



Knowledge Series 030/20

COMPENDIUM TO THE PRIMER FOR SPACE COOLING



KIGALI
COOLING EFFICIENCY PROGRAM

© 2020 International Bank for Reconstruction and Development / The World Bank
1818 H Street NW | Washington, DC 20433
202-473-1000 | www.worldbank.org

The International Bank for Reconstruction
and Development / The World Bank Group
1818 H Street NW | Washington, DC 20433 | USA

This work is a product of the staff of The World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Rights and Permissions

The material in this work is subject to copyright. Because The World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2625; pubrights@worldbank.org. ESMAP would appreciate a copy of or link to the publication that uses this publication for its source, addressed to ESMAP Manager, The World Bank, 1818 H Street NW, Washington, DC, 20433 USA; esmap@worldbank.org.

All images remain the sole property of their source and may not be used for any purpose without written permission from the source.

Attribution—Please cite the work as follows:

ESMAP. 2020. *Compendium to the Primer for Space Cooling*. Energy Sector Management Assistance Program (ESMAP) Knowledge Series 030/20. Washington, DC: World Bank.

Cover photos:

Front cover: © PPAMPicture from istock. <https://www.istockphoto.com/photo/office-skyscraper-in-the-sun-gm523875332-92089903>

Back cover: © zhaojiankang from istock. <https://www.istockphoto.com/photo/shanghai-commercial-district-modern-urban-architecture-and-green-city-park-gm880792628-245305974>

TABLE OF CONTENTS

PREFACE	vii
DEFINITIONS	viii
ACRONYMS	x
COMPENDIUM: SUSTAINABLE SPACE COOLING INTERVENTIONS—GOOD PRACTICES AND CASE EXAMPLES FROM AROUND THE GLOBE	xiii
ESTABLISH A SUPPORTIVE POLICY AND REGULATORY ENVIRONMENT	1
P1. Conduct a Country-Specific Assessment of the Cooling Landscape to Build a Case for Sustainable Space Cooling and Assess the Need to Elevate it as a Government Priority	1
At-a-Glance	1
What a Country-Specific Assessment Is and Why It Is Important	1
Key Factors to Consider for Implementation of Country-Level Assessments	2
Resources	3
P2. Leverage Labeling as an Effective, Low-Cost Way to Orient Consumers Toward Sustainable Purchasing Decisions	4
At-a-Glance	4
What Labeling Is and Why It Is Important	4
Types of Labeling	5
Labels Are Complementary to Minimum Energy Performance Standards	6
Key Factors to Consider for Implementation of Labeling Programs	7
Resources	11
P3. Establish Minimum Energy Performance Standards of Cooling Equipment and a Mechanism to Ratchet Them Up	12
At-a-Glance	12
What MEPS Are and Why They Are Important	12
Establishing MEPS	13
Need for Ratcheting Up MEPS	14
Key Factors to Consider for Establishing and Ratcheting Up MEPS	14
Resources	18

P4. Catalyze the Market by Leading by Example through Government Budgeting and Procurement Strategies for Energy-Efficient Buildings and Sustainable Cooling Equipment	19
At-a-Glance	19
What Government Lead-by-Example Is and Why It Is Important	19
Multiple Approaches for Sustainable Public Procurement	20
Key Factors to Consider for Implementation of Government Lead-by-Example	21
Resources	22
P5. Develop a Nationwide Cooling Action Plan or Road Map with Meaningful Targets and Expected Impacts	23
At-a-Glance	23
What National Cooling Action Plans Are and Why They Are Important	23
Key Factors to Consider for Implementation for Establishing Cooling Action Plans or Road Maps	24
Resources	26
P6. Cultivate Market Demand for Energy-Efficient Buildings by Increasing Visibility of Building Energy Performance	27
At-a-Glance	27
What Visibility of Building Energy Performance Is and Why It Is Important	27
Energy Performance Rating Systems	28
Key Factors to Consider for Implementation for Cultivating Visibility of Building Energy Performance	30
Resources	32
P7. Accelerate the Adoption of Passive Cooling Strategies through National Building Energy Codes with a Robust Enforcement Mechanism	33
At-a-Glance	33
What Building Energy Codes Are and Why They Are Important	33
Potential Impact of Building Energy Codes	34
Current Status of Building Energy Codes in Low- and Lower-Middle-Income Countries	35
Key Factors to Consider for Implementation for Reducing Cooling Loads through Adoption of Building Energy Codes	35
Resources	36

CREATE SUSTAINABLE FINANCING AND ENABLING MECHANISMS	39
F1. Create Incentive Mechanisms to Shift the Market Toward Sustainable Space Cooling	39
At-a-Glance	39
What Incentive Mechanisms Are and Why They Are Important	39
Upstream Incentive Programs	40
Downstream Incentive Programs	41
Key Factors to Consider for Implementation for Incentive Mechanisms	42
Resources	44
F2. Aggregate Demand to Drive Down the Acquisition Cost of Sustainable Cooling Equipment, Build Market Confidence, and Spur Greater Adoption	45
At-a-Glance	45
What Demand Aggregation Is and Why It Is Important	45
Success of Demand Aggregation in Adjacent Sectors	46
Public Sector Demand Aggregation for Cooling	46
Private Sector Demand Aggregation for Cooling	46
Key Factors to Consider for Implementation for Demand Aggregation	47
Resources	49
F3. Reduce the First Cost of Sustainable Space Cooling through Debt Subsidy and Risk Mitigation Instruments	50
At-a-Glance	50
What Debt Subsidy and Risk Mitigation Instruments Are and Why They Are Important	50
Comparisons to Subsequent Interventions	52
Key Factors to Consider for Implementation of Debt Subsidy and Risk Mitigation Instruments	53
Resources	54
F4. Implement Cooling as a Service, Including District Cooling and Beyond	55
At-a-Glance	55
What Cooling as a Service (CaaS) Is and Why It Is Important	55
CaaS for Multiple Offtakers: District Cooling	56
Key Factors to Consider for Implementation for CaaS—Multiple Offtaker Model	59
Key Factors to Consider for Implementation for CaaS—Single Offtaker Model	60
Resources	61

F5. Catalyze Investment in Sustainable Space Cooling through the Development of an Energy Service Company Capability	62
At-a-Glance	62
What ESCOs Are and Why They Are Important	62
The Two Main ESCO Models	63
Key Factors to Consider for Implementation of an ESCO Ecosystem	66
Resources	69
F6. Expand Access to Financing for Sustainable Space Cooling through the Development of Energy Service Agreements and Managed Energy Service Agreements, Derivatives of the Energy Service Company Model	70
At-a-Glance	70
What Energy Service Agreements Are and Why They Are Important	70
An ESA Derivative: MESAs	72
Current Status of ESAs and MESAs Globally and Where They Are Applicable	73
Key Factors to Consider for ESAs and MESAs	74
Resources	74
F7. Leverage Property Assessed Clean Energy or Environmental Upgrade Financing Approaches to Lower the First Cost of Energy-Efficient Construction	75
At-a-Glance	75
What Property Assessed Clean Energy and Environmental Upgrade Financing Are and Why They Are Important	75
Current Status of PACE and EUF Globally	76
Key Factors to Consider for Implementation of PACE and EUF	77
Resources	78
F8. Manage Peak Cooling LOADS THROUGH Utility-Led Demand-Side Management and Financial Measures	79
At-a-Glance	79
What Utility Demand-Side Management (DSM) Is and Why It Is Important	79
Key Factors to Consider for Implementation of Utility-Led DSM	81
Resources	85

ESTABLISH AND/OR STRENGTHEN THE SUPPORTING INSTRUMENTS	87
S1. Enhance “Cooling Awareness,” or Awareness of the Importance and Benefits of Sustainable Space Cooling Practices, to Encourage Individual Actions and Behavior Changes	87
At-a-Glance	87
Why Cooling Awareness Is Important	87
Means for Advancing Cooling Awareness	88
Key Factors to Consider for Implementation of Cooling Awareness	88
Resources	90
S2. Build Capacity in Critical Institutions as Well as Among Trade Professionals and the Heating, Ventilation, and Air-Conditioning Service Sector	91
At-a-Glance	91
What Capacity Building Is and Why It Is Important	91
Key Factors to Consider for Implementation of Capacity Building	92
Resources	94
S3. Leverage Ongoing Refrigerant Technology Transition Activity (as required under the Kigali Amendment) to Integrate Energy Efficiency in Cooling Equipment and Maximize Benefits	95
At-a-Glance	95
Why Integration of Energy Efficiency with the Ongoing Refrigerant Transition Efforts Is Important	95
Key Factors to Consider for Enabling Integration of Energy Efficiency in Cooling Equipment with Refrigerant Transition Efforts	96
Resources	97
S4. Support and Leverage a Research and Development, and Innovation Ecosystem That Enables Technology Advancement	98
At-a-Glance	98
Why Leveraging a Research and Development (R&D), and Innovation Ecosystem Is Important	98
Key Factors to Consider for Creating an R&D and Innovation Ecosystem	98
Resources	101

S5. Incorporate Strategies to Enable Access to Cooling in Off-Grid or Weak-Grid Locations	102
At-a-Glance	102
What Off-Grid Cooling Solutions Are and Why They Are Important	102
Key Factors to Consider for Enabling Access to Cooling in Off- or Weak-Grid Locations	103
Resources	105
 ANNEX 1. SUMMARY OF INTERVENTION EXAMPLES	 107
 ANNEX 2. ACCOUNTING CONSIDERATIONS	 115
 ANNEX 3. FINANCING STRUCTURES COMPARISON OF ASSET OWNERSHIP AND RISK AND SAVINGS ALLOTMENT	 116
 ENDNOTES	 118

PREFACE

This is a compendium to the *Primer for Space Cooling*. The *Primer* was developed in the context of the rapidly growing demand for space cooling and the critical need for access to affordable but sustainable space cooling solutions—that is, solutions that can respond to the need for greater access to cooling, especially in large parts of the developing world facing increasingly high temperatures, while avoiding the considerable and disruptive impacts on energy systems and the accompanying greenhouse gas emissions that would result from business-as-usual growth.

The objectives of the *Primer* are to introduce a broad audience, including practitioners in different fields, to space cooling and to help initiate and advance sustainable space cooling into policy discussions and investment considerations in developing countries. The *Primer* explains the foundational aspects of space cooling, makes the case that sustainable space cooling achieved through low-energy and low-climate-impact pathways is a critical priority, and emphasizes an integrative approach as essential to addressing space cooling sustainably. It also presents an overview of sustainable space cooling technologies, as well as refrigerant options, along with their associated characteristics, applications, and trade-offs. The *Primer* discusses the barriers to implementing sustainable space cooling and summarizes the various demonstrated space cooling intervention strategies that can help overcome these barriers. For those interested in learning more about the interventions that could accelerate the pace of sustainable space cooling, this compendium contains detailed information covering the 20 interventions presented in the *Primer*, with over 100 real-world examples of space cooling–related practices that have been implemented.

Note that cooling-specific examples have been presented when available and demonstrated at sufficient scale to enable relative success to be assessed, but when these are unavailable, examples from adjacent sectors have been included, with an explanation of how the lessons from those interventions could be applied to advancing sustainable space cooling. The compendium also provides readers with additional resources and details on space cooling interventions.

This publication has been developed under the Energy Sector Management Assistance Program (ESMAP) Efficient, Clean Cooling Program, jointly managed by ESMAP and the World Bank Climate Change group, and was initiated with the support of a grant from the Kigali Cooling Efficiency Program (K-CEP).

DEFINITIONS

Energy-Efficient Buildings (or building energy efficiency), in this publication, refer to a building designed and constructed (or renovated) to be efficient in its use of energy and having reduced thermal loads through better site planning, building design and construction, integrated building system design, and systems and processes that support longer-term efficient operation and maintenance.

Fit-for-Purpose Financing refers to financing structured to meet the specific market needs for affordable financing of energy efficiency in buildings and sustainable space cooling. These market needs can include a need to enhance credit risk, address performance risk in relation to the realization of savings, provide appropriate accounting characterization of the financing, and mitigate split incentives by matching the flow of future energy savings with the obligation of loan repayment. The combination of financing and enabling mechanisms can deliver fit-for-purpose financing. While applicable to new construction, fit-for-purpose financing is more typically needed to support the retrofit and renovation of existing buildings where the market barriers are greater.

Mechanical Cooling refers to the meeting of cooling loads through a mechanical system, such as vapor compression.

Room Air Conditioners are the smallest of all the vapor compression–based air-conditioning systems and typically have up to 15 kilowatts or 4.5 tons of refrigeration or cooling capacity. They are usually used to cool a single room in a home, an apartment, or a small office.

Space Cooling, also referred to as “comfort cooling,” refers to the means by which people are provided thermal comfort from heat by maintaining the optimum temperature, humidity, and ventilation within the built environment.

Sustainable Cooling Equipment, in this publication, refers to cooling equipment that has a lower environmental impact than current practices. This lowered impact is attained through a combination of reduced energy use and more climate-friendly refrigerants (in line with or exceeding obligations under the Montreal Protocol on Substances That Deplete the Ozone Layer and its various annexes, including the Kigali Amendment) that collectively have a lower environmental impact than do current practices and are in line with or exceed a country's internationally agreed-to greenhouse gas mitigation objectives. Cooling equipment includes all technologies that alter temperature, humidity, or air movement to create a cooling effect, for example, fans, air coolers, air conditioners, and chillers. Other publications may use different terms to convey the same or similar definitions, such as “efficient and clean cooling equipment.”

Sustainable Space Cooling, in this publication, refers to achieving human thermal comfort within buildings through a combination of energy-efficient building design and practices (that enhance thermal performance of the building thereby reducing the need for mechanical cooling), efficient cooling technologies and practices, and more climate-friendly refrigerants (in line with or exceeding obligations under the Montreal Protocol on Substances That Deplete the Ozone Layer and its various annexes, including the Kigali Amendment) that collectively have a lower environmental impact than do current practices and are in line with or exceed a country's internationally agreed-to greenhouse gas mitigation objectives. Other publications may use different terms to convey the same or similar definitions, such as “efficient and clean cooling.”

Sustainable Space Cooling Interventions are actions that a country or region could undertake to promote, support, incent, or regulate sustainable space cooling. This publication presents many sustainable space cooling interventions that may be considered by developing countries.

Thermal Comfort is defined by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) as the “condition of mind which expresses satisfaction with the surrounding thermal environment.”¹ While the commonly used indicator of thermal comfort is air temperature, a combination of both environmental and personal factors affects human thermal comfort.

Vapor Compression–Based Air Conditioners, also called simply “air conditioners” in this publication, refer to a type of cooling equipment that uses the vapor compression cycle principle to cool and dehumidify the air. A vapor compression cycle operates on four primary components: an evaporator, compressor, condenser, and expansion valve. Refrigerants, with the ability to undergo phase changes by absorbing and releasing the latent heat at relatively lower temperatures, operate in a closed-loop cycle and transfer heat from one space to another, thus producing a cooling effect. Most air-conditioning equipment available today is based on the vapor compression cycle, including room air conditioners, central air-conditioning systems, variable refrigerant flow systems, and chillers.

ACRONYMS

AC	Air conditioner
ADEME	French Environment and Energy Management Agency
APF	Annual performance factor
ASEAN	Association of Southeast Asian Nations
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ATM	Automated teller machine
BASE	Basel Agency for Sustainable Energy
BCA	Building and Construction Authority (Singapore)
BEE	Bureau of Energy Efficiency (India)
BRESL	Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling
BRPL	BSES Rajdhani Power Limited
BSES	Reliance Energy, formerly known as Bombay Suburban Electric Supply
CaaS	Cooling as a Service
CALGreen	California Green Building Standards
CEM	Clean Energy Ministerial
CES	Customized Energy Solutions
CLASP	Formerly the Collaborative Labeling and Appliance Standards Program
CO ₂	Carbon dioxide
COP	Coefficient of performance
CSPF	Cooling seasonal performance factor
DC	Direct current
DSM	Demand-side management
ECBC	Energy Conservation Building Code (India)
EDGE	Excellence in Design for Greater Efficiencies
EER	Energy efficiency ratio
EERS	Energy Efficiency Resource Standards
EESL	Energy Efficiency Services Limited (India)
EFEKT	Efektivně (Czech Republic)
EGAT	Electricity Generating Authority of Thailand
EPBD	Energy Performance of Buildings Directive (European Union)
EPC	Energy performance contract
EPRA	Energy and Petroleum Regulatory Authority (Kenya)
ESA	Energy service agreement
ESCO	Energy service company
ESEAP	EESL Super-efficient Air Conditioning Program
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUF	Environmental upgrade financing (Australia)
FONERWA	Rwanda Green Fund

GEF	Global Environment Facility
GHG	Greenhouse gas
GIFT City	Gujarat International Finance Tec-City (India)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GRIHA	Green Rating for Integrated Habitat Assessment
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbon
HERS	Home Energy Rating System (US)
HFC	Hydrofluorocarbons
HVAC	Heating, ventilation, and air-conditioning
IBRD	International Bank for Reconstruction and Development
ICAP	India Cooling Action Plan
IEA	International Energy Agency
IECC	International Energy Conservation Code
IFC	International Finance Corporation
IGSD	Institute for Governance and Sustainable Development (Brazil)
IIEC	International Institute for Energy Conservation
INR	Indian rupee
IRENA	International Renewable Energy Agency
ISEER	Indian Seasonal Energy Efficiency Ratio
ISO	International Organization for Standardization
K-CEP	Kigali Cooling Efficiency Program
kW	Kilowatt
kWh	Kilowatt-hour
LEAP	Lighting and Energy Access Partnership
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LEIA	Low-Energy Inclusive Appliances
M&V	Measurement and verification
MEPS	Minimum energy performance standards
MESA	Managed energy service agreement
MLF	Multilateral Fund
MoEFCC	Ministry of Environment, Forest, and Climate Change (India)
MOU	Memorandum of understanding
MW	Megawatt
NABERS	National Australian Built Environment Rating System
NGO	Nongovernment organization
O&M	Operation and maintenance
ODP	Ozone depletion potential
OEM	Original equipment manufacturer
PACE	Property assessed clean energy
PEECA	Punjab Energy Efficiency and Conservation Agency (Pakistan)

PELMATP	Philippines Efficient Lighting Market Transformation Project
PENHRA	Promoting Energy Efficiency for Non-HCFC Refrigeration and Air Conditioning (Indonesia)
PRSF	Partial Risk Sharing Facility (India)
PV	Photovoltaic
QR code	Quick response code
R-COOL	Rwanda Cooling Initiative
R&D	Research and development
RAC	Room air conditioner
RD&D	Research, development, and demonstration
RISE	Regulatory Indicators for Sustainable Energy
RMI	Rocky Mountain Institute
ROIC	Return on invested capital
RTU	Rooftop unit
SDGs	Sustainable Development Goals
SEED	Standard Energy Efficiency Data
SEER	Seasonal energy efficiency ratio
SEforALL	Sustainable Energy for All
SIDBI	Small Industries Development Bank of India
SIR	Saving-to-investment ratio
SMEs	Small and medium-sized enterprises
TEAP	Technology and Economic Assessment Panel
TR	Ton of refrigeration
TWh	Terawatt-hours
U4E	United for Efficiency
UN	United Nations
UNDP	United Nations Development Program
US	United States
VAT	Value-added tax
W/W	Watt/watt

COMPENDIUM: SUSTAINABLE SPACE COOLING INTERVENTIONS—GOOD PRACTICES AND CASE EXAMPLES FROM AROUND THE GLOBE

This Compendium presents examples and analyses of space cooling interventions from across the world (from both developed and developing countriesⁱ), with an aim to highlight the key insights learned.

Interventions discussed in the Compendium are meant to be options to inform strategies, implementation mechanisms, and road maps for countries that are seeking to address and increase sustainable space cooling. Interventions involve a combination of actions reducing cooling loads, serving cooling needs efficiently, and optimizing and controlling cooling loads. There is not one “right” solution, as each country’s context and need will vary. For instance, many developing countries may face greater barriers pertaining to institutional and technical capacities, policy and regulatory frameworks, and enabling financial mechanisms, and some of the interventions presented below may not immediately apply without first addressing the interventions that can build initial demand. Each country will need to develop its own path according to its priorities, opportunities, and constraints.

While interventions are presented in a particular sequence, the sequence is not meant to be prescriptive. The sequencing of interventions, as presented in this Compendium, is based on an assessment of the relative ease of implementation, required resources, and critical interdependencies. However, depending on contexts and priorities, a different sequence or grouping of interventions may serve a country’s needs better.

While each country will chart its own pathway toward sustainable space cooling, the need for a multi-pronged approach consistently applies. The best outcomes will emerge from a multipronged approach that incorporates information, policy and regulatory measures, clear leadership, financing and implementation models, training, and research and development.

ⁱ While the emphasis has been to present examples from developing countries to the extent possible, there are a substantial number of examples from developed countries simply because they have been the countries where there has generally been more activity over a longer time to advance sustainable space cooling and, consequently, more information to draw from.



Walkway in office park
Credit: Bimistock



ESTABLISH A SUPPORTIVE POLICY AND REGULATORY ENVIRONMENT

P1. CONDUCT A COUNTRY-SPECIFIC ASSESSMENT OF THE COOLING LANDSCAPE TO BUILD A CASE FOR SUSTAINABLE SPACE COOLING AND ASSESS THE NEED TO ELEVATE IT AS A GOVERNMENT PRIORITY

At-a-Glance

	Importance of country-specific assessment of cooling A macro-level cooling assessment is suggested as a foundational intervention for any country as it presents a data-backed context to build the case for integrated and prioritized actions toward sustainable space cooling, and it can help catalyze alignment among stakeholders. Assessment findings can also provide baseline conditions and a readiness indicator for other interventions, including the appropriateness and timing of developing a nationwide cooling action plan (see P5).
	Key factors to consider for implementation <ul style="list-style-type: none">• Incorporate all growth drivers and other local factors that will impact cooling demand to ensure the assessment is forward-looking and comprehensive• Highlight the whole-system impacts of cooling growth and the benefits of addressing it proactively and with an integrative approach to support evidence-based policy making
	Barriers addressed: Lack of Awareness, Misaligned Policies

What a Country-Specific Assessment Is and Why It Is Important

A country-specific assessment of the cooling landscape analyzes the expected growth in cooling demand, including both demand that will be realized and demand that will be unmet, and the implications on consumers, energy systems, and emissions.

Even though cooling is closely tied to several Sustainable Development Goals (SDGs), for some nations, cooling may not necessarily be a visible problem at present among other competing national priorities, especially in countries where adoption of cooling technologies is still nascent. However, if cooling adoption in the near future is projected to have a significant impact on the energy systems in the region and the environment, it may be important for policy makers to raise the profile of sustainable cooling, establish sustainable space cooling as a priority, and signal a political will to catalyze action for greater access to sustainable space cooling. A country-specific assessment is essential to building the evidence to inform policy decisions, creating the requisite visibility to build the case for sustainable space cooling as a priority area, and garnering support from stakeholders. It will also form a basis from which to assess progress.

While national governments should take action on country-specific due diligence and assessments, the existing body of work through the philanthropic community and international research bodies should be fully leveraged. There is a growing body of work to advance sustainable space cooling in various countries, as well as knowledge products from several international organizations,ⁱⁱ which can be built on while planning country-specific initiatives.

Key Factors to Consider for Implementation of Country-Level Assessments

- **Incorporate all growth drivers and other local factors that will impact cooling demand to ensure the assessment is forward-looking and comprehensive**

A forward-looking assessment of the country's cooling landscape—one that goes beyond just today's impact of cooling—should encompass all possible growth drivers, such as population growth, income growth trends, urbanization, and construction trends in the country. In addition, other relevant factors that could have an impact on the demand or supply of cooling—including, but not limited to, the climate, prevalent technology trends, manufacturing base for cooling equipment, and market purchase behaviors—should be factored into the assessment.

For instance, Rwanda's government-led country assessment highlighted the rapidly increasingly electrification of households: the number of new households connected to the national grid has doubled over the last five years and is expected to reach 52 percent of all households by 2024. In this context, sustainable space cooling was reinforced as an important lever to expand the capacity of the grid for new consumers by ensuring that existing electrical generating capacity is able to reach more households, since less of capacity will be wasted by outdated or inefficient cooling products.

Demand Analysis for Cooling by Sector in India in 2027, a nationwide cooling demand assessment led by a civil society organization, highlighted space cooling as the dominant sector for India's cooling demand and underscored its untapped potential—and thus the need for greater energy efficiency in buildings and equipment, and this efficiency as an important lever to sustainably address cooling.² The findings of this study were a useful reference point during the development of the India Cooling Action Plan (ICAP).

- **Highlight the whole-system impacts of cooling growth and the benefits of addressing it proactively with an integrative approach to support evidence-based policy making**

Data-driven research should be used to provide a perspective on cooling and its impacts within the context of a nation's priorities. This research should go beyond today's impact of cooling and encompass various adoption scenarios in comparison to business-as-usual to understand the future impact on a nation's energy systems and emissions contributions, as well as its developmental goals. This can help elevate the focus on cooling and introduce the requisite urgency, bring alignment among the diverse

ii Guidance and assessments to scale up energy efficiency in buildings (for example, from Energy Sector Management Assistance Program, the World Bank, Global Alliance for Buildings and Construction, and International Energy Agency [IEA]) and knowledge products to advance various aspects of sustainable cooling (for example, from IEA, Sustainable Energy for All, Kigali Cooling Efficiency Program, and Lawrence Berkeley National Laboratory) can provide useful and relevant references. This list is not exhaustive and only notes some examples. There are several reputed organizations facilitating meaningful work in the area of space cooling, and several of them are included in the endnotes for the Compendium and the *Primer*.

stakeholders, and drive focused and integrated efforts toward establishing pathways to address the cooling challenge.

As an example, in 2018, Rwanda initiated the Rwanda Cooling Initiative (R-COOL), supported under the Kigali Cooling Efficiency Program (K-CEP), to understand its nationwide cooling context and eventually help implement a national cooling strategy. Under the leadership of the Rwanda Environment Management Authority and the Ministry of Infrastructure, in partnership with the United Nations (UN) Environment Program's United for Efficiency (U4E) initiative, R-COOL aims to showcase the benefits of a rapid and comprehensive transition to sustainable cooling and refrigeration equipment (specifically, air conditioners and refrigerators). Assessment of country-specific factors and data analyses showed that the demand for cooling and refrigeration in Rwanda is projected to soar in the next 15 years as the population and economy continue to grow amid a warming climate. This due diligence was the foundational step leading to Rwanda's National Cooling Strategy (released in 2019), a proactive initiative to address Rwanda's growing cooling needs while reducing environmental impacts and peak electricity demand.

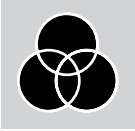

There is a growing body of research and data available in the public domain that can guide or supplement a country's assessment efforts. For example, the *Future of Cooling* by the International Energy Agency (IEA), which projects future cooling demand for various countries, can serve as a good starting point for countries to see their cooling demand projections at a high level.

RESOURCES

- “Savings and Policy Assessments,” United for Efficiency (accessed September 25, 2019), <https://united4efficiency.org/countries/country-assessments/>.
- Kumar, Satish, Sneha Sachar, Sandeep Kachhawa, Akash Goenka, Saikiran Kasamsetty, and Gerry George, 2018, *Demand Analysis for Cooling by Sector in India in 2027*, Alliance for an Energy Efficient Economy, New Delhi, India, <https://www.aeee.in/wp-content/uploads/2018/10/Demand-Analysis-for-Cooling-by-Sector-in-India-in-20271.pdf>.
- Ministry of Environment, 2019, *National Cooling Strategy*, Republic of Rwanda, Kigali, Rwanda, <http://www.fonerwa.org/sites/default/files/Rwanda%20National%20Cooling%20Strategy.pdf>.
- International Energy Agency, 2019, *The Future of Cooling in China*, International Energy Agency, Paris, www.iea.org/publications/reports/TheFutureofCoolinginChina/.
- “Four New Air Conditioner Market Studies Capture Benefits of Energy Efficiency Policies,” CLASP, June 26, 2019, <https://clasp.ngo/updates/2019/four-new-air-conditioner-market-studies-capture-benefits-of-energy-efficiency-policies>.

P2. LEVERAGE LABELING AS AN EFFECTIVE, LOW-COST WAY TO ORIENT CONSUMERS TOWARD SUSTAINABLE PURCHASING DECISIONS

At-a-Glance

	<p>What labeling is and why it is important</p> <p>Energy labeling of cooling products and technologies enables consumers to compare the efficiency of different products and consider this in their buying decisions. Effective labeling programs can help increase awareness about and drive demand for sustainable space cooling and can deliver significant impact at relatively low cost to the government. This intervention, given its fewer dependencies or prerequisites to be effective, should be considered one of the basic policy mechanisms that any country should have in place to advance sustainable space cooling practices.</p> <p>This intervention focuses on the labeling of cooling products and technologies. Due to differing enabling parameters and factors, labeling for energy-efficient buildings is discussed separately in P6, Cultivate market demand for energy-efficient buildings by increasing visibility of building energy performance.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none">• Accompany the introduction of labels (and any revision) with information and communication targeted at consumers• Reinforce the labeling program with parallel strategies, as available, to address the first-cost barrier typically faced when purchasing sustainable cooling equipment• Get buy-in from manufacturers and other critical stakeholders• Establish standardized systems and access to infrastructure for testing and certification of sustainable cooling equipment and ensure the administering program has sufficient capacity• Ensure the labels enable easy comparison of energy performance and are visually striking• Revise the labels on a regular basis
	<p>Barriers addressed: Lack of Awareness, Lack of Transparency, Lack of Valuation of Efficiency, Complexity of Choice</p>

What Labeling Is and Why It Is Important

An effective labeling program provides standardized information on product energy and performance data to consumers, allowing them to compare performance and make informed purchasing decisions. Sustained demand from consumers, in turn, leads to economies of scale for manufacturers, enabling them to cost-effectively produce sustainable products and differentiate products according to their performance. Thus, a well-implemented labeling program can increase the market uptake of sustainable cooling equipment. In addition, labeling is often a precursor to other interventions, such as consumer education, financing, and other public procurement programs. Many of these programs use already established labels to identify high-performing air conditioners, fans, or other appliances for program eligibility.

