallel, Lanka Electricity Company Ltd. (LECO), the only other power company involved in power distribution other than the CEB, introduced a loan scheme for solar rooftop systems as a precursor to ADB loan.

In addition, ADB, in its recent loan projects since 2009, undertook significant investments in the transmission network to facilitate evacuation of distributed power generation (mainly small hydropower) as well as wind power from the 100 MW wind park in Mannar. In addition, investments under some of the loans were channeled to improve the primary distribution network such as capacity expansion in substations where the distributed generation is connected. Total ADB investments since 2009 directly and indirectly supporting renewable energy development amounted to approximately \$650 million.

Currently, except the active credit line from ADB for solar rooftop installations, there are no dedicated financing schemes available specifically for NCRE promotion.

Box: Mannar Wind Power Generation Project

The project involves developing the first large-scale wind park in Sri Lanka. The park consists of a 100 megawatts (MW) of wind turbines expected to generate 345,600 megawatt-hours of electricity annually, equivalent to avoiding about 265,700 tons of carbon dioxide emissions every year. The project also helps to enhance the capacity of the Ceylon Electricity Board (CEB) to expand these investments through private sector competitive bidding. The project has been able to benchmark capital and operational costs for such private sector projects through price discovery under international competitive bidding. Most importantly, the project will help CEB to forecast, control, and manage intermittent renewable energy in the power system.

The project approved in 2017 consists of a \$200 million of Asian Development Bank (ADB) financing directly lent to CEB and \$56.7 million contribution from CEB's own resources. The project is located in an environmentally sensitive international bird migratory route. The project consists of a 28-kilometer (km), 220-kilovolt power evacuation transmission line from Mannar to Nadukuda, of which a 7 km stretch passes through Vankalai Sanctuary—a wetland of international importance prescribed by Ramsar convention. ADB supported years of bird migratory surveys and collision risk modelling and required mitigation measures are embedded in the project with an environment management plan to minimize the habitat and species disturbance during construction, and to avoid potential bird collision with wind turbines and the overhead transmission line.

One special feature of this wind park is the inclusion of a radar-based system of monitoring movement of birds and bats. The turbine operation in the park is curtailed and controlled automatically by a Supervisory Control and Data Acquisition system assisted by the radar for any potential risk of bird or bat collision. Operation of these systems will be particularly critical during the bird migration season. A biodiversity management plan covering the Vankalai Sanctuary, Adam's Bridge National Park, and other critical habitats in Mannar Island has been prepared with ADB support. This includes a conservation management plan and will ensure no net loss of biodiversity.

International competitive bidding assured the project to acquire 100 MW at a cost of \$135 million—significantly less than the estimate of \$173 million. Efficient project management and implementation has helped the construction even during the coronavirus disease (COVID-19) pandemic. The implementation of this project is nearly completed. The estimated levelized cost of generated electricity is found to be \$0.046 per kilowatt-hour. This benchmark cost of wind power led to adoption of competitive bidding for wind power development and the subsequent bidding, such as 20 MW in Chunnakam, emerged with attractive offers by the private investors.

Source: ADB.



Mannar wind power project completed in 2021 (photo by CEB).

Financing Risks

Development lead time. Development of the NCRE-based power plants involves many licensing requirements under a myriad of institutions and groups. For instance, a typical NCRE development requires engagement with the CEB, PUCSL, SLSEA, provincial governments, local authorities, local populations, and even environmental and lobby groups. These result in extended development time period of the power plants, which has a serious impact on starting of the revenue stream. This issue can be addressed only by introducing a one-stop shop for the development of NCRE, but the existing legal frameworks may not allow such a structure to operate on the ground.

Off-taker. The main financing risk associated with grid-connected renewable energy development is the risk of payments by the off-taker, the CEB. CEB's financial strength has been deteriorating in recent years due to its inability to cover the cost of supply through consumer tariffs. Though CEB has been largely honoring payments to these private generators, sometimes the payments are delayed due to cash flow issues. As the private sector invested renewable energy share in the power system grows, it is likely that off-taker risk increases even further unless the end-consumer tariffs are adjusted to reflect the cost of supply.