Energy labeling programs are prevalent worldwide. Of the 133 countries covered in the Regulatory Indicators for Sustainable Energy (RISE) data set, 80 have labeling programs for heating, ventilation, and air-conditioning (HVAC).³ Sixty-five of the 133 countries are categorized as low- or middle-income countries, and it is noteworthy that only 21 of those have labeling programs for HVAC. Room air conditioners (RACs) are one of the products most commonly covered by labels (second only to refrigerators).⁴

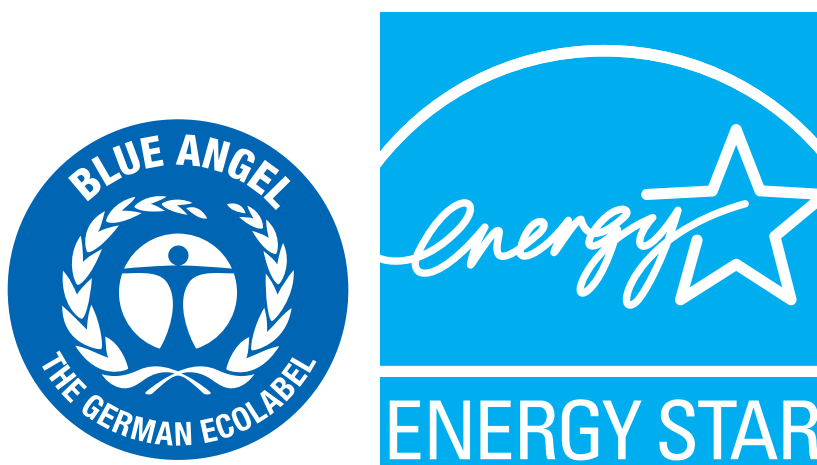
While labeling has typically been a country-specific initiative, there is a recent example of countries getting together to develop common labeling programs. Bangladesh, China, Indonesia, Pakistan, Thailand, and Vietnam were involved in a regional energy-saving project, the Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling (BRESL).^{iii, 5} These six countries received technical assistance from the Global Environment Facility (GEF) to assess energy performance standards programs for a number of products (including room air conditioners) and to support a labeling process. The project aimed to accelerate the adoption and implementation of energy standards and labeling throughout Asia and facilitated the harmonization of test procedures, standards, and labels among developing countries in Asia.

Types of Labeling

Energy-efficiency labels typically take two forms: endorsement labels and comparative labels.

- **Endorsement labels** are voluntary and do not carry product information; they simply denote that the product adheres to a high standard of efficiency or performance. They usually are simple graphics that are easily recognizable by consumers and serve as a distinct endorsement for the product. Examples are shown in figure P2.1.
- **Comparative labels** show levels (or tiers) of efficiency and allow buyers to compare different products based on efficiency performance. These labels are usually mandatory and display several kinds of information about the product, such as annual energy consumption (India label), operating cost per year (US label), and quick response (QR) codes that provide access to more detailed information (China label). The labels may also include non-energy information that may be important to consumers, such as noise level. Some sample labels are shown in figure P2.2.

FIGURE P2.1: EXAMPLES OF ENDORSEMENT LABELS



Source: <https://www.blauer-engel.de/en>, <https://www.energystar.gov/>

Note: Germany's Blue Angel label and the United States Energy Star label are examples of endorsement labels.

ⁱⁱⁱ The BRESL project is discussed in detail in intervention P3, Establish minimum energy performance standards of cooling equipment and a mechanism to ratchet them up.

FIGURE P2.2: COMPARATIVE LABELS



Source: <https://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label>, https://www.beestarlabel.com/Content/Files/Session_2.pdf, and <https://www.china-certification.com/en/cel-new-layout-with-qr-code-for-the-china-energy-label-effective/>
 Note: (left to right) The US EnergyGuide label, India's Star label, and China's energy label are examples of comparative labels.

Labels Are Complementary to Minimum Energy Performance Standards

Labeling programs are typically closely linked to and complementary with minimum energy performance standards (MEPS). MEPS incrementally raise the lowest level of efficiency that can be legally sold, while labels—such as EnergyGuide in the United States and the China Energy Label—provide consumers information about a product's energy performance beyond MEPS to enable balanced purchasing decisions.

Labels for air conditioners also can provide consumers information on the relative global warming potential (GWP) of the refrigerant. While this is not yet in practice anywhere globally, it could have a significant impact on preparing the market for more climate-friendly refrigerants.

When a country does not yet have MEPS, local manufacturers may be resistant to MEPS because of concerns about how they could affect the manufacturers' relative position in the market and consequently product sales. Labeling is often a less controversial policy to adopt than MEPS. Governments can consider implementing labeling first and then, once established, provide an opportunity to introduce MEPS as well. For example, in Thailand, the success of the Electricity Generating Authority of Thailand (EGAT), with its voluntary energy labeling program, catalyzed the government to start mandatory enforcement of MEPS for air conditioners (ACs).

Even when MEPS already exist, labels can serve to increase the aggregate efficiency of the market and in turn give policy makers the confidence to increase MEPS. For example, the China Energy Label resulted in a concentration of demand for tiers 1 and 2, the most efficient of the five tiers. In turn, this enabled the government to align the MEPS with tier 2 air conditioners, eliminating all air conditioners that previously fell in tiers 3 through 5.

Key Factors to Consider for Implementation of Labeling Programs

- **Accompany the introduction of labels (and any revision) with information and communication targeted at consumers**

Product energy labels are a common means to help spread market awareness about sustainable cooling equipment, but these alone are not sufficient. A study by the Bureau of Energy Efficiency (BEE) in India in 2015 found that only 67 percent of people recognized the five-star label, and over 40 percent of them did not know what it meant.⁶ Information and awareness campaigns are needed to emphasize the benefits, rationale, and affordability of labels, and to provide evidence on the performance of efficient appliances to build trust and drive a change in consumer decision making.

BEE launched the BEE star label mobile application in 2015 to assist consumers in making their decisions when purchasing appliances. The application allows consumers to compare different appliance categories based on energy efficiency and cost, and to verify the accuracy of labels on the products displayed in the store. In such cases, it is important to maintain the applications and keep them updated, as the effectiveness is dependent on that.

In 2016, CLASP (formerly the Collaborative Labeling and Appliance Standards Program) and China's National Institute of Standardization collaborated to develop a QR code–based energy label and a mobile application to help consumers get access to a variety of information about the labeled products and appliances. The rollout of the QR code was accompanied by consumer awareness campaigns in 30 cities. In consumer surveys, 60 percent of respondents said they would use the QR codes to make a purchase, and 63 percent said they would use them when they are using the appliance.⁷ In addition to informing consumers, the digitalization is further expected to be helpful for stakeholders, including manufacturers, retailers, and policy makers. Manufacturers have the ability to update product information and receive consumer feedback. Retailers have access to more product information to inform their customers. Policy makers can use the digital label to disseminate updated policy and testing data.

- **Reinforce the labeling program with parallel strategies, as available, to address the first-cost barrier typically faced when purchasing more sustainable cooling equipment**

Labels inform and enhance the visibility of energy performance but do not in themselves solve the first-cost barrier that many consumers face when deciding to purchase more energy-efficient and climate-friendly cooling systems. Therefore, it is also important to develop mechanisms to address the first-cost barrier. In many countries, this has been done with targeted financial incentives,^{iv} especially for the residential sector. Enabling customers to pay the cost of the more sustainable cooling equipment over time—for example, through on-bill financing—can also help address the first-cost barrier.

For example, EGAT offered interest-free loans to consumers to offset the higher first cost of #4 and #5 ACs, and rebates to shop owners who sold #5 ACs. Participating banks provided consumers 20-month, 0 percent interest loans of 5,000 baht and 10,000 baht (approximately US\$125 to US\$250) to consumers purchasing #4 and #5 air conditioners, respectively.⁸ As a result, Thailand's labeling program not only helped increase the market share of the most efficient (#5) ACs from 19 percent to 38 percent from 1996 to 1998,⁹ but also gave its domestic AC industry a boost—#5 ACs are now being exported to Sri Lanka, Indonesia, and Australia. More recently, EGAT introduced a similar program for refrigerators. In

iv This is discussed in more detail in intervention F1, Create incentive mechanisms to shift the market toward sustainable space cooling.

2018 EGAT partnered with four credit card companies that are now offering 10-month, 0 percent interest loans to consumers buying #5 domestic refrigerators that use a natural refrigerant (R-600a).¹⁰

Similarly, China's Energy Label was paired with financial incentives to drive the top tiers and MEPS to raise the floor of the bottom tier. As a result, the share of efficient ACs (tiers 1 and 2 out of five total tiers) increased from 5 percent to 70 percent over 18 months between 2009 and 2010.^{v, 11} This in turn has helped reduce the peak summer electricity load in some cities by an estimated 30 percent.¹²

One concern with using financial incentives and subsidies, particularly in the context of developing countries, is that funding may be available for a limited time. If applied for a short duration of time (say, one year), incentives will not truly reflect a sustained market impact.^{vi} Thus, it is important to have sustained funding for a period of time that is sufficient to enable economies of scale as demand moves to higher-efficiency products to achieve a meaningful and sustained impact on the market.

Another parallel strategy is the adoption of a government procurement policy to purchase only equipment labeled as energy efficient to help secure uptake and relevance of the label, as more fully discussed under intervention P4.

■ **Get buy-in from manufacturers and other critical stakeholders**

For labels to be successful, both manufacturers and regulatory and certification bodies must fully understand the program and be able and willing to participate in and comply with the requirements. To accomplish this, policy makers should consult with all key stakeholders early on in the process to seek their input. The policy makers should present the policy as well as its anticipated impact based on past experience in adjacent industries and neighboring countries. The policy makers should also seek to understand the manufacturers' and certification bodies' current processes to set a reasonable timeframe for implementing the labels. Another strategy to get manufacturers on board is to implement voluntary labels first and make them mandatory later.

Stakeholder buy-in can be enhanced by offering up at least one open comment period on the labeling program or legislation. The United States, Australia, Japan, and the European Union (EU) all offer at least one open comment period whenever they make revisions to their labels. The US Energy Star program and the Japanese Top Runner program take this one step further by formally involving industry associations and third-party certification bodies in their committees and forums.

The province of Punjab, Pakistan, launched its first energy label in 2015 and chose fans as the first appliances for labeling.¹³ The initiative was led by the newly established Punjab Energy Department and the Punjab Energy Efficiency and Conservation Agency (with support from the World Bank and CLASP).¹⁴ Throughout the process of establishing the label, the Punjab Energy Department worked to ensure that all of the fan industry's major stakeholders were included in the labeling process and understood its benefits. These included the energy ministry, the Pakistan Fan Manufacturing Association, and the national energy-efficiency agency. The World Bank helped facilitate the engagement through two stakeholder workshops and a number of additional meetings between the fan manufacturers and the government. This stakeholder engagement process ensured that all of Pakistan's major fan manufacturers are enrolled in the program, including several small and medium-sized enterprises (SMEs)—of the 13 manufacturers producing energy-efficient fans in Pakistan today, six are SMEs.

v For more information on China Energy Label financial incentives, see intervention F1, Create incentive mechanisms to shift the market toward sustainable space cooling.

vi For more information on incentives, see intervention F1, Create incentive mechanisms to shift the market toward sustainable space cooling.

- **Establish standardized systems and access to infrastructure for testing and certification of sustainable cooling equipment and ensure the administering program has sufficient institutional capacity**

Standardized and robust testing and certification practices are key to building the public's trust in the labeling program and ensuring the full environmental benefits of labeling are realized. Between 25 percent and 50 percent of expected energy savings of energy-efficiency programs are not realized because of poor compliance.¹⁵ Labeling systems should be managed by one nodal agency with the ability to monitor and enforce the labels, and there should be clear penalties for noncompliance. The nodal government entity will also need financial resources and human resources with the appropriate training.^{vii} However, monitoring and compliance practices should be standardized and streamlined so as not to increase costs unnecessarily for the administering entity or manufacturers. Testing should be performed in either government labs or certified third-party labs. When the testing is done in a third-party lab, the government should do targeted spot checks for noncompliance.

Australia, Japan, the United States, and the EU all allow manufacturers to self-certify the energy use of their products and then require third-party certification or check-testing as a means of verification. Allowing self-declarations and third-party testing greatly reduces the financial undertaking of the regulatory bodies, but the verification must be thorough to encourage honest compliance. For example, the US Energy Star program requires third-party testing in Environmental Protection Agency–accredited testing laboratories.^{viii} In its verification process, the Australian government has developed a methodology to target verification of products that are more likely to be noncompliant and publicly shares the compliance results annually. As a result, they've seen an increase in compliance rates over time. Publicly sharing results is generally a less costly way of ensuring compliance than imposing fines.

In India, all room air conditioner models sold on the market must be registered with BEE. The manufacturers carry out national and international standard performance tests, and BEE has the right to conduct random testing of any room air conditioner model and verify its label performance. If the selected model fails the verification test, the manufacturer may be asked to update the energy performance details or even recall the product from the market in some cases. In a recent testing of refrigerators, a product failed in the testing process. Subsequently, BEE published notices about the failure of the model in national and regional newspapers in 60 cities across the country for the benefit of consumers.¹⁶

Finally, where possible, testing procedures should be aligned across regions to reduce costs for manufacturers and allow the use of regional test facilities where in-country test facilities are not available. For example, Association of Southeast Asian Nations (ASEAN) countries have jointly recognized the need for harmonization of test standards for air conditioners and are building infrastructure and capacity of testing facilities in the region. This will allow air conditioners that are tested in one ASEAN country to be sold in other ASEAN countries, reducing costs and burdens for both manufacturers and national governments. The BRESL project also facilitated regional harmonization of test procedures for targeted appliances.

vii For more information and examples on capacity building, see S2, Build capacity in critical institutions as well as among trade professionals and the heating, ventilation, and air-conditioning service sector.

viii Energy Star is a voluntary endorsement label run by the US Environmental Protection Agency and the Department of Energy. It goes beyond appliances to cover building products (windows, doors, roof products, and so on) and even entire homes. Space cooling appliances covered include central air conditioners, room air conditioners, heat pumps, and fans. For more information, please view <https://www.energystar.gov>.

- **Ensure the labels enable easy comparison of energy performance and are visually striking**

It is good practice to use a technology neutral approach when developing labels. In the case of air conditioners, this means both fixed and inverter air conditioners should use the same rating system, so consumers can compare across technologies. In addition, measuring the seasonal energy efficiency ratio (SEER) instead of the energy efficiency ratio (EER) more accurately simulates full-year energy performance and therefore the energy savings from optimized part-load air conditioners using inverters or variable speed drives.^{ix}

Key features of comparative energy labels include the following:

- **Energy use.** Energy use is generally shown as kilowatt-hour (kWh) per year. Labels may also show energy performance across climate zones, such as the newly updated Australia Energy Rating Label.
- **Operating cost.** To show consumers cost savings, some labels, such as the US EnergyGuide, show an estimated annual operating cost.
- **Comparison to similar products.** Labels should include a scale to show how each product compares to others based on either energy use or cost.
- **QR code.** With the proliferation of smartphones and mobile data, labeling programs can be significantly enhanced if the physical labels feature QR codes—machine-readable optical patterns that contain information about the item to which they are attached. The China Energy Label includes a QR code that consumers can scan to learn more about the product.^x

Comparative labels should use the following design elements:

- **Color.** Labels should effectively deploy color either to draw attention to the label as a whole, such as the bright yellow US EnergyGuide label, or to differentiate between products, such as the EU energy labels.
- **Icons.** Illustrative icons should be used when possible to cater to all language speakers. Universally accessible icons, like stars, have been used by countries to denote energy performance.

- **Revise the labels on a regular basis**

To keep pace with evolving technology and push progress on energy efficiency, labels should be revised regularly, ideally when a high proportion of products are achieving the endorsement label or are in the top tiers of the comparative label. To facilitate this effectively, it is important to provide manufacturers visibility of future increases in label stringency. For example, in India, BEE publishes the energy-efficiency standards for RACs for a multiyear period.

ix SEER measures the operation of an air conditioner over multiple outdoor temperature representative of a whole season, while EER measures the operation at one specific outdoor temperature. For a more complete explanation, please see <https://energystar.zendesk.com/hc/en-us/articles/212111387-What-is-SEER-EER-HSPF->.

x The updated China Energy Label offers a consumer platform, accessed by the QR code, with the same energy-efficiency and consumption grades from the old label and a wealth of new information, such as using the product, repairs and replacement, recycling options, seasonal energy consumption, and updates on government policy and testing data. With these new features, the digitized China Energy Label brings accessibility and transparency to the Chinese appliance market.

Revision of labels should not be contingent on revision of MEPS because revision of MEPS is often a slower process involving more approvals. Energy Star in the United States is an example of a program that can be modified independently of MEPS.

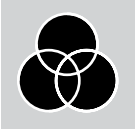

When updating labels, good practice is to rescale the label with increased thresholds to enter each labeling tier. So if a labeling system already has letters A through D, it is good practice to keep the same letters but make it harder to achieve each grade. If new letters are added, it is harder for customers to distinguish the energy performance differences between products. An example of where this was not done and the labels became less effective is the EU in 2010. The EU revised its labels, but rather than rescaling, it added A+, A++, and A+++ above its existing best-in-class label, A. However, a 2013 study by CLASP showed that consumers drew more significance from the difference between an A and a D product than they did between an A and an A+++ product, making the additional tiers less effective than they could be.¹⁷ In 2017, the EU revised its policy and now only uses A through D labels.¹⁸ And when it revises its labels, it leaves the “A class” empty, so newer, more efficient products can be distinguished from the existing market.

RESOURCES

- Global Environment Facility and United for Efficiency, 2017, *Energy-Efficient and Climate-Friendly Air Conditioners*, United Nations Environment Program, Paris, <https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-Final.pdf>.
- Zhou, Nan, and Nina Zheng Khanna, 2017, *Lessons Learned from International Energy Labeling Programs for Strengthening the China Energy Label Program*, European Council for an Energy Efficient Economy, Stockholm, https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2017/7-appliances-products-lighting-and-ict/lessons-learned-from-international-energy-labeling-programs-for-strengthening-the-china-energy-label-program/.
- CLASP, 2019, *Assessment of Brazil's Labeling Program for Air Conditioners*, Washington, DC, <https://storage.googleapis.com/clasp-siteattachments/ENG-2019-Assessment-of-Brazil%E2%80%99s-Labeling-Program-for-Air-Conditioners.pdf>.
- Abas, A. E. Pg, and T. M. I. Mahlia, 2018, “Development of Energy Labels Based on Consumer Perspective: Room Air Conditioners as a Case Study in Brunei Darussalam,” *Energy Reports* 4 (November 2018): 671–81, <https://www.sciencedirect.com/science/article/pii/S2352484718301586>.

P3. ESTABLISH MINIMUM ENERGY PERFORMANCE STANDARDS OF COOLING EQUIPMENT AND A MECHANISM TO RATCHET THEM UP

At-a-Glance

	<p>What minimum energy performance standards (MEPS) are and why they are important</p> <p>MEPS set an “energy efficiency floor” below which appliances cannot be sold. By eliminating the lowest-performing appliances, MEPS effectively raise the average efficiency of the appliances sold into the market. Establishing MEPS, if they do not already exist, is a key foundational policy intervention. Once established, the standards should be followed by a mechanism to ratchet up MEPS that automatically triggers officials to update MEPS periodically with reference to major regional or country efficiency benchmarks.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Undertake a cost-benefit analysis from the perspective of the consumer to ensure that affordability and access objectives are not compromised • Consult stakeholders to secure their buy-in for establishing and ratcheting up MEPS • Develop MEPS as part of an integrated policy approach, complemented with labeling programs, consumer and market awareness, and potential incentives for consumers • Harmonize MEPS within a region to accelerate the market toward sustainable cooling equipment, reduce costs, and create opportunities to share infrastructure • Develop monitoring, verification, and enforcement mechanisms to ensure compliance with MEPS
	<p>Barriers addressed: Lack of Awareness, Lack of Transparency, First-Cost Bias, Split Incentives, Lack of Valuation of Efficiency, Complexity of Choice</p>

What MEPS Are and Why They Are Important

MEPS are a regulatory tool that specifies the performance threshold or an “efficiency floor” below which appliances cannot be sold in the market for any commercial or consumer use. MEPS are considered an effective way to gradually increase the efficiency of energy-consuming appliances and eliminate the production, import, and sale of inefficient products, thus reducing the overall energy consumption and power demand from operation of these appliances. Adoption of MEPS by policy makers not only provides manufacturers advanced signals to progress on technology improvements to adapt to the higher energy performance requirements but also benefits consumers in the form of reduced utility bills through lower operating costs.

With MEPS in place, governments can ensure that there is no influx or dumping of inefficient products and appliances in the local market, which would result in avoidable increases in end-use energy consumption, peak power demand, and an associated environmental footprint. Moreover, MEPS almost always result in life cycle savings for consumers and monetary benefits to the government and the power sector in the form of avoided utility tariff subsidies and investment in grid infrastructure.^{xi}

^{xi} For instance, see Rwanda’s example in P1, Conduct a country-specific assessment of the cooling landscape to build a case for sustainable space cooling and assess the need to elevate it as a government priority.

For countries that do not already have MEPS in place, establishing them is one of the foundational steps to start the market transformation toward sustainable space cooling. Once MEPS are established in a country or region, they should be periodically revised or ratcheted up as the market adapts, to make them more stringent.

Establishing MEPS

MEPS are generally designed to be either “technology neutral” or “technology specific.” For cooling appliances, policy makers in many countries also use cooling capacity or size of the cooling system as an approach to design MEPS.

MEPS are said to be technology neutral when there exists a common benchmark for energy performance irrespective of the technology used. A case in point is the MEPS for RACs in India, where both fixed-speed and inverter technology RACs (of split type) have a common MEPS, denoted by the metric known as Indian Seasonal Energy Efficiency Ratio (ISEER).^{xii}

MEPS are said to be technology specific when the energy performance requirement varies with technology type. MEPS could be designed differently for fixed-speed versus inverter technology, cooling only versus heat pump technology, window versus split type, and so on. In China, MEPS for fixed-speed, inverter, and heat pump technology are different, and a unique metric is defined to represent them. EER is used as a metric for fixed-speed ACs,^{xiii} whereas SEER and annual performance factor (APF) are used for cooling only and heat pump type inverter ACs, respectively. In India, while the MEPS are the same for a fixed-speed and inverter technology for the split-type RAC category, the energy performance standards are different for window and split-type RACs.

MEPS can also vary with cooling capacity. Cooling systems on the market are available over a wide range of cooling capacities. In particular, the RAC segment (typically less than 15–20 kilowatt [kW] capacity), which is the largest segment of the market, exhibits a strong relationship between the size of the compressor and energy-efficiency level. To maximize the energy savings benefits, policy makers often adopt different MEPS for different cooling capacity ranges of space cooling systems. In China and South Korea, MEPS are more stringent for the lower cooling capacity systems (typically less than 4 kW) and gradually become less stringent for higher cooling capacity systems (4–10 kW and greater than 10 kW). On the other hand, in countries such as India and the United States, common MEPS are adopted for cooling systems up to a certain cooling capacity. For example, in India, the MEPS are the same for cooling systems up to 10.5 kW.

MEPS can be designed for different climate zones in a country depending on the range of climate conditions and usage behavior. In the United States, the Department of Energy developed MEPS for split-type central air conditioners for different regions of the country, with more stringent MEPS for regions with higher requirements for cooling, thus targeting the higher energy savings potential.¹⁹

MEPS can be designed to include low-GWP refrigerants to advance the overall climate impact reduction from space cooling systems. In the EU, the Ecodesign directive requires manufacturers to design air

xii ISEER is an energy-efficiency metric to determine the seasonal performance of the air conditioner unit under varying outdoor temperature conditions. ISEER is a ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period.

xiii EER is a ratio of how much cooling an AC can deliver with respect to the power it consumes to deliver that cooling at a specific standard temperature condition.

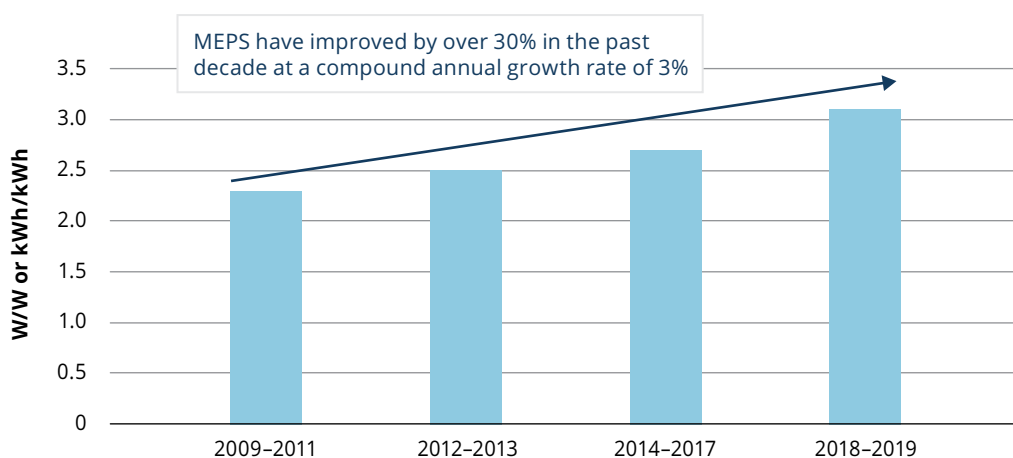
conditioners that comply with different MEPS depending on whether the GWP of the refrigerant used is greater or less than 150.²⁰

Need for Ratcheting Up MEPS

By revising MEPS at a defined frequency, governments can ensure that energy savings flow continuously while less efficient products are phased out of the market. Also, having a planned schedule for revisions provides an adequate and timely signal to the manufacturers to invest in innovation and research and development, and offer energy-efficient products into the market. This helps achieve economies of scale for more energy-efficient products, bringing their first costs down and easing the transition to more stringent levels of energy performance. With any revisions in MEPS, the appliance labels should ratchet up simultaneously.

In India, BEE publishes the energy-efficiency standards for RACs for a multiyear period, including the MEPS target for every two years, as shown in figure P3.1.

FIGURE P3.1: MINIMUM ENERGY PERFORMANCE STANDARD FOR RACs IN INDIA



Source: Developed by RMI based on information from Ministry of Power, 2017, "Part II—Sec. 3(ii)," *The Gazette of India: Extraordinary*, August 8, 2017.

Note: The MEPS shown in the figure are for mini-split-type RACs. In 2018–19, the metric for energy efficiency was changed from EER to ISEER.

Key Factors to Consider for Establishing and Ratcheting Up MEPS

- **Undertake a cost-benefit analysis from the perspective of the consumer to ensure that affordability and access objectives are not compromised**

While establishing MEPS, policy makers should undertake a cost-benefit analysis to ensure consumer affordability of the more efficient equipment, considering both current and projected future pricing as impacted by volume growth and consequent increased economies of scale. This is important to ensure consumer access goals are not compromised. Prior to this, a whole-system analysis to support implementation and ensure that the MEPS are appropriate and relevant to the market should have occurred during the due diligence and assessment stage (that is, intervention P1).

- **Consult stakeholders to secure their buy-in for establishing and ratcheting up MEPS**

When working toward establishing MEPS or ratcheting up existing MEPS for a market or region, it is important that all the relevant stakeholders—such as industry associations, testing laboratories, certification bodies, and other participants in the supply chain (including customs entities, to ensure they can identify noncompliant imports)—are involved and informed about the requirements of the standards to ensure their support and participation toward adoption of the proposed standards. When undertaking the cost-benefit analysis, it is also important to understand the relative benefits among stakeholders and, accordingly, develop support mechanisms for stakeholders who are likely to face challenges with the MEPS implementation. A phasedown schedule or a target date of implementation that allows for sufficient lead time for the industry to reach compliance is an important step toward gaining wider stakeholder support of the policy.

An example of this is Japan's Top Runner program, launched in 1997. The program mandated that by 2004, all AC manufacturers had to have a sales-weighted average EER of 5.3 (watt/watt [W/W]) for small ACs and 4.9 (W/W) for larger ACs—this was approximately 60 percent more efficient than the market average efficiency in 1997. Given the aggressive target—representing an improvement of more than 7.5 percent per year—manufacturers used several technical measures to improve efficiency. Between 1995 and 2005, RAC efficiency in Japan, which had not improved substantially over time prior to the program, improved by nearly 100 percent. In 2006, a new target was established for 2010, which required a further improvement of about 20 percent. A Lawrence Berkeley National Laboratory analysis shows that, from 1996 to 2015, the program led to improvement of AC efficiency by more than 90 percent, while the inflation-adjusted prices declined by more than 80 percent.²¹

A key consideration while establishing or ratcheting up MEPS in a country is that the need for the energy performance standards should be balanced with the local market's readiness to adapt to the new standards. Policy makers need to have sufficient insights about the local space cooling market—such as domestic manufacturers, imported products, and their relative market shares—testing infrastructure, and trade within a specific region. Establishing MEPS below the minimum energy performance that is already being delivered by manufacturers to other markets in the region will result in market proliferation of less efficient appliances with higher energy consumption. On the other hand, setting the MEPS requirements too stringent can negatively affect local manufacturers' and importers' ability to meet the standards and also significantly add to the cost burden for the government in terms of setting up requisite testing infrastructure to ensure verification and compliance of the products.

A case in point is the Kenyan MEPS. The Kenya Bureau of Standards first introduced minimum energy performance standards for RACs in 2017. However, the industry was unable to meet the standard's efficiency testing requirements, which was not well suited to Kenya's climate. This resulted in a 60 percent decrease in RAC imports from 2017 to 2018.²² Kenya does not manufacture RACs, so this means 60 percent fewer RACs were available for purchase. As a result, the Kenya Bureau of Standards convened a Technical Committee and issued revised standards that proposed following international test standards for measuring performance of RACs.

- **Develop MEPS as part of an integrated policy approach, complemented with labeling programs, consumer and market awareness, and potential incentives for consumers**

While MEPS implementation and periodic ratcheting up are key to keep growing cooling energy demand in check, consumers' preference for a low first cost is often the major barrier, particularly in developing

countries, resulting in continued adoption of the least efficient products. MEPS are key to eliminating less efficient products, and with additional policy measures, they can help push the market toward higher-efficiency and lower life cycle cost products.

In 1989, the Chinese government introduced MEPS for several domestic and commercial products, and now those MEPS expand to industrial equipment as well. While MEPS in China set the floor for the minimum performance level, the government recognized that consumer education and incentives are important to pull the market toward energy-efficient products. Key to China's accelerated market adoption of efficient products was complementing the MEPS with the following:

- **A strong labeling program.** Starting in 1999, a voluntary and then mandatory (2005) labeling program was launched to encourage consumers to purchase energy-efficient products, including air conditioners. The China Energy Label program now covers 37 products.
- **A national subsidy program.** The Promoting Energy-Efficient Appliance for the Benefit of People Program (2009–13) offered subsidies to consumers on a variety of energy-efficient home appliances, including air conditioners.
 - The subsidy program was spread out in two phases—2009–11 and 2012–13—and total subsidies worth US\$4.25 billion per phase were allocated for this home appliance subsidy program.²³
 - According to official reports, this program helped increase the share of high-efficiency RAC units from 5 percent to 70 percent within 18 months;²⁴ this increase in the overall energy efficiency in ACs sold was subsequently codified in the MEPS revision, making them more stringent. China also took steps to shift the market toward variable-speed inverter RACs, achieving an increase in their market share from 7 percent in 2007 to over 60 percent in 2016.²⁵
- **Consumer and market awareness.** China's National Institute of Standardization collaborated with CLASP (also discussed in P2) to enhance consumer access to information on energy-efficient products through the National Institute of Standardization's awareness campaigns. They undertook periodic surveys to understand consumer behavior and gauge the efficacy of the China Energy Label program. These surveys have been instrumental in improving and expanding the labeling program in China.

As a collective outcome of these market interventions, it is estimated that China will obviate the need to build 28 gigawatts of generating capacity by 2020.²⁶

- **Harmonize MEPS within a region to accelerate the market toward sustainable cooling equipment, reduce costs, and create opportunities to share infrastructure**

Harmonizing energy-efficiency standards within a region or with markets with which there exists a trade relationship is an effective way to ensure that there are no unintended consequences, such as disruption of the domestic manufacturing or import market, or price escalation of sustainable cooling equipment. Harmonizing energy performance standards across a region has a likely advantage of reduced cost of energy-efficient technologies because of the availability of standardized testing, labeling, and other compliance requirements and increased economies of scale. Policy makers of countries within a region should come together to identify common market characteristics and develop MEPS that not only meet the objective of promoting higher-efficiency products but also are amenable to all the stakeholders involved.

A case in point is the ASEAN Regional Policy Roadmap for Harmonization of Energy Performance Standards for Air Conditioners.^{xiv, 27} The policy road map, which was released in 2015, recommended that the MEPS for air conditioners in the region be updated to an EER of 2.9 W/W or cooling seasonal performance factor (CSPF) of 3.08 W/W by 2020 for all fixed and inverter technology air conditioners below 3.52 kW capacity.^{xv} The policy road map also recommended a review and update of the MEPS at a five-year frequency. In addition, the member countries recognized the need for harmonization of test standards for air conditioners and are building common infrastructure and capacity of testing facilities in the region.

In line with the proposed harmonization of MEPS, several ASEAN member countries (including Thailand, the Philippines, Malaysia, and Vietnam) had developed a national policy road map for promoting higher-efficiency air conditioners that is aligned with harmonized MEPS for the region. For example, Thailand set a target of achieving the stated MEPS by 2020 for all air conditioners up to 12 kW capacity; Vietnam set a target to achieve the stated MEPS one year in advance, that is, by 2019.

Another example is the multi-country BRESL project (introduced in P2).²⁸ Supported by the United Nations Development Program (UNDP) and the GEF, the five-year BRESL project ended in 2016 and included six countries: Bangladesh, China, Indonesia, Pakistan, Thailand, and Vietnam. The project aimed to accelerate the adoption and implementation of an energy standards and labels program in Asia for several targeted products, including fans, room air conditioners, and refrigerators. The project also facilitated harmonization of test procedures, standards, and labels among developing countries in Asia, when appropriate.

The BRESL project consisted of five major components: assisting with the development of regulations for the targeted products, capacity-building programs, technical assistance for local product manufacturers to help them develop efficient products and realize profit opportunities from efficient products, regional cooperation activities (including sharing of best practices and harmonization of standards and labels), and demonstration projects showcasing various aspects of the design, facilitation, and implementation of the standards and labeling programs.

▪ **Develop monitoring, verification, and enforcement mechanisms to ensure compliance with MEPS**

To ensure that MEPS are implemented and adopted successfully in the market, it is key that compliance with the energy performance standards is regularly monitored and verified once MEPS are established. Typically, this falls under the charge of a government entity responsible nationwide for standards (such as the Kenya Bureau of Standards) or for energy efficiency (such as the BEE in India). A regular monitoring and verification protocol ensures that manufacturers deliver the right product to the market and also helps to build confidence among consumers on product quality and stated energy savings. The requirement for manufacturers to comply with national, regional, or international testing standards for air conditioners and other cooling technologies and verify the stated performance through certified laboratories and third parties ensures that all the products entering the market meet the minimum performance requirements.

In Kenya, the Kenya Bureau of Standards demonstrated the good practices of establishing the regulatory structure to enforce MEPS and integrating the compliance checks with the importation process

xiv The Association of Southeast Asian Nations is an intergovernmental group of 10 countries in Southeast Asia that aims to promote cooperation among the members across several aspects, including economic, political, educational, and cultural issues.

xv EER is a ratio of how much cooling an AC can deliver regarding the power it consumes to deliver that cooling at a specific standard temperature condition. According to the ISO 16358-1:2013 standard, CSPF (also referred to as seasonal energy efficiency ratio, or SEER) is defined as the ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling over a period to the total annual amount of energy consumed by the equipment during the same period.

when it implemented mandatory MEPS for single-split air conditioners in 2017. The Kenya Energy and Petroleum Regulatory Authority (EPRA), formerly the Energy Regulatory Commission, oversees the Pre-export Verification of Conformity Program.²⁹ In this program, a third-party, accredited inspection company verifies conformity to Kenyan standards at the point of export before the ACs are shipped to Kenya. EPRA also requires that all the appliances are registered in a central database along with supporting test certificates. Upon successful verification, EPRA issues a certificate and an energy label that is legally required to be affixed to air conditioners. The energy label includes one to five stars and was modeled after Ghana's energy labeling system. The EPRA has the right to undertake random checks, and any noncompliance with the requirements is subject to a hefty monetary fine. The Kenyan MEPS for air conditioners are now under revision, and therefore the EPRA had not enforced the registration process at the time this publication was written. However, the overall process is already in place for appliances such as refrigerators and is not likely to face any major roadblock in its implementation. This is an example of a good practice for establishing monitoring, verification, and enforcement mechanisms.

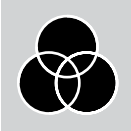

Many countries have applied penalties—mostly in the form of negative publicity—for noncompliance with MEPS. For example, the BEE in India reserves the right to have noncompliant stock removed from market shelves and also publishes a notice about noncompliant models and manufacturers in local newspapers.

RESOURCES

- Global Environment Facility and United for Efficiency, 2017, *Energy-Efficient and Climate-Friendly Air Conditioners*, United Nations Environment Program, Paris, <https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-Final.pdf>.
- Scholand, Michael, 2015, *Developing Minimum Energy Performance Standards for Lighting Products*, United Nations Environment Program, Paris, https://united4efficiency.org/wp-content/uploads/2016/09/Developing_MEPS_for_Lighting_Products_web_14-07-15.pdf.
- Park, Won Young, Nihar Shah, and Brian Gerke, 2017, *Assessment of Commercially Available Energy-Efficient Room Air Conditioners Including Models with Low Global Warming Potential (GWP) Refrigerants*, Lawrence Berkeley National Laboratory, Berkeley, CA, https://eta.lbl.gov/sites/default/files/publications/assessment_of_racs_lbnl-_2001047.pdf.
- “AC Notification,” 2017, Bureau of Energy Efficiency, Ministry of Power, Government of India, https://www.beestarlabel.com/Content/Files/AC_Notification.pdf.
- “Regional Standards Enforcement,” US Department of Energy (accessed September 16, 2019), <https://www.energy.gov/gc/legal-resources/office-assistant-general-counsel-enforcement/regional-standards-enforcement>.
- “Commission Regulation (EU) No 206/2012,” *Official Journal of the European Union*, March 6, 2012, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0206&from=EN>.
- “ASEAN Regional Policy Roadmap for Harmonization of Energy Performance Standards for Air Conditioners,” ASEAN SHINE (accessed September 16, 2019), <https://www.aseanshine.org/asean-shine-task-force/d/asean-regional-policy-roadmap-for-harmonization-of-energy-performance-standards-for-air-conditioners>.
- *Kenya Room Air Conditioner Market Assessment and Policy Options Analysis*, 2019, CLASP, <https://storage.googleapis.com/clasp-siteattachments/2019-Kenya-Room-Air-Conditioner-Market-Assessment-and-Policy-Options-Analysis.pdf>.

P4. CATALYZE THE MARKET BY LEADING BY EXAMPLE THROUGH GOVERNMENT BUDGETING AND PROCUREMENT STRATEGIES FOR ENERGY-EFFICIENT BUILDINGS AND SUSTAINABLE COOLING EQUIPMENT

At-a-Glance

	<p>What government lead-by-example is and why it matters</p> <p>As large owners or lessees of buildings and purchasers of cooling equipment and systems, governments have a huge opportunity to save money and reduce their environmental impact by following sustainable space cooling strategies. In addition, their example can instill confidence across the private sector and help drive down costs of sustainable space cooling.</p> <p>Government lead-by-example strategies may first apply to efficient or sustainable cooling equipment, as they may be easier to implement and involve fewer interdependencies (compared to those for buildings). Lead-by-example strategies for energy-efficient buildings may generally require greater government oversight capacity.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Make energy-efficient or sustainable procurement supported by life cycle cost analysis the default option • Provide training, tools, and outreach to procurement staff and provide incentives for behavior change • Monitor compliance and track impacts for continuous improvement
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Misaligned Policies</p>

What Government Lead-by-Example Is and Why It Is Important

The public sector, as one of the largest buyers in a country and typically a long-term owner or tenant of buildings, can set the precedent and catalyze market transformation through good procurement practices. The government's adoption of sustainable procurement practices builds market confidence and helps catalyze demand for sustainable cooling equipment and energy-efficient buildings. Public procurement can also be a way to drive the transition toward lower GWP refrigerants.

Government lead-by-example strategies may first apply to efficient/sustainable cooling equipment, as they may be easier to implement and involve fewer interdependencies (compared to those for buildings). Lead-by-example strategies for energy-efficient buildings will generally require greater government capacity due to the increased complexity in developing whole-building strategies and establishing benchmarks and oversight of implementation and outcomes. However, there are internationally recognized green building certification standards that could be used by different countries.

Multiple Approaches for Sustainable Public Procurement

When establishing an energy-efficient or green procurement policy, a logical first question is how to define the buildings or products that meet the procurement aims. Several approaches can be followed, such as:³⁰

1. **Labels.** When existing labels are available, require products to reach a certain level.
2. **Catalog of technical specifications.** Maintain a document with technical specifications or energy-efficiency standards for equipment that is frequently purchased.
3. **Life cycle costing/best value award.** Require a life cycle cost analysis to factor into procurement decisions.
4. **Energy-efficient preferences.** Award extra points or price preferences for more energy-efficient products.
5. **Qualifying product list.** Maintain a database of specific products that meet government energy-efficiency specifications.

In the case of vapor compression–based air conditioners, the approach should consider disallowing or disincentivizing products with refrigerants that have ozone depletion potential (ODP) and high GWP subject to phaseout or phasedown under the Montreal Protocol and its Kigali Amendment. The above list is specific to cooling equipment but can easily be adapted to apply to buildings as well.

The Australian government has set an example of using its building labeling system to inform its building leasing decisions. Per the Australia Energy Efficiency in Government Operations policy, all government operations above a certain size will lease space only in buildings that meet a National Australian Built Environment Rating System (NABERS) rating of 4.5 stars or higher.^{xvi} Over the past 10 years, the total amount of energy consumed by the Australian government within its tenancies has decreased, and the energy intensity (measured in terms of energy use per person per year) has improved by 28.5 percent.³¹ Following the government's example, many major corporations have followed suit, leasing space in energy-efficient buildings. The government's action has thus advanced the market demand for energy-efficient buildings.

The Indian government is setting a precedent in the adoption of high-efficiency appliances. In August 2017, India's Ministry of Finance directed all central government offices (2,500 buildings) to switch to energy-efficient appliances—in particular, LED lights and super-efficient air conditioners.³² The super-efficient ACs are expected to consume 30 percent less energy, translating to reductions in greenhouse gas (GHG) emissions. This is part of a broader strategy to reduce the building sector's emissions intensity—complementing efforts to increase energy efficiency in buildings through code adoption—in alignment with India's nationally determined contribution's goals to address climate change. Of 100,000 high-efficiency ACs procured during the first phase of this initiative, 40 percent also used low-GWP refrigerant R-290.^{xvii} It is envisioned that this bulk procurement—managed by India's Energy Efficiency Services Limited (EESL), a public energy service company (ESCO, also referred to as a super-ESCO)—will build greater confidence in R-290–based super-efficient AC appliances available in the Indian market

xvi This is discussed in greater detail in intervention P6, Cultivate market demand for energy-efficient buildings by increasing visibility of building energy performance.

xvii Discussed in greater detail in section 2 in the *Primer*, R-290, also referred to as propane, is a natural refrigerant with favorable thermodynamic characteristics, zero ozone-layer depletion potential, and a global warming potential (GWP) of just three (compared to most hydrofluorocarbons, which have a GWP in the thousands). However, it has high flammability and thus is restricted in the quantity that can be used for indoor applications, due to occupant safety concerns.

and encourage the transition to zero ODP and low-GWP refrigerants to accelerate the hydrofluorocarbon (HFC) phasedown. EESL has also made bulk purchases of high-efficiency fans for government buildings.^{xviii}

Key Factors to Consider for Implementation of Government Lead-by-Example

- **Make energy-efficient or sustainable procurement supported by life cycle cost analysis the default option**

A voluntary energy-efficient or sustainable procurement policy (including the transition toward more climate-friendly refrigerants) is a good first step while beginning with a small set of products, conducting analyses, and developing the full program infrastructure. However, once the program is established, its impact will be far greater if it is mandatory. If procurement officers want to procure non-energy-efficient equipment, they should be required to make the case supporting that decision. For example, US government agencies must procure Energy Star or Federal Energy Management Program–designated equipment. If no options are available or cost-effective, the head of the agency must state that in writing in order to be granted an exemption.³³

Ultimately, energy-efficient procurement practices should extend to buildings as well, promoting high-performance buildings that have a lower energy intensity and generally lower operational costs. For example, the US's Energy Policy Act of 2005 requires all new federal buildings to be designed to use 30 percent less energy than requirements under American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 or the International Energy Conservation Code (IECC).

- **Provide training, tools, and outreach to procurement staff and provide incentives for behavior change**

Government procurement decisions are made by millions of individual government staff members globally. They must fully understand why sustainable procurement is important, what their jurisdictions' policies and practices are, and what resources are available to them. Governments can provide these tools, trainings, and outreach themselves, hire consultants, or work with partners to provide the best service. Staff may still be hesitant to use sustainable procurement practices if they require more work or introduce new risks. Therefore, incentives for either institutions or individuals are often helpful to bring about behavioral change.

To provide resources and facilitate the sharing of experiences, in 1996, the Japanese government helped create the Green Purchasing Network, a nonstate, nonprofit organization with a mission to promote sustainable purchasing in Japan.³⁴ The Green Purchasing Network provides training to local government officials and maintains sustainable purchasing guidelines and an eco-products database. It also honors businesses and governments with innovative purchasing programs at its annual awards.

To incentivize sustainable purchasing in the Republic of Korea, the South Korean Ministry of Environment requires each city, county, and province to report their purchases annually.³⁵ The Ministry of Environment then provides grants or subsidies to local governments that have strong sustainable purchasing records.

xviii For more information on EESL's bulk procurement, see F2, Aggregate demand to drive down the acquisition cost of sustainable cooling equipment, build market confidence, and spur greater adoption.

■ Monitor compliance and track impacts for continuous improvement

Monitoring compliance and tracking financial and environmental impacts are key to measuring the success and reinforcing the benefits of any green public procurement program and understanding where improvements can be made.

In the United States, all federal government agencies report their public procurements greater than US\$25,000 using the Federal Procurement Data System.³⁶ Each agency must submit an annual Strategic Sustainability Performance Plan, and key milestones and activities are tracked through semiannual scorecards. Two government bodies, the Office of Management and Budget and the Council on Environmental Quality, are charged with reviewing the scorecards and ensuring compliance.

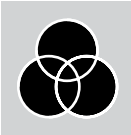

Similarly, energy data visibility and tracking are key for promoting energy efficiency in public buildings, and there are energy data management systems available to enable understanding, monitoring, and the setting of targets for continuous energy-efficiency improvements. One such example is the Standard Energy Efficiency Data (SEED) Platform, an open-source, secure enterprise data platform for managing portfolio-scale building performance data from a variety of sources.³⁷ The SEED Platform eliminates many of the technical and workflow challenges associated with collecting and managing performance data for large building portfolios. It has the potential to significantly reduce the administrative effort required by public agencies or other organizations to implement building performance reporting and transparency programs.

RESOURCES

- Singh, Jas, Alicia Culver, and Melis Bitlis, 2012, *Public Procurement of Energy Efficient Products: Lessons from around the World*, ESMAP, Washington, DC, <https://openknowledge.worldbank.org/bitstream/handle/10986/17485/735070ESMOP12700EEProducts0TR003012.pdf?sequence=1&isAllowed=y>.
- OECD, 2015, *Going Green: Best Practices for Sustainable Procurement*, Paris, https://www.oecd.org/gov/public-procurement/Going_Green_Best_Practices_for_Sustainable_Procurement.pdf.

P5. DEVELOP A NATIONWIDE COOLING ACTION PLAN OR ROAD MAP WITH MEANINGFUL TARGETS AND EXPECTED IMPACTS

At-a-Glance

	<p>Importance of national cooling action plan and road maps</p> <p>Macro-level policy initiatives can define a comprehensive strategic vision for the country, create alignment between the necessary solution linkages across all barrier categories, harmonize efforts to use an integrative approach to address the cross-cutting nature of cooling, and generate alignment among public and private entities to prioritize action toward sustainable space cooling.</p> <p>Developing a nationwide cooling action plan should typically be a cross-functional and collaborative intervention. Therefore, it may be important to first ensure critical stakeholder alignment on cooling as a priority area for action. Thus, while foundations and preparations can commence in the short term (such as during the country-specific cooling assessment in P1), it may take some time to fully develop a nationwide cooling action plan.</p> <p>Taking cue from, and in alignment with, the national cooling action plan, subnational cooling action plans could be developed as well, for supplementing the national vision with action at local levels.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Leverage and build upon existing data-driven research, integrating inputs from government, academia, civil society, and industry in order to support evidence-based policy making • Appoint a nodal agency to lead the cooling action plan development, given the cross-cutting nature of cooling, spanning multiple national ministries • Adopt a holistic approach to address cooling and establish clear pathways for systemic change • Align the cooling action plan with existing national priorities and policies, such as refrigerant transition plans, energy-efficiency targets, and nationally determined contributions
	<p>Barriers addressed: Lack of Awareness, Complexity of Choice, Misaligned Policies</p>

What National Cooling Action Plans Are and Why They Are Important

Given its cross-cutting nature, addressing cooling at a country level involves engaging multiple stakeholders—policy makers, manufacturers, refrigerant production entities, building owners, and end-users—whose interests may not always align. Therefore, establishing a strong political will and bringing alignment among the public and private stakeholders are key for prioritizing action and driving market transformation toward sustainable space cooling.

National cooling action plans can drive such alignment by establishing meaningful nationwide directives, reinforcing the issue of cooling as a national priority, and leveraging interlinkages with other government agendas. Building on the country-specific due diligence (see P1), developing a cohesive national cooling action plan can set the direction and actionable targets for addressing access to cooling while reducing its environmentally harmful impacts and maximizing the socioeconomic benefits.

In March 2019, India became the first major economy to create a national policy document on cooling—the India Cooling Action Plan (ICAP)—and was followed by China and Rwanda, which also released their nationwide cooling strategies in the same year. At the time of writing, over 25 countries were in the process of developing national cooling plans or road maps (supported by the Kigali Cooling Efficiency Program [K-CEP]).^{xix}

Countries may follow the approach of starting with due diligence (P1) as the foundational step and, once awareness has been elevated and perhaps several basic interventions are in place (creating an enabling environment for systemic change), then progressing to developing a national cooling action plan in an integrative way to scale up efforts. India is an example of this approach, while Rwanda has taken a different approach by performing the due diligence (P1) and developing national cooling plan in close succession. The Rwanda Cooling Initiative (R-COOL, also discussed in P1) includes a thorough market assessment, followed by the development of the National Cooling Strategy, which in turn proposes pathways for establishing minimum energy performance standards for cooling equipment, product labels, and financial mechanisms.

Taking cue from, and in alignment with, the national cooling action plan, subnational cooling action plans could be developed as well, for supplementing the national vision with action at local levels.

Key Factors to Consider for Implementation for Establishing Cooling Action Plans or Road Maps

- **Leverage and build upon existing data-driven research, integrating inputs from government, academia, civil society, and industry in order to support evidence-based policy making**

Building on the country-specific due diligence (P1) and leveraging the knowledge base available among both public and private sector entities, data-driven research should be used to inform a country's pathway toward sustainable space cooling. India has applied this approach, becoming the first major economy to develop a comprehensive national cooling action plan with a proactive and long-term (20-year) vision to address cooling requirements across sectors while neutralizing their impact. The development of the ICAP integrated data from different government sources and leveraged existing and new research efforts of civil society, academia, and industry organizations in order to arrive at the best available national data, which became the basis of ICAP's goals and policy recommendations.

- **Appoint a nodal agency to lead the cooling action plan development, given the cross-cutting nature of cooling, spanning multiple national ministries**

Because the cooling agenda cuts across several traditional government ministries or agencies, it is important to have one nodal agency leading the development of the cooling action plan while coordinating with and unifying inputs from all involved agencies. The lead entity should adopt a cross-functional collaborative process, engaging multiple stakeholders in the planning process to create a shared understanding of the solutions and build alignment.

The ICAP is a model where a nodal agency—the Ministry of Environment, Forest, and Climate Change (MoEFCC), Government of India—led the development process and orchestrated alignment among

xix Drawing upon this experience, the Kigali Cooling Efficiency Program provides high-level guiding principles for countries to draw on when considering their development of national cooling plans in this brief: <https://www.k-cep.org/wp-content/uploads/2019/04/Principles-for-National-Cooling-Plans.pdf>.

several involved ministries and private stakeholders. The MoEFCC established working groups to represent all the relevant cooling sectors: the consumption sectors (space cooling, cold chain, refrigeration, and transportation), the service sector, indigenous production of refrigerants, and research and development (R&D). Each working group was comprised of representatives from the relevant government ministries, industry, academia, and civil society, and was tasked with conducting a deep dive into the current and projected cooling demand and considerations across policy, technology, and market factors. The multistakeholder and collaborative process fostered alignment among diverse stakeholder interests and ensured collective buy-in of ICAP before it was published. The MoEFCC acted as the unifying entity that consolidated the research and recommendations of the various working groups and synthesized them into one cohesive nationwide cooling action plan.

- **Adopt a holistic approach to address cooling and establish clear pathways for systemic change**

A policy road map or action plan will be successful only if it takes an integrated view and approach toward addressing the cooling challenge and establishing clear policy pathways to drive market transformation. ICAP, for instance, adopts an integrated approach to cooling by encompassing passive cooling strategies to reduce cooling loads, energy-efficient active cooling strategies to serve the cooling loads efficiently, and strategies to control and optimize the cooling loads in the built environment in India. In parallel, ICAP also encompasses alternative cooling technologies and an innovative ecosystem to support the development and deployment of low-GWP refrigerant alternatives. As a 20-year road map that identifies near-term, mid-term, and long-term actions and strategies, ICAP is a live document that lends itself to iterative refinement as new information becomes available. Once a cooling action plan is developed, it is important to put in place clear and effective implementation mechanisms and ensure continued coordination and monitoring of the implementation. To that end, India has established a Steering Committee to monitor the implementation of ICAP recommendations.^{xx}

In order to catalyze market transformation in Rwanda, the R-COOL program aims to first set the policy framework in place (through the National Cooling Strategy), and then move on to raising awareness of the new efficiency standards and establishing financial mechanisms to effectively encourage the adoption of the highest performing products.³⁸ The R-COOL program will also include a national product registration system that will enable country officials to monitor the market and update policies as necessary for ensuring desired systemic changes.

- **Align the cooling action plan with existing national priorities and policies, such as refrigerant transition plans, energy-efficiency targets, and nationally determined contributions**

The cooling action plan as a national strategy document on space cooling can achieve the largest impact when aligned with existing national priorities and policies. The Rwanda National Cooling Strategy (under development), ICAP, and China's Green and High-Efficiency Cooling Action Plan all strive to integrate considerations of hydrochlorofluorocarbon (HCFC) refrigerant phaseout and HFC phasedown, as committed by these countries under the Kigali Amendment of the Montreal Protocol, with energy efficiency and access to cooling.

xx At the time of this publication, ICAP implementation process is in the nascent phase and it is too early to comment on the efficacy of the implementation mechanisms put in place by India.

ICAP calls for harmonization of the thus far separate policy streams of energy efficiency and refrigerant transitions and recommends identifying actions to promote the benefits of improved energy efficiency alongside the Fluorinated gases (F-gases) transition. In addition, the ICAP recommendations bring in synergies with ongoing government programs and schemes in India—such as Power for All^{xxi} and Doubling Farmers' Incomes^{xxii}—in order to maximize the social and economic co-benefits.

Similarly, China's Green and High-Efficiency Cooling Action Plan references several existing national priorities and policies. It is part of the 13th Five-Year Comprehensive Work Plan for Energy Conservation and Emissions Reduction and also references China's commitment to the Paris Agreement.³⁹ It also aligns itself with several more specific existing initiatives for green industries, green procurement practices, and green data centers, among others.

RESOURCES

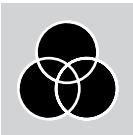

- Ministry of Environment, Forest and Climate Change, 2019, *India Cooling Action Plan*, Government of India, New Delhi, <http://ozonecell.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf>.
- Republic of Rwanda, 2019, *National Cooling Strategy*, Kigali, <http://www.fonerwa.org/sites/default/files/Rwanda%20National%20Cooling%20Strategy.pdf>.
- Institute for Governance and Sustainable Development, 2019, "Green and High-Efficiency Cooling Action Plan: English Translation," Washington, DC, <http://www.igsd.org/wp-content/uploads/2019/07/ENG-China-Cooling-Action-Plan.pdf>.
- Kigali Cooling Efficiency Program, 2018, *Principles for National Cooling Plans*, San Francisco, CA, <https://www.k-cep.org/wp-content/uploads/2019/04/Principles-for-National-Cooling-Plans.pdf>.

xxi A joint initiative of the government of India and state governments, the Power for All program has the objective to provide uninterrupted power to all households, industry, commercial businesses, public needs, and any other electricity-consuming entity in the country. Learn more here: <https://powermin.nic.in/en/content/power-all>.

xxii The government of India's Doubling Farmers' Incomes initiative sets the objective to double farmers' income by 2022–23 as central to promote farmers' welfare, reduce agrarian distress, and bring parity between the income of farmers and those working in nonagricultural professions. Learn more here: https://niti.gov.in/writereaddata/files/document_publication/DOUBLING%20FARMERS%20INCOME.pdf.

P6. CULTIVATE MARKET DEMAND FOR ENERGY-EFFICIENT BUILDINGS BY INCREASING VISIBILITY OF BUILDING ENERGY PERFORMANCE

At-a-Glance

	<p>Importance of visibility of building energy performance</p> <p>Visibility of building energy performance helps the market place a value on energy-efficient and lower-operating-cost buildings. Visibility of building energy performance is achieved through building energy performance rating systems (asset ratings or operational ratings) and building energy disclosure requirements.</p> <p>Countries may find it easier (or more palatable) to start with a voluntary rating system for new buildings, which can be made mandatory as market readiness increases. Once the institutional frameworks are advanced enough to take up existing building intervention models, the rating systems can be expanded to existing buildings.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Mandate building energy disclosures and make the information easily available, either at the time of sale or in a public data repository • Develop tools and human capacity to rate or certify buildings • Provide recommendations along with ratings • Enhance user awareness of building energy performance through visible means
	<p>Barriers addressed: Lack of Awareness, Lack of Transparency, Lack of Valuation of Efficiency, Complexity of Choice</p>

What Visibility of Building Energy Performance Is and Why It Is Important

The energy performance of a building is defined as the amount of energy actually consumed (or estimated to be necessary) to meet the needs associated with the operation of the building, such as heating and cooling, lighting, and provision of hot water, typically in relation to its size and function. There are multiple means to achieve, and enhance, public visibility of energy performance in buildings that will help to dramatically reduce the need for cooling and bring attention to the energy performance associated with cooling. At a broader level, this is achieved through methods such as building energy rating systems—for example, Leadership in Energy and Environmental Design (LEED), a globally accepted building energy rating system, and Green Rating for Integrated Habitat Assessment (GRIHA), a country-specific (India) example—and through building energy disclosure requirements. These methods facilitate benchmarking and comparisons—even healthy competition—and by stimulating demand, they help catalyze the adoption of energy-efficient design and practices.