Resource availability. The other key factor affecting the financing risk is the availability of this natural renewable energy source. For instance, any development including agriculture, which uses water at the upstream of a small hydropower plant can easily impact the planned output and hence the revenue stream. While this issue can be mitigated with proper planning at the provincial and local government level, policies and plans at decentralized levels of government lack consistency.

Quality of equipment, construction, and maintenance. The quality of equipment used in the development impacts the operation and maintenance costs and the lifetime of the plants, in the case of grid-connected larger systems, the development involves strong technical teams and hence the risk of installing low-quality equipment and construction is minimal. However, it is important to ensure high-quality equipment and installations such as solar home systems, solar rooftop systems, and off-grid community-owned systems. Currently, this risk has been largely mitigated by introducing a roster of recognized service providers by the SEA.

Lessons

Indigenous resources and energy security. The initial stages of renewable energy development focused on decentralized small hydropower in plantations led by the need for electricity in those respective places and there were no alternatives except expensive diesel generation. There was no overarching countrywide policy relating to these developments. However, the development of centralized larger hydropower became a priority of the government, again because of the improvement in energy security such development entails and the low operational costs. The policy of identifying these hydropower resource locations and ranking them according to the economic costs for subsequent development depending on the availability of concessionary financing helped the country to develop all the major hydropower resources over 6 decades since the commissioning of the first centralized hydropower plant in Lakshapana. These centralized large hydropower developments have added 1,399 MW to the Sri Lanka power system by 2020. The unwavering commitment of successive governments and the CEB helped this achievement, despite at times strong lobbying against these projects on environmental and resettlement grounds.

Increasing electricity access. The development of grid-connected hydropower systems helped to provide much-needed generation to support

the fast expansion of the national grid in the country to connect households not only in urban and suburban areas but also in rural locations. However, there were many remote rural homes that would not have received electricity supply from the national grid for many years. The community-owned small hydropower and wind power systems and also large-scale expansion of solar home systems immensely helped increase electricity access and the income-generating opportunities in these remote rural, mostly poor areas.

Standardized treatment. From late 1990s, the government and the CEB adopted four key principles when investing in NCRE: (i) development will be entirely by the private sector; (ii) renewable energy resource locations are allocated based on first-come, first-served basis; (iii) these development are undertaken with a unified SPPA; and (iv) provision of a FIT based on transparent methodology. These principles led to minimum transaction costs enabling small-time developers to invest in the industry and hence to expand the investor base. Also, the transparent methodology of calculating FIT provided the much-needed predictability and consistency. These principles gave an impetus to the rapid development of the small hydropower and small wind power sectors. Even though time-to-time, input data used in the annual FIT revision was disputed by the developers, largely this scheme has been successful in attracting investors into the NCRE sector.

Unhealthy market for resource development. At the same time, the first-come, first-served basis used in resource allocation created an unhealthy market for development permits of allocated resources. While this market rewarded the first movers who took the initiative to identify the resource locations, it also had a negative impact on resource development. Permit holders kept the license to develop the resource (a public good) until the holder manages to arrange financing for the development or gets the best deal for the trading the license. As a result, some of these sites had been locked in for long periods of time without being developed. This issue was later addressed by imposing a condition in the license that development of the site needed to start within a specified period of time and beyond that period, an extension is granted only if there is progress and a strong justification. Even though there was some subjectivity embedded in this process, the delayed development issue without a valid ground was largely arrested through this measure.

Suboptimal resource utilization. The principle of first-come, first-served basis for resource allocation did not consider the investment capacity of the prospective permit holders or their ability to muster investors for these resource locations. This resulted in one more

unexpected outcome in addition to the one described under the Quality of Equipment, Construction, and Maintenance Section above. The generation capacities of some of the locations were determined and executed not to optimize the resource available but to suit the investment capacity of the permit holder. This has led to underutilization of the energy resource available at the site, eventually leading to a reduction in the overall economic benefit from this important indigenous resource. For example, there are instances where the capacities of some small hydropower plants are kept at 9.9 MW to ensure that these plants fall into the category of small hydropower (10 MW upper limit). Such issues were arrested through an independent assessment of the optimal generation capacity for each of the sites and making that as a condition in the development permit. Under the powers vested with the SLSEA, it declares certain geographical areas as renewable energy development areas and the resource assessment is used for capacity identification and allocate permits accordingly.

Impact of FIT calculation methodology. As discussed before, the FIT calculation methodology went through several changes over time. The original intention of fixing FIT as a long-run avoided cost could be considered as the most reasonable at the time when the small hydropower sector needed to be incentivized without impacting the overall delivered cost to the electricity consumer. However, this methodology was changed to base the calculation on the annual average avoided operational cost (or short-run marginal cost). At the same time, the CEB has been unable to adhere to the long-term optimal generation plan since early 1990s. This has led to suboptimal investment in generation plants, particularly those based on liquid petroleum products leading to higher short-run marginal costs which, in turn, was reflected in a high FIT. While this situation helped to accelerate the development of the NCRE sector, the benefit went completely to the developer and nothing to the CEB or to the end consumer. Also, these high returns led to less economical sites being developed at the cost of the CEB and the electricity consumer.

The FIT was being declared every year based on the avoided cost and all the plant outputs were paid at that rate regardless of the year SPPA had been signed. However, the SPPA ensured a floor price of 90% of the FIT of its first year of operation. The other major drawback with avoided cost-based FIT was, while investments on small hydropower could be easily covered with unusually high avoided cost due to expensive oil-fired marginal power plants in operation, it was not high enough to attract other NCRE technologies such as wind and solar at the time. For instance, the avoided-cost-based FIT in 2007 was about \$0.7/kWh, while the levelized cost of small hydropower was estimated at \$0.7/kWh and wind power at \$0.12/kWh, respectively. With the introduction of the cost-based

FIT development, other NCRE technologies received a boost. One can see the rapid development of wind power as a result. At the same time, overpayment and uneconomic development of small hydropower stalled. However, this development could not be seen in solar power since it was not explicitly treated under this revised methodology, which covered only small hydropower, wind power, biomass (including biogas), and solar needed to be considered under “Other” NCRE category. The FIT for “Other” category was not attractive enough for solar power development at the time when solar power development was still a costly affair. For example, the FIT under other category was \$0.17/kWh, while the levelized cost of solar power at the time was about \$0.30/kWh.³¹

Determining FIT has always been a contested issue. At the beginning there were allegations that operational details used by CEB for the calculation of the avoided-cost-based FIT were inaccurate and deliberately lowered the FIT declared for the following year. When the methodology moved to cost-plus tariff, there were contentions on the parameters to the calculation such as assumed plant load factors (resource availability), cost of debt, expected equity returns, and annual escalation of the price allowed. However, amid all these allegations, the FIT approach helped the exponential development of the NCRE sector.

Abandonment of annual FIT declaration. The calculation of FIT and its annual declaration had been the responsibility of the CEB and the ministry in charge of the power sector. However, with the change of the regime to cost-plus FIT, this responsibility was transferred to PUCSL after declaration of the first FIT under this new methodology. However, since 2012, annual declaration of FIT has been stalled and no update to the FIT has been carried out. This has impacted the development of the small hydropower sector, which had the lowest FIT and hardly any drop investment cost unlike wind and solar power. The issue is further compounded by CEB’s reluctance to continue signing SPPAs citing technical issues of such connections. However, wind and solar power investment gradually increased because of the falling technology costs and increasing returns at unrevised FIT.

Unutilized green power agreement. The standard green power agreement pioneered by PUCSL in 2008 could have paved the way to a new line of business for NCRE development. There is an increasing demand for green manufacturing, and clean energy supply is essential element in such facilities. However, green power agreement was never used beyond

³¹ PEMBINA Institute. 2016. Fact Sheet: *The True Price of Wind and Solar Electricity Generation*.

the initial project and it was never continued as expected. The electricity industry may not have been given adequate awareness of this opportunity and the possibilities it opens up for green businesses because of lack of PUCSL's continued leadership in this approach. This approach could have expanded into supplying more green businesses if the parties involved proactively pursued it. This can be considered a lost opportunity for both the NCRE sector as well as for possible expansion of green businesses.