Visibility of building energy performance helps the market assess a building's energy-related operating costs, making the financial value of high performance more visible. Building owners can then factor operating costs into decisions, helping them justify efficiency investments in their buildings. Not only will operating costs be lower for the current owner or occupier, but once the market becomes conditioned to building energy rating systems along with their associated energy labels, the higher value of the building will be reflected at the time of sale and lease-up.

Space cooling is one of the major end uses in a building's energy consumption. For mixed-climate countries such as the United States, cooling can account for 15 percent to 20 percent of the building's

overall annual energy consumption. For tropical countries, this number is a lot higher. For instance, as per the Singapore government's Building and Construction Authority (BCA), air cooling in Singapore's nonresidential buildings accounts for 60 percent of the buildings' total electricity consumption, with a further 10 percent used on mechanical ventilation.⁴⁰ Because of the low penetration of air conditioners in many developing countries, their impact on total building energy use is still relatively low but is expected to increase rapidly. It is in fact the fastest growing end use in buildings. By 2050, air conditioners are expected to contribute 44 percent to peak electricity loads in India.⁴¹

Use of building energy rating systems may be easier to implement for new buildings first, and then can be expanded to existing buildings once institutional frameworks are advanced enough to take up existing building intervention models.

Energy Performance Rating Systems

A variety of building energy rating systems, along with associated energy labels, are used around the world as a means to increase the visibility of building energy performance. These serve to evaluate, monitor, and convey residential and commercial building energy performance during the design, construction (or renovation), and operation of a building. The two most common types are asset ratings and operational ratings. Asset ratings are based on modeled energy use with uniform conditions of climate, schedule, plug loads, occupancy, and energy management. Operational ratings are based on measured energy use, often normalized for relevant variables like weather, hours of operation, occupancy, and conditioned floor area. Building energy performance should be holistically viewed as the interaction of three independent aspects: (1) building design and engineered systems (which influence asset rating), (2) operation and maintenance practices, and (3) occupant needs and behavior. All three aspects influence the operational rating.

Asset Ratings

Asset ratings essentially answer the question "How energy efficient is this building?" while applying uniform conditions concerning climate, schedule, plug loads, occupancy, and energy management. Asset ratings are necessarily derived from simulation. One of the most common examples of an asset rating is the U.S. Green Building Council's LEED program. An internationally recognized program, LEED is the largest building rating system in the world, with 2.2 million square feet of buildings earning LEED certification every day.⁴² LEED is a sustainable building rating that goes beyond energy and considers embodied carbon of construction materials, water usage, and the building landscaping, among other criteria. In addition, there are country-specific examples such as the GRIHA in India, Home Energy Rating System (or HERS index) in the United States, and GREENSHIP^{xxiii} in Indonesia.

Asset ratings are essential in developing energy management programs and objectives for new buildings and major renovations, since they allow predictions of energy savings that will occur due to features that have not yet been installed. They also allow for quantitative comparisons of how far a building has gone compared to leading-edge practice in adopting efficiency measures and design techniques that reduce the need for heating and cooling.

xxiii GREENSHIP is a rating tool prepared and compiled by the Green Building Council Indonesia by considering the conditions, natural character, and regulations and standards that apply in Indonesia. See <https://www.gbcindonesia.org/greenship>.

The energy modeling required for asset ratings can be useful in determining where additional passive cooling measures can be employed to reduce cooling loads or where control systems can be installed to optimize cooling loads.

Operational Ratings

The operational rating answers the question “How energy intensive is the building’s day-to-day operation compared to its peers?” Operational ratings describe buildings in terms of adjusted metered energy performance per unit of conditioned floor area, with the baseline typically representing average energy use for a cohort of buildings of the same function (for example, office). The most prominent example of an operational rating is the Energy Star commercial buildings program.⁴³ This program is based on comparing metered data for at least a full year of operation to baseline consumption data, which is adjusted for the neutral dependent variables of weather, hours of operation, occupancy, and conditioned floor area. Another example is the NABERS,^{xxiv} Australia’s national rating system that measures the environmental performance of Australian buildings, tenancies, and homes. As part of a building energy disclosure policy measure driven by the Australian government, NABERS uses a six-star scale to help building owners understand how their buildings impact the environment.⁴⁴

Operational ratings work well for comparing the performance of a building from year to year or for comparing the performance of one building against another being used for a similar function. These ratings can be a useful tool to direct an organization’s attention to energy management and to motivate short-term operational improvements, which are believed to be capable of saving 15 percent to 30 percent of energy use.⁴⁵ Such short-term operational improvements could include installing systems to control and optimize cooling loads, so the cooling supply is dynamically matched with the demand.

Energy Performance Rating Systems Can Be Voluntary or Mandatory

Energy performance rating systems can be either mandatory or voluntary and, within a country, can be administered at the federal or regional level. Energy Star is an example of a voluntary system, whereas NABERS is a federally managed mandatory system.

There Isn’t One “Best” Energy Performance Rating System

When comparing asset and operational rating systems, one is not better than the other—they simply convey different information. Asset ratings tell us how energy efficient a building’s design and systems (technology) are, but these features may not ensure low energy use during building operations. Operational ratings can tell us how the building’s annual energy consumption compares to itself in previous years or to similar buildings, but these ratings do not necessarily imply optimized energy performance and could depend on a host of different factors.

xxiv This is also discussed in section P4, Catalyze the market by leading by example through government budgeting and procurement strategies for energy-efficient buildings and sustainable cooling equipment.

Key Factors to Consider for Implementation for Cultivating Visibility of Building Energy Performance

- **Mandate building energy disclosures and make the information easily available, either at the time of sale or in a public data repository**

Making building energy use, energy costs, greenhouse gas emissions, and other information available at the time of sale or in a public database allows building owners and tenants to appropriately value energy-efficient buildings. In databases, building owners can compare their performance to other buildings of similar size and age and understand where they have opportunities to improve.

The European Union has some of the most widespread building energy policies. The 2010 Energy Performance of Buildings Directive (EPBD) and the 2012 Energy Efficiency Directive are the main legislative instruments.⁴⁶ Providing consumers more data on energy performance through mandatory building energy disclosure is a key part of the EPBD. All EU member states must require energy performance certificates to be provided at the time of sale or lease of all buildings. This way, the potential buyer or renter can factor energy performance into their decision making.

The Singapore BCA's Green Mark is a building rating system for assessing the overall environmental performance of new and existing buildings to promote sustainable design, construction, and operations practices in buildings. The extensive data gathering and benchmarking of over 1,000 commercial buildings, equating to over 20 million square meters, has created meaningful visibility into the energy performance of these buildings, uncovering that the cooling systems are a major inefficiency in Singapore's commercial buildings—"the cooling systems in Singapore are effectively like a person washing their hands with a fire hose."⁴⁷ The BCA has a target for 80 percent of all commercial buildings to be Green Mark rated by 2030. The redesign of air-conditioning and cooling systems will be very important in the achievement of this target, and it is expected to have a marked impact on the energy intensity of Singapore's building stock.

The United States has no federal energy disclosure legislation, but several states and cities have mandated energy disclosures. For example, Orlando, Florida, requires commercial and multifamily buildings greater than 50,000 square feet (approximately 4,650 square meters) to report their annual energy use to the city, which the city then makes available in an annual report.⁴⁸ Similarly, New York City requires private buildings over 50,000 square feet (approximately 4,650 square meters) and public buildings over 10,000 square feet (approximately 930 square meters) to report their annual energy and water use, and it makes that data available in a database and an interactive map.⁴⁹ In 2017, 34,355 buildings were included in the database. Both Orlando and New York have significant cooling loads in the summer, so these policies incentivize the use of more sustainable space cooling practices. The publicly available data creates transparency in terms of a building's energy use, facilitates benchmarking, impacts valuations, and drives up energy-efficiency efforts, including optimization of cooling loads.

- **Invest in tools and human capacity to rate or certify buildings**

Having highly trained, independent assessors is key to the credibility of any energy rating program. The LEED program requires the professionals verifying buildings to do an online training, an in-person training, have three years of experience, and pass an exam.⁵⁰ Because of these rigorous standards, LEED is a highly credible, internationally recognized building rating program.

Training the assessors takes significant time and resources. When the EU first implemented energy performance certificates through the EPBD in 2003, member states were expected to implement it within three years. However, it ended up taking most member states about five years to implement, largely because they could not train energy assessors fast enough.⁵¹

China learned from this experience in implementing its energy labeling program. After designing the program, it devoted the first three years to training professionals. Only after this did the second phase of financial incentives for qualifying buildings begin.⁵²

- **Provide recommendations along with ratings**

Providing recommendations along with ratings can increase the likelihood that building owners will make upgrades. These recommendations are particularly effective if they include an estimation of operating cost savings from making the improvements. For example, the US Department of Energy's Home Energy Score provides recommendations of specific energy-efficiency upgrades that the homeowner should make, along with estimated annual energy savings from making the improvements.⁵³

When the EU's EPBD was revised in 2010, it mandated that the energy performance certificates include recommendations on how to improve the energy efficiency of the buildings. The certificates were required to include all cost-effective upgrades along with their associated costs, benefits, and payback periods, with the objective of catalyzing further improvements in the energy efficiency of the buildings.

- **Enhance user awareness of building energy performance through visible means**

Physical certificates or plaques showcasing a building's high energy performance, displayed in a building's lobby or other public area, can increase the desirability of a building to potential buyers, employees, visitors, and the community. Most energy performance indices offer an official certificate or plaque to display, including both LEED and Energy Star.

New York City built on its building energy public disclosure policy to make the information even more accessible to the public. Beginning in 2020, a building's energy-efficiency score will be translated to an A through F letter grade, which must be prominently displayed near the building's entrance.⁵⁴ This program was designed after New York's highly recognizable and successful practice of displaying results from health inspections as letter grades in restaurant windows.

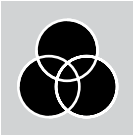

Buildings with more advanced controls have begun to display their real-time energy use through dashboards or kiosks in their lobbies. These serve both to display the energy efficiency of the building and to educate and motivate building users to use less energy. An effective display engages the user through easy-to-understand visuals and provides an enjoyable experience.

RESOURCES

- Levine, Mark, Stephane de la Rue de Can, Nina Zheng, Christopher Williams, Jennifer Thorne Amann, and Dan Staniaszek, 2012, *Building Energy-Efficiency Best Practice Policies and Policy Packages*, United States Department of Energy, Washington, DC, <https://doi.org/10.2172/1168594>.
- Burr, Andrew, Cliff Majersik, and Nick Zigelbaum, 2018, *The Future of Building Energy Rating and Disclosure Mandates: What Europe Can Learn from the United States*, Institute for Market Transformation, Washington, DC, <https://www.imt.org/wp-content/uploads/2018/02/7.5IEECBPaper33.pdf>.
- *Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings* (recast), EUR-Lex, <http://data.europa.eu/eli/dir/2010/31/2018-12-24>.
- “BCA Green Mark Assessment Criteria, Online Application and Verification Requirements,” Building and Construction Authority, https://www.bca.gov.sg/GreenMark/green_mark_criteria.html.
- “LEED Rating System,” U.S. Green Building Council, <https://www.usgbc.org/leed>.
- EDGE homepage, <https://www.edgebuildings.com/>.

P7. ACCELERATE THE ADOPTION OF PASSIVE COOLING STRATEGIES THROUGH NATIONAL BUILDING ENERGY CODES WITH A ROBUST ENFORCEMENT MECHANISM

At-a-Glance

	<p>What building energy codes are and why they are important</p> <p>Building energy codes are regulations that aim to reduce building energy use. They typically apply to the building envelope and can also incorporate codes and standards applicable to HVAC systems, lighting, and water heating systems. They have the potential for significant impact by locking in thermal efficiencies that will persist for the lifetime of each building. These strategies can be, generally, most holistically and cost-effectively integrated into a building during its design and construction (compared to in an existing building), when the incremental cost is at its lowest.</p> <p>Establishing building energy codes typically starts with the engagement process for the development of new building codes. In parallel, establishing robust enforcement mechanisms, along with the appropriate training and tools for local authorities, is critical. Where the institutional frameworks are advanced enough to take up existing building intervention models, energy code adoption for new buildings can be expanded to existing buildings when a major renovation project triggers application of code.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Promote enforcement of building energy codes by providing training and tools to local authorities • Undertake regular and transparent code revisions • Once prescriptive or performance-based codes are in place and firmly established, consider supplementing with or transitioning to outcome-based energy codes
	<p>Barriers addressed: Lack of Awareness, Lack of Transparency, First-Cost Bias, Split Incentives, Lack of Valuation of Efficiency, Complexity of Choice</p>

What Building Energy Codes Are and Why They Are Important

Building energy codes are regulations mandating or encouraging lower energy use in buildings. They can be an effective way to integrate passive cooling strategies into the building stock, thereby reducing the need for mechanical cooling.^{xxv} Most warm climate countries with growing cooling demand do not have mandatory building energy codes for all buildings. For developing economies, where a large part of the building stock will be new construction, code implementation can be particularly beneficial in terms of locking in thermal efficiencies in the built environment that will reduce cooling loads for decades to come.

Building energy codes typically cover the building envelope but also incorporate codes and standards applicable to HVAC systems, lighting, and water heating systems.⁵⁵ They can apply to both new and existing buildings. When applied to existing buildings, they normally come into force during a large-scale retrofit, typically in conjunction with the need to meet updated building safety codes. It is typically easier to implement building energy codes for new buildings, because installing passive energy-efficient measures during construction is generally much less expensive than doing so within an existing building.

xxv For an overview of passive cooling strategies, see section 3 of the *Primer*.

Building energy codes can be prescriptive, performance based, or outcome based. Prescriptive codes specify energy-efficiency characteristics such as insulation requirements or HVAC efficiency. Performance-based codes require the building designer to target a specific energy use, but they allow the designer to choose exactly how they will meet the limit. Outcome-based codes are similar to performance-based codes in that they don't require specific energy-efficient measures, but they are measured for compliance once the building is in use.

Building codes can be legislated by any level of government, but it typically falls to local governments to enforce them. Building energy codes are generally treated similarly to fire, structural, or other codes in terms of who enforces them and when. However, local governments often see building energy codes as less critical than other codes and may not prioritize their enforcement, often due to lack of resources to provide enforcement oversight.

A common model for building code development and adoption is for the national government to develop a model code that is voluntary for states or regions to adopt as legislation. For example, the United States Department of Energy reviews and adopts the IECC and ASHRAE Standard 90.1 for residential and commercial model building codes, respectively. In India, the Ministry of Power and the Bureau of Energy Efficiency launched a model commercial building code in 2007 called the Energy Conservation Building Code (ECBC).⁵⁶ At present, it is voluntary for states to adopt this code, but there are plans to make it mandatory in the near future. Some states have already legislated ECBC adoption as mandatory. In 2018, India launched the ECBC for residential buildings, currently in the voluntary stage.

Some regions will also design a “stretch code” that goes beyond the base code, which is generally voluntary for local municipalities to adopt. In 2009, Massachusetts was the first US state to adopt a stretch code. Municipalities may choose to adopt the stretch code or remain with the base code. As of September 2019, 273 Massachusetts municipalities had adopted the stretch code, covering 85 percent of the state's population.⁵⁷ Once a municipality adopts a stretch code in Massachusetts, it is mandatory for buildings to comply. In other US states and locations around the world, municipalities may adopt a stretch code that is voluntary, but buildings are provided incentives to meet it. For example, in Virginia Beach, Virginia, if a commercial or residential project is 30 percent more efficient than the state energy code, the owner pays reduced property taxes.⁵⁸

As with other building-related interventions, implementation is relatively less complex for new construction and can be expanded to include existing building retrofits once institutional frameworks are advanced enough to take up existing building interventions. For effective implementation, adequate capacities and training for the local authorities are critical. Also important are information and training for the building sector stakeholders.

Potential Impact of Building Energy Codes

Because the buildings built or retrofitted today will still be in use for decades to come, introducing building energy codes now can have significant impacts that persist far into the future.

In China, implementation of and compliance with building energy codes across new and existing urban residential, and commercial and rural residential buildings have the potential to reduce the energy demand of the building sector between 13 and 22 percent by the end of the century.⁵⁹

In India, it is estimated that a robust implementation of the ECBC in commercial buildings—which includes measures for climate-appropriate building envelopes—can reduce the commercial building stock's cooling demand by about 20 percent by 2037–38.⁶⁰

Current Status of Building Energy Codes in Low- and Lower-Middle-Income Countries

Many of the developing countries that are seeing rapid urbanization and construction of new buildings are the very ones that lack building energy codes. Of the 65 low- or lower-middle-income countries in the ESMAP RISE data set, only 16 have energy-efficiency codes for new residential buildings, and 19 have codes for new commercial buildings.⁶¹

Furthermore, even when the codes exist, it's challenging for governments to enforce them and to update them regularly. For example, only ten low-income or lower-middle-income countries with building energy codes require commission testing for final building acceptance documentation. Only five require periodic reporting, and just seven require verification to be carried out by a third party. Institutional support and training, adequate resources, and enforcement procedures are critical to advance the adoption, implementation, and enforcement of codes at the local level.

Key Factors to Consider for Implementation for Reducing Cooling Loads through Adoption of Building Energy Codes

- **Promote enforcement of building energy codes by providing training and tools to local authorities**

As with all policies, building energy codes are effective only if they have strong enforcement mechanisms that are put into practice. The local authorities charged with enforcing the energy codes are often underresourced, so providing staff the proper training and tools can help them see the importance of enforcement and then carry it out effectively. An example of a tool is code compliance software packages. Another common way to reduce costs for local governments is to allow certified third parties to perform the building code compliance checks.

The United States is one example where the federal government provides support to local authorities but is not an example of perfect compliance due to underfunding. The Department of Energy provides grants to support state and local trainings. In addition, the Department of Energy funds the development of code compliance software tools. Compliance is still an issue in the United States, with compliance rates as recently as 2010 estimated to be between 50 and 60 percent.⁶² Part of this low compliance is likely due to underfunding. According to the 2010 Code Compliance Task Force,^{xxvi} \$200 million was spent annually in the United States on building energy code compliance, while the need was \$810 million. However, the task force also estimated that if compliance was fully funded, it would have a sixfold pay-off, saving American consumers \$2.7 billion in annual energy costs by 2020.

Reports indicate that China has very high building code compliance. According to building code compliance inspection results published by the Chinese Ministry of Housing and Urban-Rural Development, the compliance rate exceeded 90 percent in 2010.⁶³ China's high compliance rate is rooted in the third-party-facilitated inspection system and the clearly announced code compliance responsibilities and penalties for noncompliance.⁶⁴

xxvi The Code Compliance Task Force was led by the Institute for Market Transformation and consisted of more than 40 representatives from various stakeholder groups.

- **Undertake regular and transparent code revisions**

As with appliance minimum energy performance standards (MEPS), as technologies advance, it's important to continue making building energy codes more stringent to effectively eliminate the bottom of the market. Also similar to MEPS, these revisions should be announced well in advance of going into effect, to allow designers and builders to plan for the updated codes. Auto ratcheting at set intervals can be a good way to make the code updates very predictable for the industry.

One example is the California Green Building Standards (CALGreen).⁶⁵ The code is updated on a triennial basis, with minor updates every 18 months. The code is typically announced in July of one year and effective in January of the following year.

- **Once prescriptive or performance-based codes are in place and firmly established, consider supplementing with or transitioning to outcome-based energy codes**

Outcome-based energy codes (fairly uncharted territory) can offer an alternate and more flexible pathway for efficiency in existing buildings, based on accountability for achieving post-occupancy performance outcomes rather than following a mandated path.^{xxvii} Such outcome-based codes may also lessen the administrative costs of enforcing building codes by replacing design review and site visits with checking utility bills. It's good practice for outcome-based codes to also be paired with prescriptive requirements for the building envelope, to enable the building to be more likely to meet minimum performance levels in the future.⁶⁶

One example of outcome-based codes for new buildings is the City of Seattle's building energy code.⁶⁷ Builders can choose to meet the code through a prescriptive path, a performance-based path, or an outcome-based path called the Target Performance Path. The Target Performance Path was introduced in 2012 and requires (1) whole-building energy modeling to show that the proposed design can meet the operational performance target and (2) utility bills showing that the actual energy use meets the energy use intensity target. The energy use target varies based on the building type. If the target is not met for at least a 12-month period within the first three years of occupancy, the building owner must pay a fine.⁶⁸

RESOURCES

- Global Buildings Performance Network homepage (accessed December 19, 2019), <http://www.gbpn.org/>.
- Levine, Mark, Stephane de la Rue de Can, Nina Zheng, Christopher Williams, Jennifer Thorne Amann, and Dan Staniaszek, 2012, *Building Energy-Efficiency Best Practice Policies and Policy Packages*, United States Department of Energy, Washington, DC, <https://doi.org/10.2172/1168594>.
- Liu, Feng, Anke S. Meyer, and John F. Hogan, 2010, *Mainstreaming Building Energy Efficiency Codes in Developing Countries*, ESMAP, World Bank Group, Washington, DC, <https://www.esmap.org/node/755>.

xxvii Outcome-based energy codes establish a target energy use level and provide for measurement and reporting of energy use to ensure that the completed building performs at the established level. Unlike typical energy codes, this approach focuses on real and measurable energy performance improvement rather than on the relationship of the buildings' energy characteristics compared to a theoretical building built to a code baseline, thus factoring in variability of energy performance outcome once the building is completed. See https://newbuildings.org/code_policy/outcome-based-energy-codes/.

- *2018 Global Status Report*, 2018, Global Alliance for Building and Construction, <https://www.worldgbc.org/sites/default/files/2018%20GlobalABC%20Global%20Status%20Report.pdf>.
- Cox, Sadie, 2016, *Building Energy Codes Policy Overview and Good Practices*, Clean Energy Solutions Center, Paris, <https://www.nrel.gov/docs/fy16osti/65542.pdf>.
- National Institute of Building Sciences, 2017, *Implementing an Outcome-Based Compliance Path in Energy Codes: Guidance for Cities*, Washington, DC, <https://cdn.ymaws.com/www.nibs.org/resource/resmgr/docs/OBP-CityLevelGuide.pdf>.
- Young, Rachel, 2014, *Global Approaches: A Comparison of Building Energy Codes in 15 Countries*, American Council for an Energy-Efficient Economy, Washington, DC, <https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf>.
- Evans, Meredydd, Volha Roshchanka, and Peter Graham, 2017, "An International Survey of Building Energy Codes and Their Implementation," *Journal of Cleaner Production* 158 (2017): 382–89, <https://www.pnnl.gov/sites/default/files/media/file/An%20international%20survey%20of%20building%20energy%20codes%20and%20their%20implementation.pdf>.
- Bekker, Vitaly, 2018, *High-Performance Energy Efficiency Standards in Buildings in UNECE Region*, United Nations Economic Commission for Europe, Geneva, https://www.unece.org/fileadmin/DAM/hlm/Meetings/2018/09_05-07_St._Petersburg/Training_Course_Topic_1.pdf.



Detail from a living wall covered with variety of plants, flowers, and grass. Eco-friendly urban architecture in Tel Aviv, Israel.
Credit: EnginKorkmaz/istock.



CREATE SUSTAINABLE FINANCING AND ENABLING MECHANISMS

F1. CREATE INCENTIVE MECHANISMS TO SHIFT THE MARKET TOWARD SUSTAINABLE SPACE COOLING

At-a-Glance

	<p>What incentive mechanisms are and why they are important</p> <p>In this publication, “incentives” are defined as any financial instruments designed to stimulate a transition to sustainable space cooling. Incentives can help address the first-cost bias among end-users—particularly in the price sensitive low- and middle-income groups, and generally entry-level buyers—by helping offset the typically higher first cost of efficient cooling equipment. By increasing market penetration of sustainable cooling solutions, incentive programs can thus help manufacturers achieve economies of scale and learning effects. Incentives can also be applied to spur investment in energy-efficient buildings.</p> <p>This intervention can be used, where feasible, to reinforce desired policy outcomes by accelerating demand for sustainable space cooling in less mature markets. Incentive mechanisms should be carefully designed and well-calibrated, and targeted to avoid misuse and to meet intended objectives. Incentives (and subsidies) should be structured in a way that allows them to be phased out and supplanted with appropriate market instruments as market adoption increases.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none">• Provide well-targeted, calibrated, and sufficiently stable funding to stimulate market transformation toward sustainable space cooling• Consider innovative incentive mechanisms—such as feebates—to boost effectiveness of ongoing policy measures by helping shift demand toward sustainable cooling equipment
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Complexity of Choice, Misaligned Policies</p>

What Incentive Mechanisms Are and Why They Are Important

End-users’ first-cost bias continues to be a strong barrier to the adoption of sustainable cooling equipment, particularly in the price-sensitive low- and middle-income groups, and generally entry-level buyers. In several countries, government-led or -supported incentive mechanisms that help offset the higher first cost of efficient equipment have been successful in accelerating their adoption.

Carefully designed and well-targeted incentive mechanisms can help to transform the market toward more efficient cooling solutions that minimize energy and peak demand and reduce the global warming and ozone impacts of refrigerants.⁶⁹ By increasing market penetration of sustainable cooling solutions,

incentive programs can thus help the manufacturers to achieve economies of scale and learning effects. Incentives can also be applied to spur investment in energy-efficient buildings.

Incentive mechanisms could take various forms, including, but not limited to, the following:

- **Rebates.** This commonly refers to discounts in sale prices of energy-efficient equipment and appliances, but the discounts can also extend to offset the cost of equipment installation, energy audits, and the construction and retrofit of energy-efficient buildings. For example, Mass Save⁷⁰—a collaborative formed by the utilities in Massachusetts, United States—offers its residential and commercial customers discounts on the purchase of energy-efficient appliances (such as smart programmable thermostats and Energy Star–certified air conditioners), offers free installation services of select equipment, provides no-cost energy assessments of homes, offers 75 to 100 percent discounts on home insulation, and offers rebates for qualifying new construction and retrofit projects for energy-efficient buildings. Another example is Mexico's Efficient Lighting and Appliances Project that offered instant discount vouchers to low-income consumers to help finance a portion of the up-front cost of acquiring new efficient appliances to replace old and inefficient ones.⁷¹ It also supplemented the discount vouchers with credits at favorable interest rates to low-income and other qualifying consumers to pay for the replacement of old and inefficient appliances with more energy-efficient appliances. Proper disposal of used equipment was also part of the objective of the program.
- **Tax credits.** The central government or state governments can offer tax credits for lowering the incremental first cost of energy-efficient technologies or building retrofits. For example, until December 2017, the US federal government offered home builders a \$2,000 tax credit for a new energy-efficient home that achieves 50 percent energy savings for heating and cooling over the 2006 IECC and supplements. At least 20 percent of the energy savings had to come from building envelope improvements, directly impacting the heating and cooling loads. For information on green mortgages, please see section F3.
- **Cash or kind awards.** Awards in cash or kind can be used to promote the purchase of efficient appliances (such as Japan's Eco-Point System, discussed later in this section). Cash awards have also been effectively used to phase out the use of old energy-hogging cooling appliances (discussed in more detail in the equipment retrofits or recycling section of F8). Examples of kind awards include nonfinancial incentives for energy-efficient, new construction in the form of faster permitting, or more permissible floor space.

Some incentive mechanisms (such as rebates) are relatively easier to implement, while others (such as tax credits and grants) require that more complex administrative frameworks be put in place.

The incentive mechanisms could be structured to apply to manufacturers and retailers, or directly to consumers, and accordingly, they can be broadly categorized as upstream or downstream incentives respectively.

Upstream Incentive Programs

These are incentives offered to manufacturers to streamline their production lines and undertake production of higher-efficiency products at a lower price. The main advantage of these programs is that they can influence a large portion of the market through fewer actors and therefore have lower transaction costs. Moreover, by reducing the price before products reach the market, the incentive has typically greater impact on purchase price than a downstream incentive. Upstream incentives are particularly effective for reducing the up-front cost of technologies that are at an early stage of penetration.

In 2009, the Chinese government implemented its program Promoting Energy-Efficient Products for the Benefit of the People. The objective of the program was to promote the uptake of more efficient products while boosting the economy. With air conditioners as a key targeted appliance, the program included upstream incentives for manufacturers to increase the production of higher-efficiency ACs, which helped drive the market transformation of the sector and increased the market share of tier 1 or 2 (the highest rated in China) AC units in March 2009 from 5 percent to 70 percent in just 18 months.^{xxviii, 72}

The main disadvantages of upstream programs are that robust monitoring and verification are required to ensure that the benefits of the financial incentives are passed through to the consumers. Also, such incentives will generally work only in relation to domestic manufacturers, and thus are applicable only to countries with domestic AC manufacturing capacity. Where a country is concerned that implementing or increasing the stringency of minimum energy performance standards (MEPS, as discussed in intervention P3) could negatively impact domestic manufacturers, a case can be made to provide those manufacturers technical assistance or targeted financial support to enable them to prepare to meet a planned implementation or increased stringency of MEPS.

In some cases, the upstream incentives are for regional distributors (not manufacturers), to encourage them to hold high-efficiency products in stock and available for replacement projects. Such incentives are also referred to as midstream incentives. One such example is the Upstream HVAC and Heat Pump program administered by National Grid in the United States.⁷³ This program aims to transform the HVAC market by creating ease of access to—and customer incentives for—high-efficiency commercial HVAC equipment.