Ad hoc renewable energy development. There seems to be a recent trend of going through a process of calling bids to install solar and wind power systems without an orderly process, which should have included identified resource locations and provision of adequate supporting infrastructure such as power evacuation capacity. In most of these cases, the geographical locations have not been identified and hence no proper resource assessments have been carried out or made available to the prospective developers. This means the required land is not identified and acquired, and the availability of power evacuation infrastructure has not been assessed. Uncertainties in these areas likely to lead to negative impact on the bided costs and the development timelines. Therefore, these issues need to be carefully and timely addressed to ensure systematic development of these important renewable energy source in the most economical manner for the benefit of the country. Sri Lanka can learn from the successful experience of India and other countries in bringing investments from the private sector through orderly development of wind and solar parks with the proper planning and provision of all supporting infrastructure funded through sovereign financing.

Conclusion and Way Forward

The paper discussed in detail the developments in the overall renewable energy sector in Sri Lanka over the years. This includes the many initiatives taken by both the government and the main utility CEB to incentivize NCRE development. Also, the paper dealt with the issues that may have impacted negatively on such development. Contrary to the claim by Xi et al.,³² NCRE policies in Sri Lanka have been consistent and greatly assisting the development of this important sector. However, there is room for improvement in implementation of these policies particularly in coordinating different government agencies.

³² S. Xunpeng et al. 2018. Development of Variable Renewable Energy Policy in Developing Countries: A Case Study of Sri Lanka. *International Journal of Public Policy*. Vol. 14(1/2):10–29.

The initial period of small hydropower development through individual efforts mainly for business reasons in the plantation industry provided the much-needed momentum to the development of the renewable energy sector. Also, the community-owned systems helped the remote rural communities to have electricity access well before a centralized national grid penetrated these communities. Treatment of both these types of systems as self-generation not requiring a license was appropriate at the time and greatly helped expand the renewable energy sector for the benefit of these respective communities.

The government's overall policies for the NCRE sector that are conducive toward private sector investment, and CEB's support for the implementation of these policies helped the NCRE sector quickly expand in the initial years. However, the increasing financial burden placed on CEB due to its inability to secure cost-reflective consumer tariffs, led to slow down the development of the sector.

It is important to minimize risk for private investment to be attracted to the NCRE sector and to secure maximum benefit for the country.

Overall, current government policies and strategies encouraging NCRE development need to be continued with greater vigor. However, it is important to make timely essential adjustments to the related actions to ensure stronger NCRE growth. Some of the important actions include the following:

- (i) Continue to provide financial and other incentives for NCRE development including provision of attractive credit lines by tapping concessionary financing sources like Green Climate Fund and other climate funds.
- (ii) Emphasize orderly development of renewable energy parks in identified locations with adequate resource assessments, safeguards assessments, and development of the supporting infrastructure, including power evacuation infrastructure, before inviting investments.
- (iii) Limit cost-based FIT regime to only isolated small and micro-scale systems such as small hydro and solar rooftops systems, and for new NCRE technologies that need initial impetus for development.
- (iv) Limit deployment of mature and widely used technologies such as wind and solar in concentrated format like parks to larger-scale development through bidding processes. This will provide the benefit of economy of scale and optimal cost of generation.

- (v) Compensate the off-taker, CEB, for any cost difference either through direct subsidy provision or allowing cost pass through to the consumer tariff. This is critical for sustainable NCRE development.
- (vi) Explore smart technology interventions to address grid stability issues as the NCRE penetration in the grid becomes significant and compensate the grid operator appropriately to cover such costs.