Downstream Incentive Programs

These programs encourage consumer uptake of more sustainable cooling equipment and reduce stock of old, unsustainable equipment. The downstream incentives—which should be well calibrated per the market need—are offered directly to the targeted consumer to offset some of the first cost of more sustainable equipment. Downstream incentives should be used to leverage other government interventions. For example, they could incent top-tier products on a newly introduced labeling system. This brings awareness to the labels and can institutionalize demand for top-tier products, which has positive spill-over effects on other energy-efficiency purchases. Moreover, downstream programs have the flexibility to be directed to select populations, such as low-income households. For example, Mass Save has a range of no-cost or discounted energy-efficiency services for income-eligible residents.^{xxix, 74}

In 2009, the Japanese government implemented the Eco-Point System, which encouraged consumers to purchase highly energy-efficient appliances such as ACs and refrigerators through the provision of subsidies in the form of reward points. Consumers were awarded points for purchasing a product with four or more stars, and each point was worth 1 yen (~US\$0.01), which could be exchanged for other goods and services. Per the Eco-Point program design, depending on the cooling capacity of an AC or volume of a refrigerator, a consumer could receive anywhere from 3,000 to 9,000 points for an AC and about the same for a refrigerator (typically 5–10 percent of purchase value).⁷⁵ Following the success of the eco-point system in promoting energy-efficient appliances, the Japanese government expanded the program to include residential buildings and launched an eco-point system for housing that offers points to citizens who remodel their house with better insulation or energy efficiency or who build a new eco-friendly house.⁷⁶

xxviii More details on this program are discussed in P3, Establish minimum energy performance standards of cooling equipment and a mechanism to ratchet them up.

xxix Refer to F8, Manage peak cooling loads through utility-led demand-side management and financial measures, for more details.

Reliance Infrastructure Ltd. implemented the Five-Star Split AC Pilot Program in Mumbai, India, with the objective of achieving peak load reductions and adding service value to customers. The pilot program began in 2014 for commercial customers, to promote replacement of old window units with five-star split units. The pilot combined features of demand aggregation (discussed in detail in F2), as well as downstream incentives. Through a bid process, Reliance Infrastructure worked with the manufacturers to minimize pre-rebate unit prices. An innovative feature was that the unit price included transportation, recycling, and installation costs. With already competitive prices through demand aggregation, Reliance Infrastructure provided incentives to customers per each five-star AC unit to further offset the first cost.

A disadvantage of downstream programs is the transaction costs involved in engaging and giving rebates to a large number of customers on an individual basis.

Key Factors to Consider for Implementation for Incentive Mechanisms

- **Provide well-targeted, calibrated, and sufficiently stable funding to stimulate market transformation toward sustainable space cooling**

One of the challenges, particularly in the context of developing countries, is that available funding may be for a limited duration. Incentive programs, if applied for too short a duration (for example, less than one year), will typically not enable sustained market impacts. While incentives should be time-bound, they should be sustained long enough to ensure meaningful impact and market transformation. In addition, there should be a strategy to exit and ensure that the market for sustainable space cooling can be sustained without the subsidy.

In Japan's Eco-Point program, the Japanese government had issued about US\$3.2 billion worth of eco-points to boost consumer purchase of efficient appliances that rated four or more stars in the national system of energy-efficiency standards. Started as a one-year program in 2009 to promote global warming countermeasures and revitalize the economy, the program was extended for another year with additional budgets from the government, recognizing its market transformation potential.⁷⁷ Starting in 2011, given the successful market shift achieved toward efficient products, only five-star appliances were eligible for eco-points.

In addition to being well-timed and stably funded, other important aspects for designing an effective incentive program are:

Targeted program design, to avoid misuse and meet intended objectives. Incentive programs should be designed keeping the target market and the intended objectives in mind, and measures should be taken to avoid misuse of the financial incentive. A common challenge faced by program and administrators and utilities offering incentive programs is that of "free riders." In the context of energy-efficiency incentive programs, a free rider is someone who would install an energy-efficiency measure without any incentives because of the return on investment of the measure but receives a financial incentive or rebate anyway.^{xxx} Careful program design can help mitigate the issue of free ridership.

For example, National Grid has a system of random or mandatory inspections—depending on the cost and complexity of the energy-efficiency measures—to ensure that the measures for which rebates are being claimed were in fact installed and operational on-site. In another example, Mexico's Efficient

xxx While a detailed discussion on the issue of free ridership is outside the scope of this publication, much literature is available on this topic. For example, *Energy Efficiency and the Spectre of Free-Ridership*, https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/ACEEE_buildings/2006/Panel_12/p12_8/paper.pdf and *The Trouble with Freeriders*, <https://www.cadmusgroup.com/wp-content/uploads/2012/11/Haeri-Khawaja-PUF-TroublewithFreeriders.pdf>.

Lighting and Appliances Project,^{xxx} which offered customers incentives for replacement of old and inefficient air conditioners and refrigerators, took steps to ensure that customer and grid benefits were maximized. To ensure this, the household eligibility criteria required that the AC or refrigerator be at least 10 years old and in working condition in order to qualify to exchange for the new appliance. This important criteria ensured that the equipment being replaced was in fact past its useful life but still in operation—that is, drawing from the grid—and that the program was not being misused simply to get discounted newer appliances; moreover, replacing more recent appliances would not generate large energy savings or grid benefits.

Another approach for mitigating free ridership is through performance-based incentives. Typically, a majority of the incentive programs are cost based—that is, they provide a fixed fraction of the expenditures on efficiency, or in some cases the incremental expenditures on efficiency, as the incentive. In contrast, performance-based incentives pay a fixed amount of money for meeting a specified performance level, or pay a fixed amount per unit of energy savings for products that meet or exceed a threshold. The incentive amounts are driven by the performance and are independent of the incremental cost of achieving the efficiency.⁷⁸ However, performance-based incentives are more complex to administer and require greater monitoring and human resources.

Technology neutral. Incentive programs should be technology neutral and only target the most sustainable technology.

Cost-effective. It is important to balance the cost of funding and administering an incentive program against targeting highly efficient products that have a low market penetration. For instance, from the perspective of a utility offering an incentive program, justification of the program generally requires that its funding and administration cost is lower than the cost of adding new generation.⁷⁹

- **Consider innovative incentive mechanisms—such as feebates—to boost the effectiveness of ongoing policy measures by helping shift demand toward sustainable cooling equipment**

A feebate program is a self-financing system of fees and rebates whereby energy-efficient or environmentally friendly practices are rewarded while failure to adhere to such practices is penalized. The concept of feebates can be applied to shift market purchasing behavior—for example, to shift the market away from fixed-speed ACs toward more efficient and low-GWP inverter AC options. Fixed-speed compressors cost more to operate, run longer at peak, and create a less comfortable environment for users. A well-designed feebate program that applies a fee reflecting societal cost to fixed-speed units and subsidizes the small incremental cost of inverter units could result in 20–30 percent reduced energy consumption for cooling through these ACs. This strategy would be particularly meaningful in markets that are still heavily skewed toward fixed-speed ACs.

In South Korea, the government implemented a feebate program to encourage the purchase of efficient ACs and other appliances. The program applied a 5–6.5 percent tax on energy-consuming home appliances, and the revenues from this tax were used to subsidize the purchase of energy-efficient appliances for low-income households. In 2008, the government launched a downstream financial incentive program called the Carbon Cashbag program, to guide consumers to purchase products with low GHG emissions and high efficiency.⁸⁰ Under this program, consumers who purchase low-carbon products—including high-efficiency ACs—earn points (carbon credits) from participating manufacturers, retailers,

xxx This project, supported by the World Bank, is also discussed in more detail in F8, Manage peak cooling loads through utility-led demand-side management and financial measures.

or banks. These points can be used for discounts on public transportation, basic utilities charges, purchases of other efficient appliances, or tickets to cultural events. Carbon Cashbag is a voluntary program, and participating companies (mostly appliance manufacturers) benefit from reductions in advertising fees and other public incentives.⁸¹

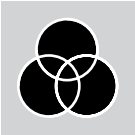

As a result of these incentive mechanisms, the South Korean market saw a transition toward the adoption of energy-efficient appliances, particularly ACs. The incentive programs helped to create demand for energy-efficient appliances among consumers, which in turn encouraged manufacturers to develop energy-efficient products and achieve industrial scale of high-efficiency products, helping drive down their cost.

The incentive programs supported the effectiveness of other ongoing measures, such as MEPS and the Energy Frontier Program, which sets energy-efficiency criteria for key appliances at 30–50 percent more efficient than baseline. As a combined impact, the share of inverter ACs in the market increased from less than 10 percent to more than 90 percent between 2009 and 2015, and efficiency of the air conditioners sold on the market more than doubled over the same period.⁸²

RESOURCES

- “Programs,” Database of State Incentives for Renewables & Efficiency (accessed December 19, 2019), <https://programs.dsireusa.org/system/program>.
- De la Rue du Can, Stephane, Greg Leventis, Amol Phadke, and Anand Gopal, 2014, “Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances,” *Energy Policy* 72 (September 2014): 56–66, <http://www.sciencedirect.com/science/article/pii/S0301421514002705>.
- De la Rue du Can, Stephane, 2015, “ACs: Cooling Growth in Energy Demand,” Super-efficient Equipment and Appliance Deployment Initiative, http://eta-publications.lbl.gov/sites/default/files/2015_ac_cooling_the_demand.pdf.
- De la Rue du Can, Stephane, Greg Leventis, and Nihar Shah, 2015, “Lessons Learned from Incentive Programs for Efficient Air Conditioners: A Review,” Super-efficient Equipment and Appliance Deployment Initiative, <https://eta-publications.lbl.gov/sites/default/files/lbnl-191145.pdf>.
- PWP, 2017, *Current Methods in Free Ridership and Spillover Policy and Estimation*, Energy Trust, Portland, OR, https://www.energytrust.org/wp-content/uploads/2017/07/FR_Spillover_1702.
- Eil, Andrew, Alan Miller, Alexander Hillbrand, and Sheldon Cheng, 2019, *Discussion Paper: Architecture & Financing Models for Efficient Cooling Alongside the Montreal Protocol*, Natural Resources Defense Council and Climate Finance Advisors, New York and Washington, DC, <https://www.k-cep.org/wp-content/uploads/2019/07/NRDC-CFA-2019.-Architecture-Financing-Models-for-Efficient-Cooling-alongside-the-Montreal-Protocol.pdf>.

F2. AGGREGATE DEMAND TO DRIVE DOWN THE ACQUISITION COST OF SUSTAINABLE COOLING EQUIPMENT, BUILD MARKET CONFIDENCE, AND SPUR GREATER ADOPTION

At-a-Glance	
	<p>What demand aggregation is and why it is important</p> <p>Demand aggregation is the practice of bringing together a sufficiently large demand for sustainable cooling equipment and leveraging the resulting scale to secure lower prices and higher-quality products from suppliers. Demand aggregation can be led by both the public and private sectors and is generally an effective way to enable bulk procurement to drive down the first cost of sustainable space cooling in markets where a sufficiently large volume of demand aggregation can be ensured. At larger scales, demand aggregation can transform a market, bringing scale to manufacturers and lowering prices for all consumers.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Design demand aggregation programs to be driven by a well-resourced organization, with the necessary commitment from those that it is procuring for • Specify performance attributes aligned to the objectives of those whose demand is being aggregated (rather than prescriptive requirements)—for example, life cycle energy and emissions footprint—and allow manufacturers to bid the solutions that best fit these attributes • Take into account bid price implications when considering out-of-market consumer and purchaser protections • Use an integrated procurement strategy
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Complexity of Choice</p>

What Demand Aggregation Is and Why It Is Important

Demand aggregation can be an effective way to address the higher first cost of sustainable cooling equipment while mitigating the perceived risks and challenges of installation and warranties. Demand aggregation can be achieved through either government bulk procurement,^{xxxii} or it can be achieved through private sector “buyers clubs,” where private companies and consumers pool together to achieve lower costs and higher quality (such as membership organizations that negotiate discounts on rental cars and hotels for their members).^{xxxiii}

In both the public and private sector models, open competitive bidding must be used to promote competition between suppliers for the best costs and quality. Suppliers are able to offer lower costs than typically available on the market because of the scale of the procurement and the fact that their costs are lower for marketing and distribution. Aggregating demand and offering a public tender can also promote best practices around installation and inspection by specifying these in the tender documents.

^{xxxii} For more information on public sector procurement, see intervention P4, Catalyze the market by leading by example through government budgeting and procurement strategies for energy-efficient buildings and sustainable cooling equipment.

^{xxxiii} For more information, see *Buyers Club Handbook—January 2020 Update* published jointly by the Institute for Governance and Sustainable Development and OzonAction/United Nations Environment that aims to guide any organization in setting up a buyer’s club for super-efficient room air conditioners using lower global warming potential refrigerants.

Success of Demand Aggregation in Adjacent Sectors

Demand aggregation has successfully been used in other industries to drive down costs, such as the rooftop solar photovoltaic (PV) industry in the United States and LEDs in India. India's EESL uses a bulk procurement model to drive economies of scale in supply and to encourage demand through competitive pricing, thus transforming markets and supporting further private sector participation in India's retail market for energy-efficient appliances. EESL's demand aggregation and bulk procurement for LEDs successfully led to a market transformation, with its bulk purchase price of LEDs dropping 88 percent between 2014 and late 2016.⁸³ Demand aggregation for cooling equipment is newer and poses additional challenges compared to LEDs (due to bulkier and more expensive equipment, greater financial risk, and more complex installation considerations) but has showed promising results thus far in India.

Public Sector Demand Aggregation for Cooling

In 2017, EESL, building on the success of its demand aggregation program for LED lights, created the EESL Super-efficient Air Conditioning Program (ESEAP).^{xxxiv} EESL released a tender for 100,000 1.5 tons of refrigeration (TR) inverter ACs with a minimum ISEER of 5.2, which was more efficient than the best available (at the time in the Indian market) five-star RAC, at ISEER 4.5. The bulk procurement strategy resulted in higher-efficiency ACs at ISEER 5.2, at prices 25–30 percent lower than the average market price (at the time) of the five-star RACs.

Of 100,000 high-efficiency ACs procured during the first phase of this initiative, 40 percent were R-290 based.^{xxxv} R-290 has zero ODP and a GWP of only three—significantly lower compared to most HFCs, which have a GWP in the thousands. While it has an A3 flammability designation that limits the refrigerant charge that can be used in this size unit, the maximum charge is sufficient to enable the higher system efficiencies to still be met. The bulk procurement also served to advance confidence in the R-290–based AC appliances available in the Indian market.

Private Sector Demand Aggregation for Cooling

In 2019, for the first time, EESL aggregated cooling demand from private customers to provide super-efficient air conditioners at lower costs. In February 2019, EESL launched its Super-efficient Air Conditioning Program for residential and industrial consumers in the Reliance Energy, formerly known as Bombay Suburban Electric Supply (BSES), area of Delhi.⁸⁴ Through an online platform, customers of BSES Rajdhani Power Limited (BRPL) have been able to purchase air conditioners that consume 20 percent less than the best available five-star units, making them the equivalent of seven-star air conditioners, for 30 percent lower cost than the current market price of five-star units.⁸⁵

In the past, EESL attempted to aggregate demand for ACs for banks' automated teller machines (ATMs) in India, but it was not able to get enough banks interested. Most banks lease their ATMs, and ATM owners were not willing to invest capital for them to be run more efficiently (yet another example of a split incentives barrier).

xxxiv The World Bank supports EESL, including its air conditioner program, through a \$220 million Performance-for-Results loan and an \$80 million International Bank for Reconstruction and Development guarantee, India Energy Efficiency Scale-Up Program (P162849), which is expected to leverage \$200 million in commercial financing.

xxxv Also see intervention P4, Catalyze the market by leading by example through government budgeting and procurement strategies for energy-efficient buildings and sustainable cooling equipment.

Private sector demand aggregation for cooling is also being tried in the following examples:

- **India, Lodha Group.** Lodha Group, an Indian real estate developer, procured more than 20,000 five-star rated (minimum ISEER 5.2) RACs of one to two tons each through a competitive bidding process. Lodha floated the tender to multiple reputable equipment manufacturers and achieved approximately 25 percent savings compared to the average prices of similar units available in retail stores.⁸⁶
- **United States, Advanced Rooftop Unit (RTU) Campaign.** The United States Department of Energy set up a campaign asking for commitments from building owners to install high-efficiency rooftop units and controls in their buildings.⁸⁷ Initial results of the challenge revealed that several manufacturers introduced higher-efficiency rooftop units to the market.⁸⁸ At the time of publication, the campaign is ongoing.
- **Brazil.** The Institute for Governance and Sustainable Development (IGSD), with partner organizations, started pursuing Private Buyers Club opportunities in Brazil in 2018, engaging with government, banking, and industry partners. The opportunity assessment in Brazil highlighted that inverters that were currently more expensive could dominate if test methodologies took into account partial loads and if lower Buyer Club prices and incentives boosted market transformation. As part of this initiative, IGSD and Brazil's Institute for Climate and Society are supporting market transformation activities to drive the market to more efficient ACs.⁸⁹

Key Factors to Consider for Implementation for Demand Aggregation

- **Design demand aggregation programs to be driven by a well-resourced organization, with the necessary support and commitment from those that it is procuring for**

Insights on the use of demand aggregation programs for energy-efficient appliances—and, more recently, cooling appliances—are largely derived from the experience of India's EESL. In this context, it is important to recognize that EESL is a unique organization in that it is a national energy service company (ESCO) backed by four public entities, and the political support backing EESL has helped to leverage significant national and multilateral financing and enabled it to mitigate the up-front cost of energy-efficient investments for customers by offering the option to make payments over a period of time through an on-bill financing approach.⁹⁰ Another often noted characteristic is EESL's competent leadership, which has been able to leverage the assurance of public sector demand to expand into demand aggregation strategies in India's large market more broadly.^{xxxvi}

Starting with public demand may be an effective way to begin a demand aggregation program, as it keeps the number of interlocutors more manageable. Countries should carefully assess and consider options to manage and implement such a program. If no obvious organizations with the desired characteristics exist—including discerning leadership, political support, and ability to attract financing—then steps should be taken to build the institutional capacity prior to initiating demand aggregation programs.⁹¹

xxxvi At the time of this writing, it is still too early to determine how well the EESL model (especially given its unique organizational setup) can be adapted in the context of other countries facing different circumstances and realities.

- **Specify performance attributes aligned to the objectives of those whose demand is being aggregated (rather than prescriptive requirements)—for example, life cycle energy and emissions footprint—and allow manufacturers to bid the solutions that best fit these attributes**

In reviewing the EESL demand aggregation program for insights, we find that the 2017 RAC tender asked for bids to provide 1.5 TR RACs with an ISEER of 5.2 or higher, without being prescriptive about refrigerant specifications, as long as those complied with the MoEFCC's requirements. Three major manufacturers participated in the bid:⁹²

- Panasonic: 5.2 ISEER, R-410A, Indian rupees (INR) 35,000/unit (approximately US\$515);
- Daikin: 5.4 ISEER, R-32, INR 41,000/unit (approximately US\$605); and
- Godrej: 5.2 ISEER, R-290, INR 51,000/unit (approximately US\$750).

Daikin and Godrej were offered the option to meet Panasonic's price. Godrej chose to meet it, but Daikin did not. Thus, Panasonic was awarded a contract for 60,000 units, and Godrej was awarded a contract for 40,000 units. On the positive side, the manufacturers had flexibility in terms of the choice of refrigerant; however, while the ultimate outcome is very good, neither Daikin nor Godrej were rewarded for proposing low-GWP refrigerants. The bid evaluation also did not account for differences in energy efficiency (ISEER 5.2 versus 5.4). To ensure an outcome that takes into account sustainability, the bid evaluation should consider overall environmental impact over the equipment's lifetime rather than energy performance alone.

- **Take into account bid price implications when considering out-of-market consumer and purchaser protections**

In the EESL 2017 tender, several consumer or purchaser protections were put in place that may have increased the bid price.⁹³ While some of these protections may have been warranted, their advantages should be carefully balanced with their costs. The following insights and lessons are drawn from the EESL tender experience:

- **Require a large deposit for bid security.** This increases the cost of the bid price so manufacturers can cover the cost of borrowing the deposit or the alternative yield on investment of such funds.
- **Withhold 10 percent of the winning bid until the warranty expires.** This increases bid price because of the interest costs to the manufacturer.
- **Require a three-year comprehensive warranty.** While this measure was put in place to ensure quality, it also contributed to substantially increasing the bid price compared to a one-year standard warranty. It was likely more expensive than an aftermarket warranty or the expected cost for repairs.

Two additional factors that likely increased bid prices in the 2017 EESL tender were requiring immediate delivery and not specifying the delivery location. With immediate delivery, manufacturing and distribution costs may increase, and without a specific delivery location, manufacturers may price assuming the worst-case scenario.

- **Use an integrated procurement strategy**

Using a procurement strategy that provides full service—for example, requiring the bidder to provide installation and services—not only eases the administrative burden, it can also maximize energy and

environmental benefits and bring leverage to the cost of such services that would otherwise be procured locally by consumers (for example, the Reliance Infrastructure Five-Star Split AC Pilot Program discussed in F1). However, such an inclusion will increase the price compared to a solution seeking to procure the appliance only.

In the tender documents, the purchaser should specify the best practices for installation and service to be provided by the bidder. These are normally provided through local distribution channels, but by incorporating them in the bid, the cost of these services can be reduced and so can the hardware costs of the products. In addition, in specifying these, the purchaser can ensure best practices are followed, leading to additional energy savings and environmental benefits.

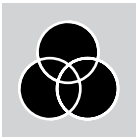

The administering organization should be sure to plan and budget for all steps in the process not covered by the bidder. For example, if the bidder is not installing the appliances, where will the administering organization store the appliances and who will install and service them?

RESOURCES

- Garnaik, Soumya, 2018, “Super-efficient AC Program in India,” ESMAP, World Bank Group, https://www.esmap.org/sites/default/files/events-files/Int%20Conf%20Sust%20Cooling/SPGarnaik_WB_USA_Optimized.pdf.
- Institute for Sustainable Government, 2017, *Leap Frogging to Super Efficiency*, Washington, DC, <http://www.igsd.org/wp-content/uploads/2017/08/Updated-EESL-AC-Bulk-Procurement-4-Aug.pdf>.
- Institute for Governance & Sustainable Development and OzonAction/United Nations Environment, *Buyers’ Club Handbook—January 2020 Update*, <http://www.igsd.org/wp-content/uploads/2018/01/Buyers-Club-Handbook-Jan2020.pdf>.
- Singh, Manjeet, and G. Gurprasad, 2019, *Bulk Procurement in Room Air Conditioning: A Critical Analysis of the EESL Programme*, The Energy and Resources Institute, New Delhi, India, <https://www.teriin.org/policy-brief/bulk-procurement-room-air-conditioning-critical-analysis-eesl-programme>.
- Sarkar, Ashok, and Sarah Moin, 2018, “Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs,” *World Bank Livewire*, <https://openknowledge.worldbank.org/bitstream/handle/10986/30385/129781-BRI-PUBLIC-VC-ADD-SERIES-6-9-2018-12-9-31-LWLJfinalOKR.pdf?sequence=1&isAllowed=y>.
- World Bank Group, 2018, *International Bank for Reconstruction and Development Program Appraisal Document on a Proposed Loan in the Amount of US\$220 Million and a Proposed Guarantee in an Amount of up to US\$80 Million in Support of Commercial Financiers to Energy Efficiency Services Limited with the Guarantee of the Republic of India for the India Efficiency Scale-Up Program*, Washington, DC, <http://documents.worldbank.org/curated/en/532521527391818294/pdf/India-Energy-Efficiency-PAD-125034-IN-04272018.pdf>.

F3. REDUCE THE FIRST COST OF SUSTAINABLE SPACE COOLING THROUGH DEBT SUBSIDY AND RISK MITIGATION INSTRUMENTS

At-a-Glance

	<p>What debt subsidy and risk mitigation instruments are and why they are important</p> <p>Affordable and accessible financing for sustainable space cooling allows facility owners and consumers to leverage future energy savings to undertake an energy retrofit of existing buildings or to purchase sustainable cooling equipment. Debt subsidy can lower the cost of capital, and risk mitigation instruments can enhance credit and default risk for commercial lenders. Both are key drivers in encouraging the financial sector to develop and offer sustainable space cooling financing and to help build familiarity and experience with sustainable space cooling and building energy-efficiency financing in general. Multiple debt subsidy instruments exist (for example, revolving loan funds and green credit lines) and may be applied as per the maturity level of the respective market and suitability by the targeted sector.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Determine market readiness and suitability by targeted sector when evaluating the most appropriate financial mechanism • Ensure sufficient sustainability of underlying subsidies to support the establishment of a market that is able to successfully transition to full commercial self-sufficiency without the need for ongoing public funding
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias</p>

What Debt Subsidy and Risk Mitigation Instruments Are and Why They Are Important

As discussed in the *Primer* (within the discussion of barriers in section 4), facility owners and consumers tend to base building energy efficiency and space cooling purchasing decisions on the lowest first cost as opposed to the lowest life cycle cost. For both building energy efficiency and sustainable cooling equipment, future energy savings are not an asset that can easily be secured. The very nature of the building energy-efficiency measures and sustainable space cooling being integrated into buildings that are often highly indebted allows little opportunity to secure financing against the building-integrated assets. Debt subsidy and risk mitigation instruments can be viewed as a bridge, and ultimately a complement, to fit-for-purpose financing and market-based mechanisms that have been designed to address the full spectrum of needs for this sector, and thereby reducing the extent of the need for debt subsidy. These needs include lower credit risk, lower performance risk in relation to the realization of savings, appropriate accounting characterization of the financing, and elimination of split incentives by matching the flow of future energy savings with the obligation of loan repayment. Debt subsidy and risk mitigation instruments can help establish a market and create demand by increasing access to and affordability of financing, which allows facility owners and consumers to access the lower life cycle costs without having to directly invest their own funds in the incremental first cost of building energy efficiency and sustainable space cooling.

This intervention discusses a few debt subsidy and risk mitigation instruments that have been used for energy efficiency in general, including cooling efficiency. This publication is not intended to go into

detail on each of these financial mechanisms, but rather to provide a brief overview of those that are most applicable to space cooling. For more information on each of these financial mechanisms, see the resources list.

- **Revolving loan funds.** Revolving loan funds function similarly to traditional loans for borrowers but are generally managed by the government, a government-backed entity, or a nongovernment organization (NGO) rather than a bank. Revolving loan funds require initial seed money, often from governments, with support from multilaterals or other donors, but then should be self-sustaining as repaid financing is utilized to support further loans. As such, they provide a way to channel subsidies and provide financing for projects that may struggle to secure traditional financing at affordable rates. Revolving funds can be used to lend to homeowners and small and medium-sized enterprises, and they are also commonly used to fund energy-efficiency projects in the public sector.

Revolving loan funds are by definition restricted to the extent of the initial supporting capital and cannot make more loans until the initial loans are repaid. Also, revolving loan funds will often have high administrative costs due to their relatively small scale and high governance requirements of assuring use in accordance with fund objectives, which can add to the need for subsidies and in turn limit either the scope of operation (such as to public sector buildings where credit and governance risk is low) or the long-term sustainability of the fund.

Public sector revolving loan funds are very common in the United States and the United Kingdom. Energy efficiency revolving funds have also been established in other parts of the world, with support from international financial institutions such as the World Bank or from climate finance instruments such as the Global Environment Facility in Armenia and Bulgaria, among other countries.⁹⁴

- **Green credit lines.** Green credit lines are credit lines made available by public finance institutions to support investments in renewable energy and energy efficiency. The credit lines are made available via commercial financial institutions to homeowners and businesses looking to make energy-efficiency investments. These credit lines generally offer below-market interest rates or longer-term tenors to the borrowers than traditional credit lines. Green credit lines are common at banks all over the world.

Some shortcomings of green credit lines are that they may have high collateral requirements and their interest rates may still be considered too high and their tenors too short for many facility owners and consumers. Green credit lines can be used only by homeowners and businesses with accounts at financial institutions, leaving out 1.7 billion unbanked adults globally. In addition, businesses will generally prioritize investments they consider core to their business over investments in sustainable space cooling.

- **Credit or risk guarantees.** To reduce risk to local financial institutions offering energy-efficiency or sustainable space cooling loan products, international finance institutions, governments, or utilities can provide guarantees to the local institution. The two parties enter into an agreement, the financial institution pays a small fee to the guarantee issuer, and then the financial institution initiates transactions with borrowers. Credit guarantees typically cover all types of loan defaults, whereas partial-risk guarantees cover losses due only to specific causes. In both cases, the guarantees generally cover less than the full loan amount to incentivize the financial institution to appropriately assess the credit risk of the borrower and fully pursue recovery on defaults.

Credit guarantees reduce commercial lenders' perceived higher risk of lending, which allows them to offer more favorable terms to borrowers. In the long term, loan guarantees serve to increase the confidence of local financial institutions in specific energy-efficiency project developer models. Loan

guarantees are best used when there is already a highly functional banking system in place and the markets are mature.

- **Green mortgages.** Green mortgages, also called energy-efficient mortgages, are similar to typical residential mortgages except they can be used only for energy-efficient buildings or to make energy-efficient upgrades to an existing building. Banks or mortgage lenders may offer lower interest rates and allow borrowers to borrow more compared to a regular mortgage because of the borrower's lower building operating expenses as a result of the energy savings, which enhances their credit status. Green mortgages are available in the United States, parts of Europe, and a few developing countries.

In Europe, the Energy Efficient Mortgages Action Plan is an initiative that aims to create a standard energy-efficient mortgage. It currently has 51 banks and 33 other organizations that have committed to test the implementation of the energy-efficient mortgage framework with their current products and processes, with plans to implement an energy-efficient mortgage product in the future.⁹⁵

In Mexico, the Sociedad Hipotecaria Federal (Federal Mortgage Society) began offering green mortgages to low-income households through its EcoCasa program in 2013. The Sociedad Hipotecaria Federal received support from the Inter-American Development Bank and the KfW Development Bank to offer mortgages with interest rates up to 3 percent lower than it typically offered.⁹⁶ About 20 percent of the Sociedad Hipotecaria Federal's portfolio is through the EcoCasa program, and by the end of 2016, EcoCasa had provided mortgages for 27,600 homes, which was initially its 2019 goal.

- **Green bonds.** Bonds are debt instruments issued by large organizations and public entities to fund large-scale green infrastructure projects. Financial institutions use them to raise capital that is made available to facility owners at more competitive rates for energy-efficiency projects. They have a set repayment timeframe and a set interest rate. Green bonds must be used as described in the documentation of the offering to fund specified green projects. The Green Bond Principles are voluntary but widely adopted process guidelines, formulated by the International Capital Market Association, that recommend transparency and disclosure and promote integrity in the development of the green bond market; they explicitly define the eligible categories under which projects can be labeled "green."

The World Bank issued the first green bond in 2008. By 2018, the World Bank had issued 147 green bonds in 20 currencies, totaling approximately US\$11 billion.⁹⁷ Forty-four percent of these bonds were for renewable energy or energy efficiency.

Comparisons to Subsequent Interventions

The debt subsidy and risk mitigation instruments in this intervention have attributes that distinguish them from regular financing instruments. However, the five subsequent financial interventions in this publication go further to address credit and performance risks, match repayments to savings, or structure potential off-balance sheet treatment. As such, they do not directly impact facility owner or consumer debt capacity and can be considered fit-for-purpose or dedicated to energy efficiency or sustainable space cooling.

- **F4. Cooling as a Service (CaaS).** The implicit financing of a well-structured CaaS arrangement is not even visible to the facility owner or consumer. They are simply paying for the provision of sustainable space cooling as they use it as a service.

- **F5. Energy service companies (ESCOs).** Under the ESCO model, financing and repayment are matched to the energy savings, and the risk of nonperformance is underwritten by the ESCO, which ensures that savings provide the cash flow to cover the loan repayments.
- **F6. Energy service agreements (ESAs).** Financing is provided by a specialty energy services agreement provider, and the facility owner or customer pays for these savings at an amount that is less than the savings enjoyed. Because of this, no performance risk falls on the facility owner or consumer.
- **F7. Property assessed clean energy (PACE) and environmental upgrade financing (EUF).** Financing is provided via the local municipality and secured through the property (or land) tax assessment, which provides credit enhancement and matches debt repayment to the energy savings. As an added benefit, this structure is designed to transfer the repayment obligation to future owners at the time of sale so that the repayment always matches the beneficiary of the energy savings.
- **F8. Utility-led demand-side management.** Financing is provided via the utility and secured through the utility bill, which provides credit enhancement and matches debt repayment to the energy savings.

Key Factors to Consider for Implementation of Debt Subsidy and Risk Mitigation Instruments

- **Determine market readiness and suitability by the targeted sector when evaluating the most appropriate financial mechanism**

Each financial mechanism is best suited to a market at a particular maturity level, with less mature markets relying on public financing and more mature markets able to sustain themselves on fit-for-purpose commercial financing.

After grants (which are typically limited), revolving loan funds are often one of the first financial mechanisms that see success in underdeveloped financial markets. While the seed capital for the fund is typically publicly sourced, the required repayments help provide a credit history for borrowers and demonstrate the commercial viability of energy-efficiency investments. Green credit lines are one of the next financial mechanisms that become viable as the market matures. They are typically funded by development banks first and then incorporate funding from commercial banks. Credit or risk guarantees are appropriate for more mature markets once commercial banks have begun lending. Green mortgages may need support of green credit lines and credit and risk guarantees in the early stages of adoption to be viable for commercial banks, so they will typically be introduced once these are in place. Finally, outside of mature markets, green bonds will typically be limited to public entity and large corporate issuers.

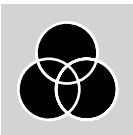

- **Ensure sufficient sustainability of underlying subsidies to support the establishment of a market that is able to successfully transition to full commercial self-sufficiency without the need for ongoing public funding**

While the ultimate goal is to develop markets that are not reliant on public financing, incentives, and debt subsidy, there is a risk of transitioning to commercial financing too quickly. Sufficient market experience and capacity must develop to sustain the investments as public support decreases.

RESOURCES

- Magallón, Daniel, Jasmine Neve, Aurélien Pillet, Thomas Motmans, Livia Miethke Morais, and Peter Lemoine, 2019, *Manual of Financing Mechanisms and Business Models for Energy Efficiency*, United for Efficiency, Paris.
- Limaye, Dilip, and William Derbyshire, 2014, *Financing Municipal Energy Efficiency Projects*, ESMAP, Washington, DC, <https://www.esmap.org/node/4794>.
- “Revolving Loan Funds,” 2020, American Council for an Energy Efficient Economy, February 5, 2020 (accessed December 5, 2019), <https://www.aceee.org/toolkit/2020/02/revolving-loan-funds>.
- Palmer, Karen, Margaret Walls, and Todd Gerarden, 2012, *Borrowing to Save Energy: An Assessment of Energy-Efficiency Financing Programs*, Resources for the Future, Washington, DC, http://www.puc.state.pa.us/Electric/pdf/Act129/OBF_Article-RFF_Study-Borrowing_to_Save_Energy-2012.pdf.
- World Bank, 2018, *Green Bond Impact Report 2018*, Washington, DC, <http://pubdocs.worldbank.org/en/632251542641579226/report-impact-green-bond-2018.pdf>.
- Sarkar, Ashok, Jonathan Sinton, and Joeri de Wit, 2014, *Designing Credit Lines for Energy Efficiency*, ESMAP, Washington, DC, <https://openknowledge.worldbank.org/handle/10986/18410>.
- Aditya, Lukas, 2018, “Financing Energy Efficiency, Part 1: Revolving Funds,” ESMAP, <https://www.esmap.org/node/170491>.
- Wu, Yun, Jas Singh, and Dylan Karl Tucker, 2018, “Financing Energy Efficiency, Part 2: Credit Lines,” ESMAP, <https://openknowledge.worldbank.org/handle/10986/30386>.

F4. IMPLEMENT COOLING AS A SERVICE, INCLUDING DISTRICT COOLING AND BEYOND

At-a-Glance	
	<p>What Cooling as a Service is and why it is important</p> <p>Cooling as a Service (CaaS) is an innovative business model that places ownership and operation of cooling equipment with a service provider, and offtakers pay for the availability or use of the cooling they receive, rather than for the physical product or infrastructure that delivers the cooling. Under this model, incentives are fully aligned: offtakers seek to minimize demand for cooling as a variable cost, and suppliers seek out the lowest life cycle cost of delivering cooling services procuring the highest efficiency cooling solution along with high-quality operation and maintenance practices.</p> <p>There are two distinct models for this intervention, and the attributes of each determine sector applicability and likelihood of scaling. The first, and by far the largest, of these is the multiple offtaker model, more commonly known as district cooling. District cooling systems are suited to new construction and are relevant where significant new districts or cities are planned and certain preconditions are met. The preconditions include significant anchor loads, building density, and multiple offtakers with a diversity in cooling loads, to enable a significant reduction in aggregate cooling capacity.</p>
	<p>The second, relatively new, model is the single offtaker model, based on a combination of a fixed cooling availability fee and variable cooling usage fee. An understanding of accounting considerations across market sectors is key to successfully structuring single offtaker contracts but can result in increased risk to the service provider. There are a range of risk mitigation strategies that can be incorporated, particularly when designing Cooling as a Service (CaaS) for higher-risk market sectors.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Multiple Offtakers <ul style="list-style-type: none"> • Ensure offtake through long-term concession rights or long-term offtake agreements with high-credit anchor clients—typically government or institutional entities • Integrate district cooling network construction with the infrastructure construction of new developments. Develop in high-density areas to offset distribution network costs. • Recruit multiple offtakers with noncontiguous cooling loads to enable a significant reduction in aggregate cooling capacity • Leverage available heat sinks, thermal energy supply, and storage to further increase efficiency and reduce peak load demand • Single Offtaker <ul style="list-style-type: none"> • An understanding of accounting considerations across market sectors is key to successfully structuring single offtaker contracts but can result in increased risk to the service provider. There is a range of risk mitigation strategies that can be incorporated, particularly when designing CaaS for higher-risk market sectors.
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Lack of Transparency, Split Incentives, Complexity of Choice</p>

What Cooling as a Service (CaaS) Is and Why It Is Important

CaaS is an innovative, service-based business model that places ownership and operation of cooling equipment with a service provider, and the customers pay for the availability or use of the cooling they receive, rather than for the physical product or infrastructure that delivers the cooling. The model is very

similar to the established district heating or *chauffage* model deployed extensively across Europe and North America. Under a CaaS structure, the service provider has a strong incentive to procure equipment with the lowest life cycle cost (highly efficient equipment) rather than on the purchase price and to ensure quality maintenance, as doing so enhances their competitiveness and their profitability.

CaaS holds great promise, as it has the potential to solve many of the major market failures and barriers that can prevent the adoption of high-efficiency, sustainable cooling equipment, along with high-quality operation and maintenance practices. There are two distinct models, with the attributes of each determining sector applicability and likelihood of scaling. The first, and by far the largest, of these is the multiple offtaker model, more commonly known as “district cooling.” The second model is the single offtaker model, based on a combination of a fixed cooling availability fee and variable cooling usage fee.

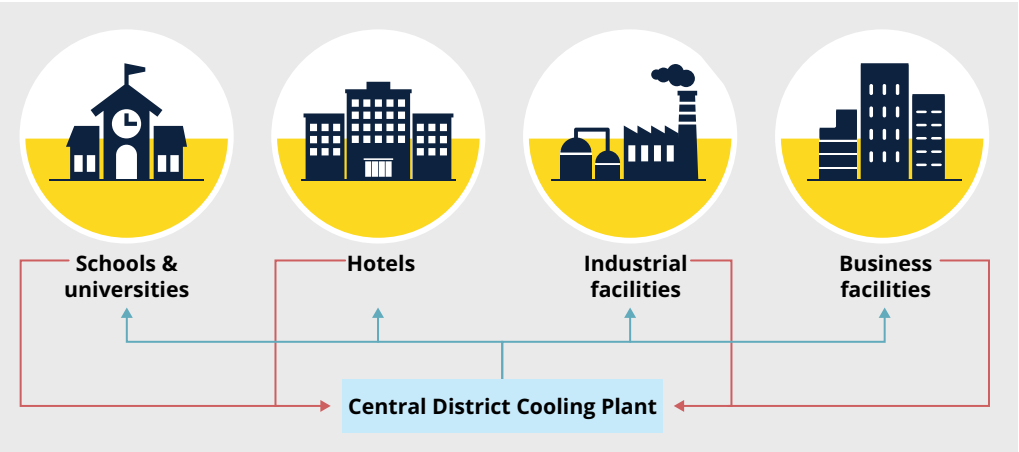
Both of these models provide the structure to enable the deployment of sustainable cooling equipment but do not address the building energy-efficiency opportunity more generally. With the majority of the CaaS opportunity being associated with the new construction of districts, a good practice would be to require building energy efficiency—possibly through a specifically adopted building code or covenant across the district—to ensure that efficient buildings are connected to the cooling infrastructure of a CaaS delivery model.

For a comparison of the asset ownership and risk and savings allocation of CaaS with energy service companies (ESCOs), energy service agreements (ESAs), and managed energy service agreements (MESAs), please see Annex 3.

CaaS for Multiple Offtakers: District Cooling

District cooling is the distribution of cooling energy, typically in the form of chilled water from a centralized plant to multiple buildings in a district, as shown in figure F4.1. Centralizing the cooling infrastructure offsets the need for dedicated cooling systems in each building within the district.

FIGURE F4.1: DISTRICT COOLING PLANT



Source: Authors, composed by Rocky Mountain Institute.

As with many electric utilities, there is typically a fixed payment for the connection and availability of cooling and a variable payment for the actual supply (for example, cost-per-unit for volume and temperature of chilled water supplied). The demand is controlled by the building owner through their building automation system or thermostats.

The developer or owner of the centralized plant is incentivized to run with the lowest levelized (or life cycle) cost. In addition to high-efficiency equipment and advanced maintenance practices, they will seek to incorporate available heat sinks (from cooling towers to geo-exchange and river water), and even heat sources (utilization of waste heat to power absorption chillers), to further increase efficiency.

Advantages of District Cooling

- **Lower aggregate installed capacity.** District cooling plants can take advantage of noncontiguous cooling loads. Noncontiguous cooling loads are loads that naturally appear at different times of the day or week—for example, the sports complex that needs cooling for weekend events, the factory that needs cooling during the workday, and the residential buildings that need cooling in the evening and through the night.
- **Avoided capital costs for building owners.** The multiple offtaker model ensures true service accounting treatment for the building owners under international accounting standards, enabling them to enjoy the full benefits of the avoided cooling capital costs and effectively reducing the overall capital cost of their building.
- **Lower aggregate energy consumption.** While there are many variables to be considered in undertaking a cost and sustainability comparison of a district cooling system, compared to business-as-usual individual building systems, an optimally sized district cooling system can be expected to operate with 40–50 percent less energy for the served cooling load—and potentially more, depending on the availability of heat sinks beyond cooling towers.⁹⁸
- **Ability to use thermal storage to shift loads.** District cooling plants can integrate thermal storage solutions (ice storage), which can shift the time of energy demand and have the potential to provide significant grid benefits through utilization of off-peak power. The benefit of this capability is likely to increase with the increased penetration of renewables and the consequent increased variability of supply.

Limitations of District Cooling

- **Typically, only applicable to new construction zones.** The nature of district cooling with underground distribution systems can economically limit applicability to new construction zones or districts. Furthermore, the capital cost savings to building owners are realized only if the owners have not already invested in a cooling system for their building.
- **Sizing considerations.** The higher efficiency of a centralized cooling plant is partially offset by the need for an underground distribution system to all connected buildings. This distribution system will use pumping energy and also be subject to thermal losses. These factors need to be considered in determining the viability of an individual district cooling system, as project economics may be insufficient below a certain level of aggregate cooling load and building density.

A relatively new model, CaaS for a single offtaker (that is, single entity, often but not necessarily a single building) is structured similarly to the district cooling model, where the building owner pays for cooling

based on a combination of a fixed cooling availability fee and a variable cooling usage fee. The service provider is incentivized to deliver cooling for the lowest levelized (or life cycle) cost, creating demand for high-efficiency equipment and advanced maintenance practices.

Compared to district cooling, individual building CaaS does not benefit from noncontiguous loads and has more limited availability of heat sinks due to single building containment. It may also be riskier for the service provider because the offtake and credit risk are concentrated with a single offtaker. However, the individual model remains of interest due to the potential opportunity to secure many of the benefits of district cooling without the complexity and typical new construction constraint.

With individual building CaaS, the contract between the building owner and the service provider may or may not require full amortization of the installed cooling solution. Each contracting model has its advantages and disadvantages, as discussed below.

Considerations for Contracts Requiring Full Amortization

The single offtaker model requiring full amortization (write down) of the installed cooling solution is unlikely to achieve true service accounting treatment (that is, off-balance sheet) for the building owners under international accounting standards. It is likely to be recharacterized as a capital lease, having the same balance sheet impact as if the building owner had taken out a loan to finance the purchase of the installed cooling system (see Annex 2 for discussion on key accounting considerations). This recharacterization risk effectively limits the opportunity to those building owners for whom this recharacterization risk is not a concern—generally residential, smaller commercial, and institutional sectors.

Considerations for Contracts Not Requiring Full Amortization

The single offtaker model under a contract term that does not imply full amortization of the installed cooling solution can achieve service characterization if appropriately structured, but it does place more risk on the service provider. This risk can be partially mitigated through the use of redeployable cooling equipment, such as modular or rental solutions that can be redeployed post-contract if not renewed or extended into a secondary term.

Future Potential of Single Offtaker CaaS

There are relatively few examples of CaaS outside of district cooling. However, CaaS represents significant potential as an enabler for the deployment of highly efficient cooling technology overcoming the typical higher first-cost barrier of new technologies in segments where accounting requirements are not a consideration. It is a market-based model that has been proven in other sectors, such as mobility-as-a-service.

The Basel Agency for Sustainable Energy (BASE) is leading the CaaS initiative for scaling up the demand for efficient, clean cooling systems through the use and promotion of the innovative CaaS business model. The initiative aims to create a toolkit of standardized CaaS mechanisms; raise awareness among technology providers, financial institutions, and policy makers; institutionalize CaaS through an alliance; and support demonstration projects in iconic or well-known buildings in Latin America and the Caribbean, the Middle East, Africa, and Asia in order to showcase the benefits of the model.^{xxxvii}

xxxvii More information about the CaaS initiative is available at <http://energy-base.org/project/cooling-as-a-service/>.

Key Factors to Consider for Implementation for CaaS—Multiple Offtaker Model

- **Ensure offtake through long-term concession rights or long-term offtake agreements with high-credit anchor clients—typically government or institutional entities**

The primary success factor is around mitigating offtake risk for the CaaS service provider, who is making a long-term investment in the cooling assets that will deliver the service and needs sufficient assurance on future offtake.

- **Concession rights.** Consider long-term rights to provide cooling to a district or zone, effectively requiring new developments to connect to the district cooling network under a price-controlled concession arrangement.
- **Offtake agreements.** Consider long-term supply contract to a high-credit anchor client that will commit to taking a minimum offtake from the district cooling network, reducing the extent of the offtake risk that the service provider is exposed to. This would typically be a government or institutional entity.

One example is the district cooling system in Amravati, the new greenfield capital city of Andhra Pradesh, India. Tabreed, a United Arab Emirates–based cooling provider, has entered into a 30-year concession with Andhra Pradesh Capital Region Development Authority to build, own, operate, and ultimately transfer the district cooling system.⁹⁹ The offtakers are all government buildings, including the state’s assembly, high court, and secretariat, among others. As government buildings, they provide sufficient assurance of continued cooling offtake.

Singapore District Cooling, a subsidiary of Singapore Power, planned, designed, constructed, and now operates and maintains the Marina Bay district cooling system. The Marina Bay system, started in 2006, is the largest fully underground district cooling network in the world. The Marina Bay project in Singapore was made possible by early government planning with the Energy Market Authority, mandating 1.25 million square meters of gross floor area to be set aside in Marina Bay, to be served by the district cooling system.

Paris has the first and largest district cooling system in Europe.¹⁰⁰ Since 1991, Climespace has had a concession to operate the district cooling system in Paris for offices, banks, stores, hotels, museums, and other buildings. It leverages the river Seine as an available heat sink, mitigating the need for more traditional cooling towers. Approximately 60 percent of the chilled-water distribution system is routed through the sewage network, an innovative approach to implementing the system in an established city.¹⁰¹

- **Integrate district cooling network construction with the infrastructure construction of new developments. Develop in high-density areas to offset distribution network costs.**

New residential and commercial developments in highly dense urban environments should consider building the cooling (and heating) infrastructure network into their planning and construction to ensure they offset any future reconstruction costs associated with the CaaS model. As an example, Gujarat International Finance Tec-City (GIFT City), India, is being built as a high-density city with 5.8 million square meters of built-up area over 886 acres of land, making it more dense than the central business districts of Tokyo and London.¹⁰² As a greenfield development, district cooling has been planned for since the beginning stages, reducing its infrastructure costs. For example, the city has an underground utility pipe that houses the chilled-water pipes, along with other utilities.

- **Recruit multiple offtakers with noncontiguous cooling loads to enable a significant reduction in aggregate cooling capacity**

Different offtakers naturally demand cooling at different times of the day or week. Therefore, by aggregating cooling demand across a district, the total cooling capacity required is less than the capacity required if each building were to have its own cooling system. This results in significantly lower up-front capital costs.

In GIFT City, India, the reason for adoption of a district cooling system over individual chiller systems for buildings was the ease of managing, operating, and maintaining a central facility, as well as the improved overall efficiency of the system because of a consistent baseload resulting from the need to serve a diverse set of consumers. GIFT City consists of office buildings, residential apartments, schools, a hospital, hotels, retail stores, and recreational facilities. The assessment study shows that when fully built out, the district cooling system would reduce the requirement for installed cooling capacity from 270,000 TR to 180,000 TR. When fully developed, the system is expected to reduce the cooling power demand of the city by 105 megawatts (MW).¹⁰³

- **Leverage available heat sinks, thermal energy supply, and storage to further increase efficiency and reduce peak load demand**

At larger scales, it becomes economically feasible to use a heat sink or shift loads through thermal energy storage, as discussed in section 3 of the *Primer*. Heat sinks decrease the total electricity needed, while thermal energy storage decreases the peak load, serving to reduce emissions while avoiding capital costs for new electricity generation capacity.

The district cooling system in GIFT City includes stratified thermal energy storage tanks that are used to meet the cooling loads during peak demand periods, thus reducing the total power demand of the system.

Paris's district cooling system uses the Seine as a heat sink to pre-cool water before it enters the electric chillers.¹⁰⁴ During the night, when the demand for cooling is lower, Climespace takes advantage of off-peak electricity and stores thermal energy as either chilled water or ice, which is then used during the hours of peak demand during the day. This storage has the potential to decrease peak power for cooling by 15–50 percent.¹⁰⁵

Key Factors to Consider for Implementation for CaaS—Single Offtaker Model

- **An understanding of accounting considerations across market sectors is key to successfully structuring single offtaker contracts but can result in increased risk to the service provider. There is a range of risk mitigation strategies that can be incorporated, particularly when designing CaaS for higher-risk market sectors.**

Single offtaker contracts with full amortization of equipment will typically need to be of longer tenor to be economically viable (that is, affordable monthly payments). The longer term increases the credit risk to the service provider, but this can be mitigated with full or partial payment guarantees, which are important when considering CaaS to reach higher-risk market sectors.

Single offtaker without full amortization of equipment can be of much shorter tenor but places increased risk of stranded assets on the service provider.

Under both single offtaker approaches, risk can be mitigated by ensuring that installed equipment is able to be easily removed and redeployed in instances of default or at contract termination. This is especially important in the without-full-amortization approach, where modular or even rental solutions should be considered.

BASE is supporting the Swiss government to design a program in Colombia targeting SMEs to increase the uptake of sustainable energy technologies, including cooling systems, through performance contracts. The program design incorporates payment guarantees that will be used to cover part of the risk if an SME defaults on their payments to the solution provider.¹⁰⁶

A latest example of application of the CaaS concept (single offtaker with full amortization of the installed cooling solution) is Rwanda's Coolease scheme, launched in July 2019 to promote adoption of sustainable space cooling solutions. Launched by the Rwanda Green Fund (FONERWA) and the Rwanda Business Development Fund, in partnership with the UN Environment Program's U4E initiative and BASE, Coolease is a financial mechanism that will complement policy measures to increase and accelerate the adoption of efficient cooling technologies and the use of climate-friendly refrigerants. Coolease aims to address the first-cost barrier by enabling suppliers and consumers of air-conditioning and refrigeration products to transition to the latest and most efficient technology without an up-front investment.¹⁰⁷



A dedicated leasing subsidiary is being set up by the Rwanda Business Development Fund to serve as a special purpose vehicle to finance the cooling system for the customer in exchange for monthly payments. The customer will pay back the monthly leasing fee as well as the maintenance costs over time. It is expected that using a more efficient system will save the customer money on electricity every month, which will facilitate the repayment of the loan. The technology provider will install the equipment and commit to providing high-quality maintenance, which is embedded in the Coolease agreement. The program eligibility considers both the technology efficiency and refrigerant type. A contract between the Rwanda Business Development Fund and the technology providers will establish requirements for supply, quality, installation, maintenance, and willingness to relocate the equipment. A Green Growth Guarantee Fund is set up by the Rwanda Business Development Fund and the Rwanda Green Fund as a risk mitigation strategy to mitigate the loss in case of default.

RESOURCES

- Basel Agency for Sustainable Energy (BASE) Cooling as a Service website, <https://www.caas-initiative.org/>.
- Kigali Cooling Efficiency Program, 2018, *Cooling as a Service (CaaS)*, San Francisco, CA, https://www.k-cep.org/wp-content/uploads/2018/07/Cooling-as-a-service-Knowledge-brief-6.7.2018_Final_online_v1.pdf.
- Riahi, Lily, 2015, *District Energy in Cities*, United Nations Environment Program, Paris, https://wedocs.unep.org/bitstream/handle/20.500.11822/9317/-District_energy_in_cities_unlocking_the_potential_of_energy_efficiency_and_renewable_ene.pdf?sequence=2&isAllowed=y.
- District Energy in Cities Initiative homepage (accessed September 18, 2019), <http://www.districtenergyinitiative.org/>.

F5. CATALYZE INVESTMENT IN SUSTAINABLE SPACE COOLING THROUGH THE DEVELOPMENT OF AN ENERGY SERVICE COMPANY CAPABILITY

At-a-Glance

	<p>What ESCOs are and why they are important</p> <p>Energy service companies (ESCOs) overcome one of the primary barriers to deploying energy efficiency: project performance risk. ESCOs shift performance risks away from facility owners and end-users and bring commercial finance into the market, allowing the energy-efficiency market to grow.</p> <p>To work effectively, ESCOs require a set of enabling regulatory, market, and financial conditions. Generally, a country may start with simpler ESCO models (for example, ESCO-as-a-borrower models) and then expand to more complex models (for example, facility-owner-as-a-borrower models) that enable larger projects once the market has been established.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Conduct robust checks on the financial institutions and the ESCOs and offer them technical assistance, support, and capacity building • If available, consider providing financial incentives/support to ESCOs directly and to commercial banks lending to ESCOs, to help establish market capacity • Adopt a standardized contract structure and savings calculation methodology in newer ESCO markets • Establish a nodal agency to streamline administration of the ESCO program • Start with the simpler ESCO as a borrower model, then expand to include a facility owner as a borrower model once the market has been established
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Split Incentives, Complexity of Choice</p>

What ESCOs Are and Why They Are Important

Energy service companies (ESCOs) undertake project engineering and installation and, subject to being satisfied with ongoing service and maintenance requirements, provide performance guarantees or other performance risk mitigation support to facility owners. The main differentiator between ESCOs and other sustainable space cooling or energy-efficiency contractors is the assumption of project performance risk with either a guarantee of energy savings to the client or having their compensation tied to a share of energy savings actually achieved. This performance is specified as part of the terms of an energy savings performance contract (or commonly known as energy performance contract [EPC]) under which projects are delivered. The ESCO model in its various forms effectively provides a delivery mechanism for sustainable space cooling (and, more broadly, energy efficiency) to the market, providing not just the technologies but installation, warranty, performance assurance, financing, and neutral to positive cash flow.

The ESCO model is generally relevant in all markets in order to take project energy performance risks away from the end-user to catalyze greater adoption of efficient cooling projects. Projects can be undertaken as stand-alone cooling projects or as part of a larger energy-efficient project, although in many countries in hot climate zones up to 70 percent of building energy load is cooling and ventilation related, making cooling a priority within any energy-efficiency project.¹⁰⁸ Undertaking projects in conjunction with other energy-efficiency measures increases their size and helps address the transaction cost barrier, allowing better debt terms to be secured.

Super-ESCOs are ESCOs that are owned by governments which, in addition to providing typical ESCO services, may undertake additional energy-efficiency work, such as procuring products in bulk to drive down costs. EESL in India is an example of a super-ESCO.

When establishing an ESCO's capability, there are a number of critical considerations to stimulate demand, provide effective supply, and secure financing while each of the three main actors seek to reduce their risk. Without a deep understanding of the underlying needs and motivations of these actors and the structures that enable them to be met, the success of the ESCO model (and its derivatives—energy service agreements [ESAs] and managed energy service agreements [MESAs]—described under F6) would be at significant risk. This is also reflected in the mixed experience of countries around the world that have sought to establish this capability within their market.

- **ESCOs.** They will generally seek to avoid the credit risk associated with longer-term receivables and will ideally seek project sales treatment—that is, ownership for the project transfers to the client (facility owner) at the time of installation completion, at which point the ESCO can record a sale and recognize revenue on the project, as opposed to recognizing a fraction of the revenue ratably over the term of the financing. (See Annex 2 for discussion on key accounting considerations.)
- **Facility owners.** They want to ensure that energy savings are delivered as planned—without compromising facility safety, productivity, or comfort—and that energy savings are greater than the debt service associated with the project. They may also be concerned about whether the financing will be characterized as debt or an operating expense for accounting purposes. (See Annex 2 for discussion on key accounting considerations.)
- **Financiers.** They will want to ensure that they have no responsibility for performance risk, the risk is appropriately allocated between the parties, and the likelihood of dispute is low. This leaves them to focus on credit risk and price the financing accordingly.