References

- Asian Development Bank. 2019. *Sri Lanka Energy Sector Assessment, Strategy, and Road Map*. Manila.
- ADB and United Nations Development Programme. 2017. *100% electricity generation through renewable energy by 2050: Assessment of Sri Lanka power sector*. Manila.
- Bellini, E. 2017. *Sri Lanka seeks bids for 60 MW of large-scale PV*.
- . 2019. *Tender for megawatt scale solar-plus-storage launched in Sri Lanka*.
- . 2020. *Sri Lanka launches 150 MW solar tender*.
- Dhanapala, K. and P. Wijayatunga. 1999. *Best practices of micro-hydro development*. Colombo, Sri Lanka: Intermediate Technology Development Group.
- Fernando, S. 2002. An assessment of the small hydro potential in Sri Lanka. *Energy for Sustainable Development*. 2002:(VI).
- Government of Sri Lanka. 2007. *Sri Lanka sustainable energy authority act*. Colombo.
- Government of Sri Lanka, Ceylon Electricity Board. 2019. *Long term generation expansion plan 2020–2039*. Colombo: Ceylon Electricity Board.
- Government of Sri Lanka, Lanka Public Utilities Commission of Sri Lanka. 2011. *National policy for off grid hydro power generation*. Colombo: Lanka Public Utilities Commission.
- Government of Sri Lanka, Ministry of Irrigation, Power, and Energy. 1997. *Draft national energy policy*. Colombo: Ministry of Irrigation Power and Energy.
- Government of Sri Lanka, Ministry of Power and Energy. 2009. *Energy policy and strategies of Sri Lanka*. Colombo: Ministry of Power and Energy.
- . 2019. *Energy policy and strategies of Sri Lanka*. Colombo: Ministry of Power and Energy.

Government of Sri Lanka, Sri Lanka Sustainable Energy Authority. 2009. *Sri Lanka energy balance 2009*. Colombo: Sri Lanka Sustainable Energy Authority.

———. 2012. *Sri Lanka energy balance 2012*. Colombo: Sri Lanka Sustainable Energy Authority.

———. 2015. *Sri Lanka energy balance 2015*. Colombo: Sri Lanka Sustainable Energy Authority.

———. 2017. *Sri Lanka energy balance 2017*. Colombo: Sri Lanka Sustainable Energy Authority, accessed in August 2020.

Nadaraja, L. 2013. *Sri Lanka Lights Up*. Washington, DC: World Bank.

Nagendran, J. Undated. *Financing Small Scale Renewable Energy Development in Sri Lanka*.

Narayana, M. 2007. *Demand and supply analysis of community type wind power system at Gurugoda village in Sri Lanka*. International Conference on Industrial and Information Systems. August 2007. Peradeniya, Sri Lanka.

National Renewable Energy Laboratory. August 2003. *Wind and solar resource assessment of Sri Lanka and Maldives*. Golden, Colorado: NREL.

PEMBINA Institute. 2016. *Fact sheet: The true price of wind and solar electricity generation*.

Resource Management Associates (Pvt.) Ltd. 2001. *Study on grid connected small power tariff in Sri Lanka*. Colombo: Resource Management Associates.

Shrestha, R., et al. 2021. *Energy Efficiency in South Asia: Opportunities for Energy Sector Transformation*. Manila.

Wijayatunga, P. 2009. *Energy status and future outlook: Sri Lanka and Maldives*. SLEMA J.

———. 2014. *Regulations for renewable energy development: Sri Lanka experience*. Renewable Energy.

Wimalasurendra, D.J. 1918. *Economics of hydro power utilization in Ceylon*. Colombo, Sri Lanka (formerly Ceylon): Engineering Association of Ceylon.

World Bank. 2004. *Renewable Energy Project Toolkit for World Bank Task Managers: Sri Lanka Renewable Energy Program*. Washington, DC: World Bank.

Xunpeng, S., C. Hengsi, Y. Yang, and W. Fushuan. 2018. Development of variable renewable energy policy in developing countries: a case study of Sri Lanka. *International Journal of Public Policy, Inderscience Enterprises Ltd*. Vol. 14(1/2):10–29.

Financing Clean Energy in Developing Asia—Volume 2

This book examines clean energy financing and approaches in hydropower and demand-side energy efficiency projects. It presents policies and strategies on energy, based on the experiences in South Asia. This is the second of two volumes that reviews tried and tested approaches and instruments in scaling up clean energy development in Asia and the Pacific.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members—49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.



ASIAN DEVELOPMENT BANK

6 ADB Avenue, Mandaluyong City

1550 Metro Manila, Philippines

www.adb.org