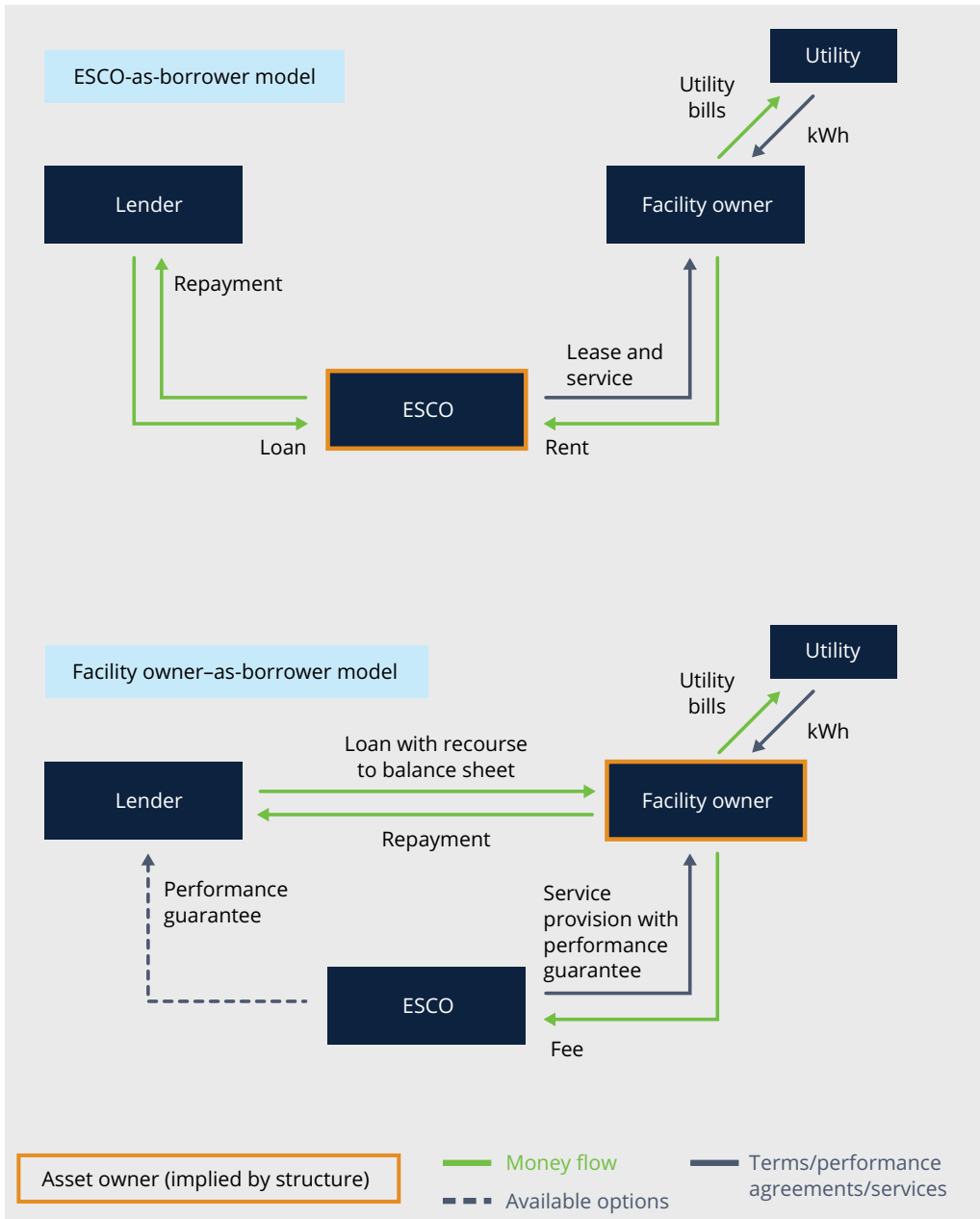
The Two Main ESCO Models

Two primary financing models can satisfy the majority of the ESCO and facility owner considerations—ESCO-as-borrower and facility owner-as-borrower^{xxxviii}—with a number of structuring derivatives within each model, primarily guaranteed savings and shared savings. In either case, savings may be measured (measurement and verification [M&V]) over the life of the financing, measured through the first year and stipulated (or deemed) over the life of the financing, or calculated at design and stipulated over the life of the financing. Measurement virtually eliminates facility owner risk but can add significant cost to a project over time, as it tends to be used when projects are large and diverse in scope, stipulation of savings costs less and is simpler, and projects are smaller and more narrowly focused. An overview of both models is shown in figure F5.1.

For a comparison of the asset ownership and risk and savings allotment of both these ESCO models with Cooling as a Service, ESAs, and MESAs, please see Annex 3.

^{xxxviii} In many publications the two models are identified as “shared savings” and “guaranteed savings” based on an early market correlation of shared savings models to ESCO-as-borrower model and guaranteed savings to the facility owner-as-borrower model. However, as the market has matured, this correlation is no longer evident with shared savings and guaranteed savings models being underpinned with both ESCO-as-borrower and facility owner-as-borrower models driven by customer and market preference. Whether the savings are shared or guaranteed does not fundamentally shape the ESCO market; it is simply how the performance risk and savings are allocated. But who the borrower is does impact sector applicability, financing capacity, project size, and project tenure, and for this reason, this publication has identified the two models as ESCO-as-borrower and facility owner-as-borrower with shared savings and guaranteed saving being structuring derivatives used within each.

FIGURE F5.1: MODELS FOR ESCO FINANCING



Source: Authors, composed by Rocky Mountain Institute.

Note: There are a number of structuring derivatives within each model, primarily guaranteed savings and shared savings.

ESCO-as-Borrower Model

In the ESCO-as-borrower model, the financing flows through the ESCO. This model is simpler to implement, meets all primary facility owner considerations, and can catalyze broad market demand. It has become the preferred approach for developing markets where the ESCO industry is at a nascent stage.

However, the ESCO-as-borrower model does not meet the ESCO consideration of avoiding the credit risk associated with longer-term receivables. Also, because the financing flows through the ESCO, the ESCO may not be able to secure sales treatment for the project at completion and will likely be required to record the cost of the project and the associated debt on its balance sheet, with sales recognized ratably over the contract term. (See Annex 2 for discussion on key accounting considerations.) A further consequence of this is the potential impact on the debt-equity ratios of the ESCOs, which in some jurisdictions are subject to statutory minimums.^{xxxix}

As a result, the ESCOs will typically focus on more narrow-scope, highly profitable, shorter-tenor projects with high creditworthy clients, effectively using the financing as a mechanism to “lease” their own products to clients. For instance, China, which was supported by an enabling policy environment under the 12th five-year plan, has grown to be the world’s largest ESCO market in absolute size—over 6,000 ESCOs have been established there, with industry as the primary segment served. The average revenue per ESCO is approximately US\$2.5 million per annum, and the primary structuring derivatives are guaranteed savings and shared savings orientated to stipulated or deemed savings (calculated and contractually agreed to at the time of contract or implementation) to avoid the complexity, cost, and increased risk of dispute associated with annual measurement and normalization.

Facility Owner-as-Borrower Model

The model more common in mature markets is the facility owner-as-borrower model, with the most typical structuring derivative being measured guaranteed savings. In this case, the funding flows to the building owner, and the ESCO guarantees energy performance. Under this arrangement, the ESCO can secure sales treatment on project implementation as project ownership transfers to the facility owner, with the lender providing full project payment at completion. The credit risk is with the financier, and the performance risk is with the ESCO, which provides a guarantee of savings and is contractually obligated to rectify any shortfall. Thus, this model tends to encourage projects with much broader scope and longer tenor, and also favors large corporations that have sufficient balance sheet strength to underwrite the project performance guarantee. With the financing being directly with the facility owner, there is a greater likelihood that the debt associated with the project will have to be recorded as such by the facility owner, which can be a major barrier to scaling, depending on the balance sheet sensitivity of the sector. (See Annex 2 for discussion on key accounting considerations.)

For instance, in the United States—the largest of the mature ESCO markets where this model has been used extensively—this barrier has been largely overcome in the public sector by enabling state-level legislation that provides public sector institutions the authority to enter into qualifying financing for ESCO projects when the repayment obligation is matched by a qualifying ESCO’s performance guarantee, without having to seek separate approval for the financing and associated debt obligation. This resulted in the establishment of a largely public and institutional sector end market that focuses on major

^{xxxix} There is an opportunity to overcome the barrier to scaling of ESCO debt capacity, which may often be a factor of regulated debt equity ratio requirements, through the use of a derivative of the European forfait model, where the long-term receivables generated by a project post-measurement and stipulation are “sold” or “factored” to the lender in satisfaction of the original ESCO loan. This would increase the ESCOs’ capacity to undertake projects, as they would only hold the project debt for a short period of time. This approach has the potential to overcome the debt constraints faced by ESCOs under the ESCO as a borrower model more broadly around the world.

energy-efficiency opportunities across multiple end uses,¹⁰⁹ with an emphasis on deeper energy retrofits, such as building envelope upgrades and major capital equipment replacements of HVAC systems. There are fewer than 50 active ESCOs in the United States, but the average revenue per ESCO is approximately \$160 million per annum.

Key Factors to Consider for Implementation of an ESCO Ecosystem

- **Conduct robust checks on the financial institutions and the ESCOs and offer them technical assistance, support, and capacity building**

To ensure successful execution of the energy-efficiency projects through the ESCO route, clear procedures and robust checks have to be put in place for financial institutions and ESCOs. For example, financial institutions may need to set up an energy-efficiency group and have their staff undergo training in energy-efficiency financing. For the ESCOs, a national entity or an authorized credit rating agency should determine their creditworthiness. In turn, the ESCOs must be required to undertake energy audits for each of their projects.

As an example, in the Partial Risk Sharing Facility (PRSF) project in India, interested financial institutions (commercial banks, non-banking finance companies) must meet the eligibility criteria and conduct a host of preparatory activities before getting empaneled with the Small Industries Development Bank of India (SIDBI). These preparatory activities include capacity building of their staff on appraisal of energy-efficiency financing, creation of an energy-efficiency cell at their head office, and appointing a single point of contact for all PRSF-related activities. Once all the activities are completed, SIDBI and the financial institution enter into an agreement, through a memorandum of understanding (MOU), for the latter to be recognized as a Participating Financial Institution.

Similarly, the ESCOs eligible to participate in a project in India must be empaneled with the BEE—the national policy-making entity for advancing energy efficiency in India—following a defined due diligence procedure. Non-empaneled ESCOs can participate only after they are graded by authorized credit rating agencies. Before a loan application is submitted (by the ESCO or facility owner) to undertake an energy-efficiency project, the empaneled ESCO conducts energy audits at the facility and develops detailed project reports capturing all the relevant information, such as energy savings, investment, and environmental impact, following which an energy savings performance contract is signed between the ESCO and the facility owner.

To build the institutional capacity of the Participating Financial Institutions and ESCOs, SIDBI is organizing regular workshops to create awareness about the PRSF and overcome the perceived barriers on energy-efficiency projects. BEE is also undertaking independent but integrated efforts to advance the objectives of the PRSF project by conducting workshops for banking professionals across the country.

- **If available, consider providing financial incentives/support to ESCOs directly and to commercial banks lending to ESCOs, to help establish market capacity**

Before an ESCO market has been established, ESCOs and commercial banks may be hesitant to invest if they don't have a good understanding of the risks and opportunities for success. Governments and multilaterals can kick-start the market by providing support for the model, measures to build market confidence, and subsidized financing or other financial incentives to attract the first adopters.

The PRSF project in India, which is supported by the World Bank, promotes investments in energy-efficiency projects by supporting the ESCOs as they deliver projects through energy savings performance contracts. It catalyzes commercial finance for energy-efficiency investments across various demand-side sectors, thereby triggering large-scale energy-efficiency market transformation. This project has two core components. The first is the facility to provide partial credit guarantees to the financial institutions or lenders, to cover a share of the default risk faced by them when extending loans to eligible energy-efficiency projects implemented through ESCOs. Both ESCO models—ESCO as the borrower assuming both credit and performance risk, and facility owner as the borrower, where ESCO assumes only the performance risk—are eligible to receive financing to advance the implementation of energy-efficiency projects. The medium-term pipeline of projects includes HVAC upgrades. The second component of the project is to provide the necessary technical assistance and capacity building to ensure that the first component is successful and to address other aspects of the energy-efficiency ecosystem needed to sustain a strong energy-efficiency market transformation.^{xi}

While the China ESCO market is large now, it was originally propelled by international development finance institutions and bilateral organizations, including the World Bank, International Finance Corporation (IFC), Asian Development Bank, the French Environment and Energy Management Agency (ADEME), and the German KfW, among others.¹¹⁰ The Chinese government sets energy intensity reduction targets in each of its five-year plans and provides incentives equal to 15–20 percent of typical project investment costs. Provincial governments may contribute additional incentives.

Governments can also encourage the development of the ESCO market by offering tax incentives for new ESCOs, including exemption from or reductions in taxes such as corporate income taxes and sales tax value-added tax (VAT). These incentives can be phased out as the market matures and becomes self-sustaining.

To jump-start its ESCO market, China very effectively provided tax incentives to ESCOs in its 12th five-year plan (2011–15).¹¹¹ These policies for ESCOs included the following:

- Three years of corporate income tax exemption,
- A 50 percent reduction in corporate income tax the following three years,
- Exemption from sales tax VAT, and
- Authorizing ESCO subsidies by both central and local governments for eligible EPC projects.

In its 13th five-year plan, China was able to roll back several of these policies without materially disrupting what is today the world's largest ESCO market.

■ **Adopt a standardized contract structure and savings calculation methodology in newer ESCO markets**

In a nascent ESCO market, adoption of a standardized contract structure and savings calculation methodologies is key. Typically, the ESCO-as-borrower model is most suitable in these newer markets, using calculated (and sometimes measured at project commissioning) and stipulated savings. Standardization not only helps create trust and scalability but also greatly reduces the transaction costs for financiers, thereby providing further impetus to the industry.

xi For more information on the technical assistance and capacity building, please see <http://projects.worldbank.org/P128921/partial-risk-sharing-facility-energy-efficiency?lang=en>.

In the PRSF project in India, SIDBI and EESL are jointly offering the technical assistance to project stakeholders, including Participating Financial Institutions, ESCOs, and facility owners. Legal documents such as MOUs and guarantee claim forms—and formats for loan applications, detailed project reports, energy savings performance contracts, measurement and verification reports, and so forth—have been standardized in the form of templates. This reduces the transaction costs for Participating Financial Institutions and allows ESCOs or facility owners to develop a strong, bankable project loan application that aligns with the understanding and requirements of Participating Financial Institutions.

China did not seek to adopt standardized ESCO methods and contracts when it was first starting out, giving ESCOs flexibility to develop and innovate. Since then, an ESCO industry association was formed, and best practices have been established, which have likely led to an increase in levels of trust around the model and supported scaling.

■ **Establish a nodal agency to streamline administration of the ESCO program**

When the government is providing subsidies, the program should be administered by one government entity to reduce transaction costs and ease the process for the ESCOs and financial institutions. The nodal agency should make the program information freely available to the public through model contracts and other documents when possible.

For example, in the Czech Republic, subsidies are available through the program EFEKT (EFEKT is short for “efektivně,” which translates to “effectively”).¹¹² The Ministry of Industry and Trade administers this program, maintains a register of ESCOs and EPC providers, and developed a model contract in cooperation with the association of ESCOs.^{xli} The ministry also maintains a website with documents that outline the process for preparing and implementing EPC-based projects, including information on the public tendering procedure.

In the PRSF project in India, a dedicated PRSF web portal and SIDBI action as the nodal agency have been key aspects to bringing transparency to and streamlining administration on the project. The Participating Financial Institution, upon completing its due diligence and checking the eligibility of the project under the PRSF program, may approve the loan application and submit a credit guarantee claim form on the PRSF website portal. It is then approved by SIDBI.

■ **Start with simpler ESCO models, then expand to include facility owner as a borrower model once the market has been established**

Business models in emerging markets need to be innovative, simple, scalable, and sustainable. While starting with the ESCO as a borrower model puts the credit risk on the ESCO, it is a simpler structure and brings lenders into the space. However, ESCOs in turn will typically only work with clients who have good credit, as they carry the credit risk and do not have the sophistication of commercial lenders. Prime sectors for initial focus would be government, institutional, and industrial.

Once the trust in energy-efficiency savings is established and the industry matures in capability, lenders will be more willing to lend larger sums to ESCOs, potentially securing against project receivables. Over time the market can expand to provide lender financing to building owners directly under the facility owner-as-borrower model, where financing can be secured against the building, enabling longer-term credit and consequently larger projects.

xli The model contract can be found on the Ministry of Industry and Trade website: <https://www.mpo.cz/dokument105425.html>.



In the United States, this has allowed ESCOs to grow significantly larger, averaging \$160 million each in annual revenue in the sector. In Germany, the ESCO model is somewhat of a derivative of the facility owner-as-borrower model. In this model, the ESCO is the initial borrower and undertakes the project, and the facility owner provides letters of payment that, once the project is complete, are sold by the ESCO to the bank (forfait model).

RESOURCES

- “Partial Risk Sharing Facility for Energy Efficiency (PRSF),” Small Industries Development Bank of India (accessed December 19, 2019), <http://prsf.sidbi.in/>.
- Boza-Kiss, Benigna, Paolo Bertoldi, and Marina Economidou, 2017, *Energy Service Companies in the EU*, Joint Research Center of the European Commission, Brussels, Belgium, <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-service-companies-eu-status-review-and-recommendations-further-market-development>.
- Taylor, Robert P., Chandrasekar Govindarajalu, Jeremy Levin, Anke S. Meyer, and William A. Ward, 2008, *Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond*, World Bank, Washington, DC, <http://documents.worldbank.org/curated/en/838051468026936715/pdf/425290PUB0ISBN11OFFICIAL0USE0ONLY10.pdf>.
- International Finance Corporation, 2017, *China Energy Service Company (ESCO) Market Study*, Washington, DC, <https://www.ifc.org/wps/wcm/connect/5d1cfd04-36fc-4f80-9900-c419940bd69b/IFC+final+ESCO+report-EN+.pdf?MOD=AJPERES&CVID=jZVnBBO>.
- Kumar, S., N. Kumar, K. Cherail, S. Setty, N. Yadav, and A. Goenka, 2017, *Transforming the Energy Services Sector in India—Towards a Billion Dollar ESCO Market*, Alliance for an Energy Efficient Economy, New Delhi, India, <https://www.aeee.in/wp-content/uploads/2017/09/Transforming-the-Energy-Services-Sector-in-India-Towards-a-Billion-Dollar-ESCO-Market.pdf>.

F6. EXPAND ACCESS TO FINANCING FOR SUSTAINABLE SPACE COOLING THROUGH THE DEVELOPMENT OF ENERGY SERVICE AGREEMENTS AND MANAGED ENERGY SERVICE AGREEMENTS, DERIVATIVES OF THE ENERGY SERVICE COMPANY MODEL

At-a-Glance

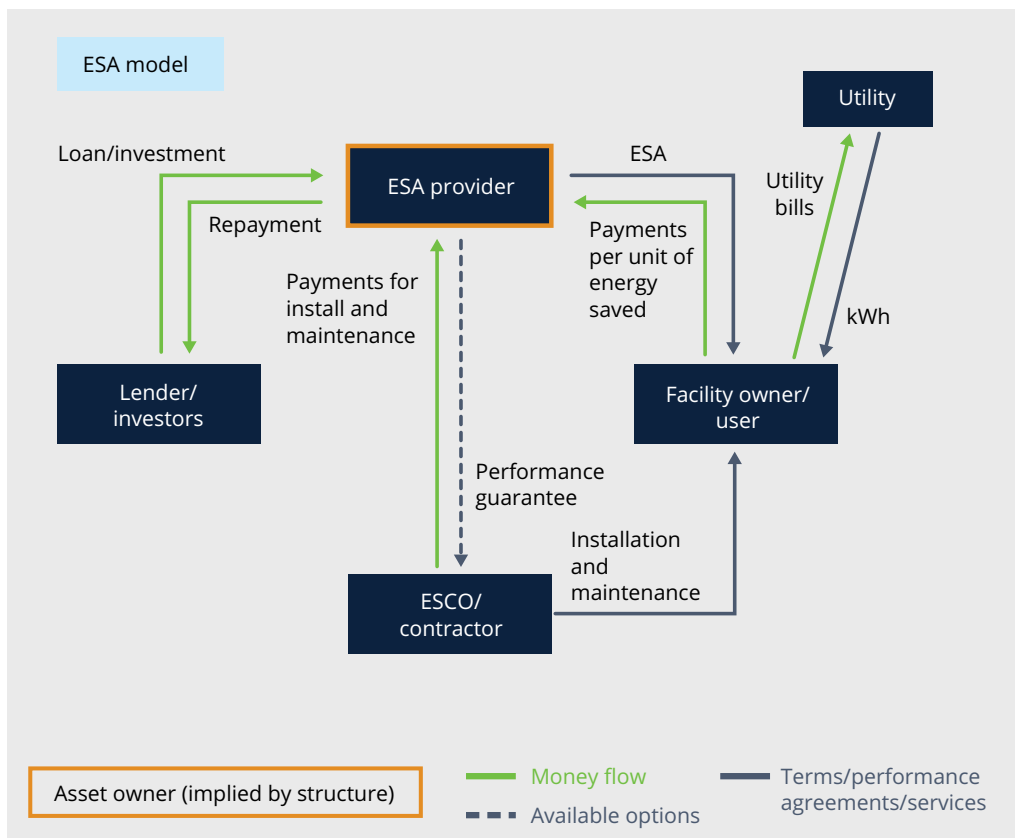
	<p>What ESAs and MESAs are and why they are important</p> <p>Energy service agreements (ESAs) and managed energy service agreements (MESAs) are emerging efficiency financing structures that, similar to energy service company (ESCO) models, overcome the two primary barriers to deploying energy efficiency: lack of availability of financing and project performance risks. Such projects are often undertaken by ESCOs that have developed expertise around project performance risk and measurement and verification practices. The primary difference from the ESCO models described in F5 is that they are designed to deliver off–balance sheet treatment for both the facility owner and the ESCO or contractor implementing the project (also see Annex 3). This intervention is most relevant in countries where the value of energy efficiency is well established and a robust ESCO market exists.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Establish ESCO capabilities that are foundational to delivering performance-based energy contracts and their derivatives (see F5) • Develop good practice or standardized contract structures and savings calculation methodologies to support the emergence of ESA and MESA models • Start with the simpler ESA model, then expand to include the MESA model where assessed market opportunity is felt to be material
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Split Incentives, Complexity of Choice</p>

What Energy Service Agreements Are and Why They Are Important

Energy service agreements (ESAs) are derivatives of the energy service company (ESCO) models described under F5, wherein they finance energy-efficiency projects and provide an implicit performance guarantee of energy savings. However, in the ESCO facility owner–as-borrower model, the facility owner effectively accounts for a capital lease, whereas the ESA is designed to be a service agreement providing the potential for off–balance sheet treatment for the facility owner. The ESA does this by characterizing the payment stream as payment for efficiency savings as opposed to payment for assets and services. This model could also be termed “Efficiency as a Service,” placing it somewhere between the ESCO facility owner–as-borrower model and the Cooling as a Service (CaaS) model with regard to its principal characteristics.

Under an ESA, the energy service provider enters into the ESA directly with the facility owner for a contracted period (typically five to 15 years). Before equipment is installed, the ESA provider assesses the customer’s baseline energy consumption and calculates an up-front estimation of savings. The ESA provider then pays and manages a contractor/ESCO to install the high-efficiency equipment and help maintain the equipment through the contract period. Once project installation is complete, a measurement and verification analysis is performed to determine actual savings compared to baseline energy use.

FIGURE F6.1: ESA MODEL



Source: Authors, composed by Rocky Mountain Institute.

The customer immediately has reduced operating expenses. They pay lower utility bills through the contract term and pay the ESA provider a charge per unit of energy saved. The payment to the ESA provider is set below the customer's baseline utility price. This effectively places the performance risk on the ESA provider, who will typically have recourse to the implementing contractor/ESCO. The ESA provider retains ownership of the equipment for the duration of the ESA term and pays for maintenance to ensure reliability and performance. New efficiency measures can be added during the contract. At the end of the contract, the customer can elect to purchase the equipment at fair market value, extend the contract, or (less commonly) return the equipment. An overview of the ESA model is shown in figure F6.1.

The analysis of the parties' risk preference and ESA attributes below is contrasted with that of the ESCO facility owner-as-borrower model to explain the key distinctions between the two:

- **Contractor/ESCOs.** They will generally seek to avoid the credit risk associated with longer-term receivables and will ideally seek project sales treatment—that is, ownership for the project transfers at the time of installation completion, at which point the contractor/ESCO can record a sale and

recognize revenue on the project, as opposed to recognizing the sale ratably over the term of the financing. (See Annex 2 for discussion on key accounting considerations.)

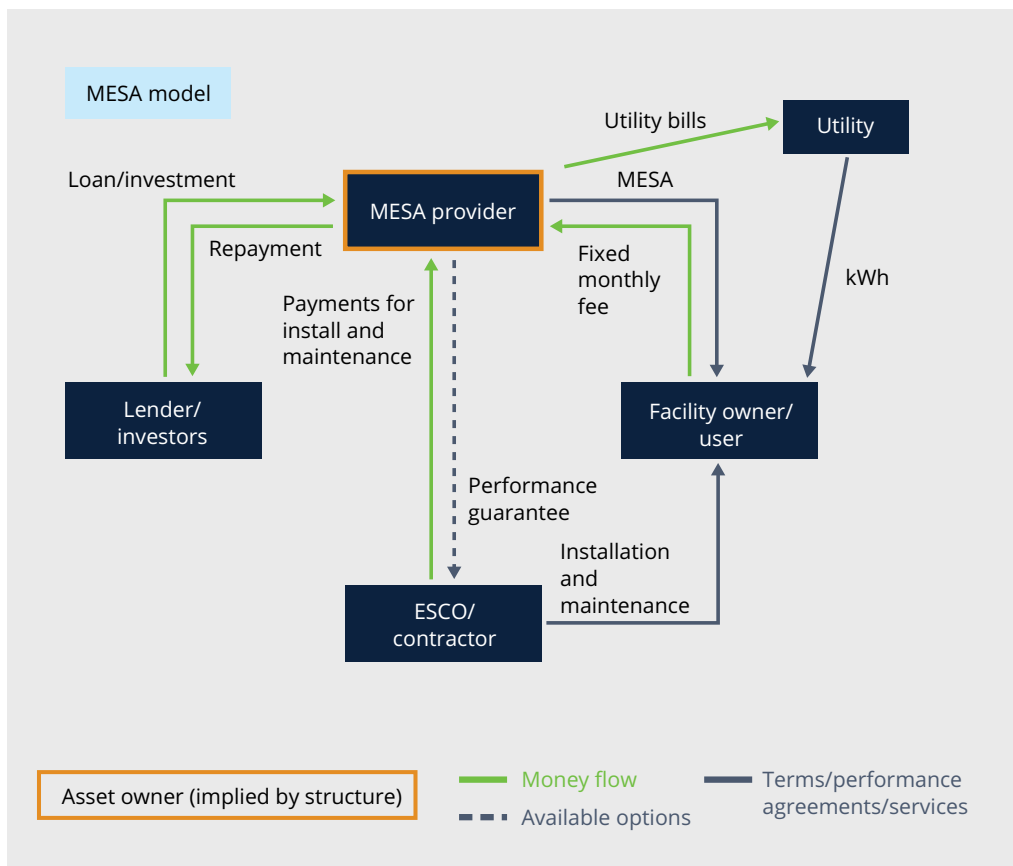
- **In the ESA model.** Contractor/ESCO transfers ownership of the project to the ESA provider, who holds the credit risk.
- **In the facility owner-as-borrower model.** Contractor/ESCO transfers ownership of the project to the facility owner, who in turn borrows from a financier, typically arranged by the ESCO, who then holds the credit risk.
- **Facility owners.** They want to ensure that energy savings are delivered as planned—without compromising facility safety, productivity, or comfort—and that energy savings are greater than the debt service associated with the project. They may also be concerned about whether the financing will be characterized as debt or operating expense for accounting purposes. (See Annex 2 for discussion on key accounting considerations.)
 - **In the ESA model.** The facility owner has an implicit guarantee of savings, as they make payment for measured energy saved at a lower rate than the rate that those savings accrue. With the ESA structured as a service agreement, it has potential for off-balance sheet (operating expense) treatment.
 - **In the facility owner-as-borrower model.** The facility owner has an explicit guarantee of energy savings. With the financing being based on the installed project and included assets, accounting treatment will generally follow that of a capital lease, so on-balance sheet (debt) to the facility owner.
- **Financiers (ESA provider).** They will want to ensure that they have no responsibility for performance risk, the risk is appropriately allocated between the parties, and the likelihood of dispute is low. This leaves them free to focus on credit risk and price the financing accordingly.
 - **In both the ESA model and the facility owner-as-borrower model.** The financier will hold the contractor/ESCO accountable for nonpayment associated with performance and as such will be concerned as to the creditworthiness of both the contractor/ESCO and the facility owner.

The primary distinction between the two is that the ESA structure is designed to be off-balance sheet for the facility owner. Such treatment, though, is contingent on the accounting review, which will typically focus on the nature of assets being deployed—structures that are service heavy or made up of discreet assets—and systems are most likely to retain this designed characterization through the review. Those that are predominantly made up of highly integrated building assets are most likely to be recharacterized to capital lease (on-balance sheet) accounting. If off-balance sheet treatment is achieved, this allows the facility owners to characterize the payments as operating expenses rather than capital lease repayments against debt recorded to finance the installed assets. (See Annex 2 for discussion on key accounting considerations.)

An ESA Derivative: MESAs

The managed energy services agreement (MESA) is a variation on the ESA, with a few important distinctions. In a MESA structure, the provider assumes the broader energy management of a customer's facility, including the responsibility for utility bills. The MESA provider essentially acts as an intermediary between the customer and the utility. The MESA provider will charge the customer an agreed-upon fixed rate based on historical energy consumption, thus protecting the customer from utility rate changes. MESAs are especially of interest in sectors where a split incentive between landlord and tenant is an

FIGURE F6.2: MESA MODEL



Source: Authors, composed by Rocky Mountain Institute.

issue, as the structure of the agreement can generally allow MESA charges to be passed through to tenants. An overview of the MESA model is shown in figure F6.2.

For a comparison of the asset ownership and risk and savings allotment of ESAs, MESAs, ESCOs, and CaaS, please see Annex 3.

Current Status of ESAs and MESAs Globally and Where They Are Applicable

ESAs and MESAs are mostly being used in the United States and the United Kingdom. Because of the complexity of the model and the associated transaction costs, the most suitable customers for ESAs are typically large companies with typical minimum project sizes in the millions of dollars.

ESAs and MESAs are most suited for markets where the value of energy efficiency is well established and a robust ESCO market exists to provide the performance contracting.

ESAs and MESAs are generally a more expensive form of financing than traditional capital leases under the ESCO structures. As a result of both higher transaction costs and ensuring that the assets being deployed hold up to off-balance sheet accounting (operating expense) treatment, most ESAs are offered to well-understood customer segments for standardized measures (such as lighting and commercial building retrocommissioning) and are best suited for markets where the benefits of off-balance sheet accounting outweigh the higher cost of capital.

There is also some experience with ESAs in developing countries. For example, the World Bank has supported energy-efficiency projects in public facilities that establish energy-efficiency revolving funds offering ESAs (for example, in Armenia and Mexico).

Key Factors to Consider for ESAs and MESAs

- **Establish ESCO capabilities that are foundational to delivering performance-based energy contracts and their derivatives (see F5)**

ESA providers typically rely on ESCOs to provide performance guarantees, freeing up ESAs to focus only on credit risk. Without well-established ESCOs, ESA providers would have to directly manage or ensure project performance risk, making these projects much less attractive to finance.

For example, Metrus Energy is a large ESA provider in the United States, with over 36 million total square feet in its portfolio.¹¹³ For most of its projects, it partners with an ESCO, such as Siemens, which provides energy performance guarantees.¹¹⁴

Additional key factors that can help facilitate ESA and MESA capabilities are:

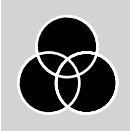

- Develop good practice or a standardized contract structures and savings calculation methodology to support the emergence of ESA and MESA models.
- Start with the simpler ESA model, and expand to include the MESA model where assessed market opportunity exists.

RESOURCES

- “Efficiency as a Service,” Better Buildings Initiative, US Department of Energy (accessed December 13, 2019), <https://betterbuildingsinitiative.energy.gov/financing-navigator/option/efficiency-a-service#case-studies>.
- Nadel, Steven, 2019, “Energy Service Agreements: Potential Big Kid in Town?” American Council for an Energy-Efficient Economy, February 12, 2019, <https://aceee.org/blog/2019/02/energy-service-agreements-potential>.

F7. LEVERAGE PROPERTY ASSESSED CLEAN ENERGY OR ENVIRONMENTAL UPGRADE FINANCING APPROACHES TO LOWER THE FIRST COST OF ENERGY-EFFICIENT CONSTRUCTION

At-a-Glance

	<p>What property assessed clean energy and environmental upgrade financing are and why they are important</p> <p>Property assessed clean energy (PACE) and environmental upgrade financing (EUF) are both financing mechanisms being used in the United States and Australia, respectively, that enable building developers (in the case of new construction) and building owners (in the case of existing buildings) to integrate deep efficiency measures in their buildings and have the cost paid off by the future building occupiers as the energy-saving benefits accrue. Repayments are made through tax assessments secured by the property. By default, the lien is associated with the property and not the owner, but repayment through property tax becomes the obligation of the current building occupiers each time the building is sold.</p> <p>This intervention is more suited to new construction and particularly relevant when significant new districts or cities are planned and there is a strong property- or land-based taxation program within the country.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Ensure strong property or land taxation program and compliance mechanisms at both the federal and state levels • Require mandatory energy modeling to ensure a saving-to-investment ratio (SIR) greater than one for larger projects (commercial sector and all new construction) • Enable PACE for near- or net-zero new construction to incentivize greater adoption of energy-efficient building design and cooling appliances
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Split Incentives</p>

What Property Assessed Clean Energy and Environmental Upgrade Financing Are and Why They Are Important

Globally, there are two well-established programs that allow building owners to secure financing to pay for energy-efficiency upgrades and have the financing repaid through payments on their property tax bills, which are typically the obligation of the building occupiers, who will also typically be the recipient of the associated energy savings. The programs are property assessed clean energy (PACE) financing in the United States and Australia’s environmental upgrade financing (EUF).

In both programs, regional legislation first enables the financing mechanism, and subsequently local governments and lenders create programs to make financing available to building developers and owners. Typically, private lenders provide the financing, but in some cases, it is government financing. In all cases, the repayments are made through additional payments as part of property taxes to the local government. Interest rates are typically 6–10 percent, which, while higher than most mortgages, are substantially lower than mezzanine financing or unsecured or subordinated debt.¹¹⁵ Both programs are designed with long loan terms, typically five to twenty years, depending on the useful life of the upgrade, so the regular payments are usually materially less than the anticipated energy savings.

A key feature of both PACE and EUF is that the assessments are secured by liens on the property, as opposed to being loans in the name of the property owner. Therefore, when the property is sold, the obligation secured by the lien passes to the new owner of the property, unless it is extinguished as part of the negotiated sales transaction. This feature helps overcome the barrier of property developers and owners not investing in energy-saving features and upgrades because they think they will not recoup their up-front investments at the time of sale.

PACE and EUF have both been successful in financing commercial and multifamily properties. Single-family residential PACE is only available in a few states in the United States and has faced various challenges as a consequence of the typically small transaction size, which necessitates a lighter governance model around both savings and ability to pay and as such is not yet viewed as a transferable model for developing countries. Commercial PACE has seen significant success for new construction in the United States in the past few years.¹¹⁶ New models are evolving that are able to finance the full incremental cost of buildings in near- or net-zero energy/carbon developments, removing the first-cost burden of such performance from the building developer and future owners.

In summary, the following are key features of both PACE and EUF:

- They finance the full first cost of energy efficiency, resiliency, and renewable energy for new construction and retrofits. This addresses the barrier around access to competitive energy-efficiency financing.
- The assessment is attached to the property and not an individual, allowing it to survive ownership changes, including through bankruptcy. This means the amortizing cost of deployed efficiency is always matched to the current beneficiary of the energy savings.
- Longer tenures, when compared with typical loan durations, allow consumers to pay lower annual amortized costs and reap the benefits of energy savings over the effective lifetime of the energy-efficiency measures.
- Also, by attaching to the property or land and having a senior lien status, the credit is materially enhanced, addressing a major barrier for efficiency financing.

Current Status of PACE and EUF Globally

PACE and EUF have seen success in the United States and Australia, respectively. The model is also being piloted in some countries in Europe, as well as in South Africa and Canada. However, it is not yet present in developing countries, largely because it requires strong existing property or land tax structures and regulatory support.

United States

PACE first began in the United States in California in 2007. Today, more than \$5 billion in financing has been used for projects through residential PACE and \$800 million through commercial PACE. Commercial PACE is enabled through legislation in more than 35 states, though not all of these states have programs. Installing sustainable space cooling systems is a common use of PACE funds.

Australia

EUF loans, also known as Environmental Upgrade Agreements, have been used in Australia since 2011, when they were first used in Melbourne.¹¹⁷ Three states currently have enabling legislation for EUF: Victoria, New South Wales, and South Australia.¹¹⁸ A few lenders offer EUF loans in Australia. One of the largest and most established is the Sustainable Australia Fund.

The Sustainable Australia Fund was established in 2002 as the Sustainable Melbourne Fund as a revolving fund for projects that would help the City of Melbourne reduce its carbon dioxide emissions. The fund was renamed Sustainable Australia Fund in 2019 after significant scaling and 200 million Australian dollars (A\$) in support from the Bank Australia. This fund has offered more than A\$30 million in financing since its founding.¹¹⁹

Other Countries

In Canada, the provinces of Ontario and Nova Scotia have PACE legislation, and programs are in effect in some municipalities. Alberta passed PACE-enabling legislation in January 2019.¹²⁰

A PACE program is in development in Cape Town, South Africa.¹²¹

In November 2017, eight organizations won a grant from the European Union's Horizon 2020 research and innovation program to bring PACE to Europe.¹²² The three-year project, called EuroPACE, launched in March 2018 with a market readiness assessment. At the time of publication, the first pilot is planned for Olot, Spain, for residential properties. After that, the program will expand to four additional cities across Europe.¹²³

Key Factors to Consider for Implementation of PACE and EUF

- **Ensure strong property or land taxation program and compliance mechanisms at both the federal and state levels**

A prerequisite to enabling PACE- and EUF-like financing mechanisms for providing energy-efficiency financing to homeowners and building owners is having a strong and existing property- or land-based taxation program within the country, alongside robust compliance mechanisms that work seamlessly at both the federal and state levels. In the absence of this structure, it is not possible to emulate this mechanism in another country.

In the United States, PACE was based on land-secured financing districts, which allow local governments to issue bonds to raise funds for public infrastructure projects and have been in use for more than 100 years.¹²⁴ To enact PACE, the law was modified to allow homes and businesses to use the same financing mechanism for energy efficiency and renewable energy.

- **Require mandatory energy modeling to ensure a saving-to-investment ration (SIR) greater than one for larger projects (commercial sector and all new construction)**

Energy-modeling simulations must be developed, and the SIR must be over one for all planned projects funded under PACE or PACE-like financing mechanisms. This is the standard practice for approval in the United States for all commercial PACE projects. This approach ensures that the building owner gets verifiable energy savings from their investments and that mortgage holder security is not compromised or diluted.

- **Enable PACE for near- or net-zero new construction to incentivize greater adoption of energy-efficient building design and cooling appliances**

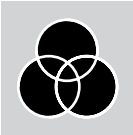

PACE is a unique financing mechanism that, when enabled for near- or net-zero energy/carbon new construction, allows large commercial developers to finance the incremental first cost of construction of these super-efficient building developments and also pay for the higher first costs of super-efficient appliances such as cooling equipment. Paying for the incremental first cost of efficiency is one of the largest financial barriers for developers. Once the construction of the development is complete, the lien stays on the property, allowing for owners and tenants who benefit from the energy-efficient building to pay for the associated costs. This eliminates the split incentive problem in large developments and spreads the costs over the useful lifetime of the interventions in a way that the energy savings from these interventions will more than pay for themselves.

RESOURCES

- PACENation homepage (accessed December 19, 2019), <https://pacenation.us/>.
- Lalit, Radhika, and Alisa Peterson, 2017, *R-PACE: A Game Changer for Net-Zero Energy Homes*, Rocky Mountain Institute, Boulder, CO, http://rmi.org/wp-content/uploads/2017/10/RMI_R-Pace_for_NZE_Insight_Brief_2017.pdf.
- “Property Assessed Clean Energy (PACE),” American Council for an Energy Efficient Economy (ACEEE), February 6, 2020 (accessed December 19, 2019), <https://www.aceee.org/toolkit/2020/02/property-assessed-clean-energy-pace>.
- US Department of Energy, 2018, *Lessons in Commercial PACE Leadership*, Washington, DC, https://www.energy.gov/sites/prod/files/2018/02/f49/Lessons_In_CommercialPACE_Leadership_FINAL.pdf.
- Better Building Finance homepage (accessed December 19, 2019), <https://betterbuildingfinance.com.au/>.
- Sustainable Australia Fund homepage (accessed December 19, 2019), <https://sustainableaustraliafund.com.au/>.

F8. MANAGE PEAK COOLING LOADS THROUGH UTILITY-LED DEMAND-SIDE MANAGEMENT AND FINANCIAL MEASURES

At-a-Glance

	<p>What demand-side management (DSM) is and why it is important</p> <p>Utilities, as the electricity network distributors, promote initiatives and technologies that encourage consumers to optimize their energy use. Collectively referred to as demand-side management (DSM), these measures aim to lower the electricity demand, which in turn reduces the energy bills for customers, optimizes the use of power systems and avoids new capacity addition, and brings associated benefits to the environment. Common DSM measures include energy efficiency programs that offer customers incentives to increase efficiency and, therefore, decrease overall electricity demand, and demand response programs that are designed to decrease customer demand during times of very high system demand or emergencies.</p> <p>While an enabling regulatory environment is important for successful utility DSM implementation, utility DSM can also make financial sense where the cost of capacity addition exceeds the cost of administering DSM programs.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Robust financial health of the utilities and an enabling regulatory environment—where utilities are mandated or incentivized to deliver on energy-efficiency targets—are critical for successful utility DSM implementation • Leverage the unique credit enhancement that comes with on-bill financing when utility bill collection is robust • Establish institutional frameworks and capacities for sustained administration of utility-led DSM initiatives • Leverage the utility's wide customer reach to influence sustainable space cooling across the entire value chain
	<p>Barriers addressed: Lack of Awareness, First-Cost Bias, Split Incentives</p>

What Utility Demand-Side Management (DSM) Is and Why It Is Important

In most service-based economies, residential and commercial electricity demand is a significant portion of the power system peak demand, owing to a high volume of energy-intensive appliances, of which air conditioners are a major contributor. Therefore, it makes logical sense for utilities and the electricity network distributors (and governments, where utilities are nationalized enterprises) to be involved in the management of the overall energy and cooling energy demand. Utility-led adjustments to demand can occur in various ways, collectively referred to as demand-side management. The following are some common instruments or models used for DSM measures:

- **Incentives and rebates.** Utilities offset the cost of building energy-efficiency measures or energy-efficient cooling equipment through financial instruments such as incentives and rebates (which are discussed in greater detail in F1). These financial instruments could be government- or rate-payer funded and are passed on to consumers through energy-efficiency programs administered by

the utility. The energy-efficiency programs could take various forms, leveraging financial support (incentives) for the following:

- Adoption of energy-efficient building construction or building retrofit,
 - Procurement of energy-efficient cooling equipment and appliances, and
 - Catalyzing behavioral interventions to drive energy-efficient operational practices among end-users.
- **On-bill financing.** Utilities finance sustainable space cooling retrofits or equipment and uses the customer utility bill as the repayment vehicle, recovering the investment over a set period of time. For effectively leveraging on-bill financing, robust bill collection by utilities and payment discipline of consumers are key.
 - **Peak-demand pricing.** This is a peak load management strategy where the utility rates are established such that customers can save by simply shifting energy use to off-peak hours and by staggering the use of major appliances across on-peak hours.
 - **Demand response.** Demand response is a strategy used by electric utility companies to reduce, flatten, or shift demand by offering customers financial incentives to shift their energy consumption from peak hours of the day, when the demand for electricity is the greatest, to leaner demand periods. Simply put, demand response can be viewed as a technology-enabled economic rationing system for electric power supply. Demand response measures require a certain level of technology readiness. Advance metering technology such as smart meters,^{xlii} which help validate load shifting, and smart grid infrastructure are increasingly enabling the demand side to become more responsive to the varying gap between demand and supply. Historically, demand response programs have focused on peak reduction to defer the high cost of adding capacity. However, demand response programs are now being leveraged to assist with changing the net load shape and to help with integration of variable renewable energy.

In 2012, Tata Power Company, one of the largest utilities operating in Mumbai—India’s financial capital, with a peak demand of over 3,300 MW—launched the country’s first demand response pilot program. The Voluntary Pilot Demand Response Program¹²⁵ covered commercial customers such as malls, hospitals, IT parks, municipal sewage treatment plants, and the airport. Through 12 events of two hours each, the pilot achieved nearly 15 MW of capacity curtailment. One of the key takeaways was that, among the various load curtailment measures incorporated (such as lowering air-conditioning load, using thermal storage, or shifting process load), managing air-conditioning achieved the greatest demand response curtailment. The pilot reinforced promotion of controls on RACs as a key demand response measure.¹²⁶ In 2013, India’s Ministry of Power issued *Smart Grid Vision and Roadmap for India*, which stipulates a “mandatory Demand Response program for selected categories of customers by 2017, and for larger sections for customers by 2022.”¹²⁷

- **Dynamic demand.** This concept states that by advancing or delaying appliance operating cycles by a few seconds at optimal moments, a power utility can balance the overall system load with generation, reducing critical power mismatches. As this switching would only advance or delay the appliance

xlii A smart meter is an electronic device that enables two-way communication between the customer meter and the central system by recording consumption of electric energy and communicating the information to the electricity supplier for monitoring and billing.

operating cycle by a few seconds, it would not be noticeable to the end-user. This type of dynamic demand control is frequently used for air conditioners that are remotely controlled, such as through the SmartAC program in California, which aims to avoid power interruption during the summer months.¹²⁸ The California utility offers \$50 incentive and installs a free SmartAC device (load control switch) on the participating customer's AC. In case of an energy shortage during predesignated months, the utility sends a signal to the SmartAC device, directing the AC to run at a lower capacity; no action is required on the part of the end-user.

DSM measures have already proven successful in countries within Europe and the United States where the appropriate regulatory frameworks are in place.

Key Factors to Consider for Implementation of Utility-Led DSM

- **Robust financial health of the utilities and an enabling regulatory environment—where utilities are mandated or incentivized to deliver on energy-efficiency targets—are critical for successful utility DSM implementation**

Robust financial health of the utilities and an enabling regulatory environment where the utilities are mandated or incentivized to deliver on energy-efficiency targets—both often a challenge in the context of developing countries—are critical to enable utility-driven market transformation. In the United States, utilities within each state typically play a key role in delivering demand-side energy efficiency programs to customers, including for cooling. The funding for these programs usually comes from a dedicated (small) charge paid by consumers through the utility bill (referred to as a “systems benefits charge”). In many states, utilities have energy-efficiency mandates or goals designed to lower the growth of electricity consumption by promoting energy efficiency. While it may seem counterintuitive for a utility to drive reduction in the sale of electricity, a combination of enabling policy frameworks, such as decoupling and Energy Efficiency Resource Standards (EERS), has been foundational in the success of utility-driven energy efficiency and the reduction of infrastructure investments in building peak load capacity.

Decoupling is a rate adjustment mechanism that “decouples” utility profits from total electric or gas sales and ensures that utility revenue is adequate to cover their costs and a fair return. While decoupling in and of itself does not incentivize utilities to promote energy efficiency, it achieves the important objective of removing the disincentive to sell less electricity or gas. To promote energy efficiency, decoupling policies should be combined with other policies that require or incentivize energy efficiency. EERS is one such policy that requires utilities to meet long-term energy-saving targets with customer efficiency programs. Positive financial incentives for effective energy-efficiency programs, such as performance bonuses, and enhanced rates of return have also been effectively combined with decoupling.

While enabling frameworks such as energy-efficiency mandates and funding sources for energy-efficiency incentives are currently rare in developing country contexts, there is an opportunity to draw from the successful models in the United States and Europe without going through the same learning curve. It should be noted that regulatory mandates are helpful in eliminating the disincentive for the utility to advance energy efficiency, but they are not a prerequisite for DSM. For instance, in situations where a utility cannot afford to build a new plant for capacity addition, DSM might make more financial sense.

- **Leverage the unique credit enhancement that comes with on-bill financing where utility bill collection is robust**

Utility on-bill financing is a unique lending mechanism since there is a lower risk of credit default with utility bills than other unsecured credit mechanisms. Other than the administrative convenience of leveraging the monthly customer bill for loan repayment, on-bill loans are substantively different than conventional loans due to two factors:

- Loans are tied to the utility service. Many on-bill programs allow the utility to suspend service to customers who fail to make their loan payments.
- Loans account for the borrower's utility savings. Many on-bill programs require "bill neutrality," which means savings from the funded improvements are expected to equal or exceed the new on-bill loan payments. An energy auditor reviews the efficiency improvements and estimates the reduction in utility expenses expected after the project. In contrast, conventional loans typically do not involve assessment of the expected savings through an energy-efficiency project.

Mexico's Efficient Lighting and Appliances,¹²⁹ a World Bank–supported project, effectively used an on-bill financing mechanism for repayments of credits through utility electricity bills.

The objective of the program was to support the government of Mexico's focus on efficient use of energy and to mitigate climate change by increasing the use of energy-efficient technologies in end-use sectors such as lighting, refrigeration, and air-conditioning at the residential level. A key component of the project was the replacement of old and inefficient appliances, including air conditioners.

Under the program, consumers were categorized into levels based on the electricity tariffs paid—driven by the electricity consumption of their appliances, such as air conditioners and refrigerators—during the summer months. Based on these levels, the customers were provided varying amounts of price incentives in the form of vouchers (for low-income households) and credits (for low-income and other qualifying consumers). The purchased appliances had to meet a specific energy-efficiency standard. In the case of air conditioners, the capacity of a new air conditioner purchased was restricted based on the capacity of the old air conditioner being replaced. Mexico's utility, the Federal Electricity Commission, was an integral part of the project and administered repayments of credits through customers' electricity bills.

- **Establish institutional frameworks and capacities for sustained administration of utility-led DSM initiatives**

Sustained administration of DSM programs requires—aside from regulatory support and financial resources—skilled teams for energy-efficiency program design; data analytics; customer outreach; program implementation, including recycling and disposal of equipment; and standardized systems for measurement and verification. Given the breadth of required skill sets and human resources, it generally may not be feasible for the utility to house all these functions in-house. Historically, utilities in the United States have administered energy-efficiency programs through a combination of in-house staff and third-party service providers. In the more mature markets—such as the states of California and Massachusetts in the United States, where utility DSM programs have existed for decades—recent years have seen a greater shift toward using third-party service providers for administering energy-efficiency programs. One of the drivers for this is to control the utility program administration costs. Particularly in

mature markets, where the low-hanging fruit of energy-efficiency programs have largely been harvested, program administration costs are on the rise. In 2016, the California Public Utilities Commission passed an order (Decision 16-08-019) that required California utilities to transition a majority of their portfolios of energy-efficiency program design and delivery to third parties, with at least 60 percent of the total portfolio budget going to third-party programs by 2020.¹³⁰

For their demand response pilot, India's Tata Power used a third-party service provider and aggregator, Customized Energy Solutions (CES), for implementation. CES assisted Tata Power in program design and obtaining approval from state regulators. In addition, CES undertook the program implementation, leading customer engagement to explain the program and decide on specific load curtailment strategies, measuring program performance, and paying customers based on performance on behalf of Tata Power.

- **Leverage the utility's wide customer reach to influence sustainable space cooling across the entire value chain**

While incentivizing the market toward purchase of energy-efficient appliances is the more commonly visible role of utility DSM programs, utilities, through their unique leverage with a wide customer base, can influence efficient cooling in multiple ways. Some examples that are particularly relevant in the context of developing countries are described below.

User behavioral adaptations. Utility programs can influence optimization of cooling energy use through user operational interventions. This can be done through incentivizing use of technologies, such as occupancy sensors and building automation and controls. Such technologies help ensure that cooling is delivered only when and where it's needed.

Another approach is to influence user behavior—and therefore cooling energy use—through user-focused messaging, such as, through education programs and social interaction programs.^{xliii} Generally referred to as “behavioral energy-efficiency programs,” such programs are relatively easier to implement—even in developing countries, where utility institutional capacities may be limited—as they are not impeded by the need for new rates or new technologies.

BSES Rajdhani Power Limited is undertaking India's first large-scale behavioral energy-efficiency pilot program, working with Oracle Utilities (Opower) to send personalized home energy reports to a representative group of 200,000 customers in southern and western Delhi.¹³¹ Over 75 percent of these customers have monthly energy consumption exceeding 200 kWh, suggesting the use of energy-intensive appliances like air conditioners. Through bimonthly home energy reports providing peer-group comparisons of energy-efficient behaviors, web-based interactive appliance-level information, and customized insights and recommendations, the program aims to promote energy-efficient behaviors. The 18-month pilot hopes to prove the potential of such programs to achieve aggregated grid load reduction, ideally in overloaded network areas.

There is growing recognition that changing behavior may be a more cost-effective means of ensuring energy use reduction and cutting carbon emissions than some of the more expensive technologies that are currently being subsidized.¹³²

xliii See also the Energy Sector Management Assistance Program's 2020 (forthcoming) publication *A Practitioner's Guide to Integrating Behavior Change in Energy Efficiency Projects in Developing Countries*.

Equipment retrofits or recycling. It is common practice in developing countries to continue use of cooling equipment such as ACs and refrigerators past their useful life, resulting in inefficient energy use and strain on the grids. Utilities can play a key role in motivating users to phase out the use of old and inefficient cooling appliances through effective equipment retrofit programs.

A key component of Mexico's Efficient Lighting and Appliances Project was the replacement of old and inefficient air conditioners and refrigerators. The household eligibility criteria required that the AC or refrigerator was at least 10 years old and in working condition to qualify to exchange for the new appliance.^{xliv} This was an important criterion to ensure that the program was not misused to simply get newer discounted appliances; replacing more recent appliances will not generate as large energy savings or grid benefits. Another important criterion was to ensure a high level of energy efficiency of the eligible new appliances to maximize energy savings impact.

An innovative feature of Mexico's program was the integrated procurement strategy, which focused on providing full service (that is, procurement of equipment, installation, and replacement of old equipment, along with its disposal).

In the United States, more than 60 utilities across the country have been offering cash or bill credits to customers in exchange for old energy-hogging refrigerators, freezers, and window air conditioners. These programs could be stand-alone (that is, recycling only) or an exchange of the old working appliance for a new energy-efficient appliance (also referred to as upcycling).

New Jersey's Clean Energy Program, which includes energy-efficiency programs for eight utilities in the state, started its equipment recycling program in 2009, offering cash for old refrigerators and freezers. The New Jersey Board of Public Utilities envisioned that this program would help it shave off "a lot of demand out of the system."¹³³

Not only do such recycling or exchange programs offer customer convenience, operational cost reductions, and grid benefits, but they also bring environmental benefits as a result of proper disposal of refrigerants and equipment components.

xliv This is also discussed in F1, Create incentive mechanisms to shift the market toward sustainable space cooling.

RESOURCES

- Chuneekar, Aditya, Mrudula Kelkar, and Shantanu Dixit, 2014, *Demand Side Management in India: An Overview of State Level Initiatives*, Prayas Energy Group, Kothrud, Pune, India, <http://www.prayas-pune.org/peg/publications/item/281-demand-side-management-in-india-an-overview-of-state-level-initiatives.html>.
- “Utility Rate Decoupling,” 2013, Alliance to Save Energy, October 24, 2013, <https://www.ase.org/resources/utility-rate-decoupling-0>.
- American Council for an Energy-Efficient Economy, 2016, *Energy Efficiency Resource Standard*, Washington, DC, <https://aceee.org/policy-brief/energy-efficiency-resource-standard-eers>.
- Henderson, Philip, 2013, *On-Bill Financing: Overview and Key Considerations for Program Design*, National Resources Defense Council, New York, <https://www.nrdc.org/sites/default/files/on-bill-financing-IB.pdf>.



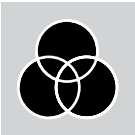

The landmark King Fahd National Library Building in Olaya District, Riyadh, Saudi Arabia with the Al Faisaliyah Centre in the background.
Credit: benedek/istock



ESTABLISH AND/OR STRENGTHEN THE SUPPORTING INSTRUMENTS

S1. ENHANCE “COOLING AWARENESS,” OR AWARENESS OF THE IMPORTANCE AND BENEFITS OF SUSTAINABLE SPACE COOLING PRACTICES, TO ENCOURAGE INDIVIDUAL ACTIONS AND BEHAVIOR CHANGES

At-a-Glance

	<p>What cooling awareness is and why it is important</p> <p>While end-users are typically seen as the key target audience for cooling awareness, advancing awareness across all stakeholder groups—such as policy makers, procurement officers, retailers, and lending institutions—helps promote decisions and actions that support and advance sustainable space cooling. The impact of almost every intervention can be maximized when accompanied by informed and aware users and stakeholders. This cross-cutting intervention can be applied in multiple phases per the local context and should reinforce contextualized messages that make the benefits of sustainable space cooling relatable.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none">• Identify and use key stakeholders and influencers to convey the message• Enable widespread access to reliable information on cooling technologies and solutions• Reinforce messages that reference social norms, and make the benefits of sustainable space cooling relatable
	<p>Barrier addressed: Lack of Awareness</p>

Why Cooling Awareness Is Important

In addition to using push mechanisms such as policies and financial incentives, it is equally important to generate sustained demand for energy efficiency and sustainable space cooling technologies from the market. A key factor in enabling this market demand—and one that can supplement and magnify the positive impacts of any other intervention—is increasing market awareness about the environmental, social, and financial benefits of sustainable space cooling. For the purpose of this discussion, we refer to it as “cooling awareness.”

While end-users are typically seen as the key target audience for cooling awareness drives, advancing awareness across all stakeholder groups—including policy makers, procurement officers, retailers, and lending institutions—through effective communications campaigns helps promote decisions and actions that are aligned toward sustainable space cooling practices. The impact of almost every intervention can be maximized when accompanied by informed and aware users and stakeholders.

Means for Advancing Cooling Awareness

Market awareness can take many forms, including the following:

1. **Websites and portals.** These can include basic information and tips for consumers in the form of online articles, blogs, videos, and so on.
2. **Mass informational campaigns.** These typically include a call to action and are typically operationalized using advertisements on the Internet, TV, and radio, and in magazines and public spaces. These may also include newsletters distributed through the mail or electronically, or leaflets distributed in person. In this type of campaign, the message should be tailored to the specific audience in their local language and should be repeated to increase engagement.
3. **Online calculation tools.** These tools can allow consumers to easily estimate their net costs, energy savings, and CO₂ emission reductions.
4. **Data sets.** These databases can include comprehensive lists and key facts on cooling appliances and passive cooling measures that allow consumers to compare and make an optimal decision for their situation. There can also be data sets of sustainable space cooling experts or additional resources to help consumers take the next step. Data sets generally target more engaged consumers or stakeholders with previous knowledge.
5. **Energy disclosures and comparisons to similar cooling users.** Energy disclosure (as discussed in P6) is one way to facilitate peer-group comparisons and benchmarking by enhancing the visibility of building energy performance. Customer-specific peer-group comparisons, such as home energy reports (discussed in F8), can be provided by the utility. Initiated as a program by Opower (now Oracle Utilities) in 2008, the home energy reports delivered in partnership with local utilities have been shown to be effective in various countries (including the United States, Japan, and Malaysia) to advance residential energy efficiency by including comparisons with past energy use as well as comparisons with neighbors.¹³⁴ While not specifically targeted at cooling, this tactic promotes overall energy efficiency and optimization, which also covers cooling loads as one of the dominant energy uses in residential and commercial buildings.
6. **Training and education.** Other means to promote cooling awareness may include education programs at schools, adult consumer training, awards and recognition, and provision of experts and information centers in public locations.

The above list was adapted from the European Commission Joint Research Center report on the information measures for the National Energy Efficiency Action Plans in the member states of the European Union.¹³⁵ Product energy labels are also seen as a common means to help spread market awareness about efficient cooling products—these are discussed in detail in intervention P2.

Key Factors to Consider for Implementation of Cooling Awareness

- **Identify and use key stakeholders and influencers to convey the message**

In creating a consumer education campaign, consider the credibility of the channel of communication and research consumers are likely to trust and, when possible, ensure that the message is delivered through that channel.

A survey conducted in India revealed that consumers rarely use government sources when researching appliances (3.5 percent use central government sources and 3.4 percent use state government sources).¹³⁶ However, they rely heavily on friends and family (50 percent) and the media (43 percent). Consumers also cited salespeople and manufacturers as influential in their appliance purchasing and use decisions.

- **Enable widespread access to reliable information on cooling technologies and solutions**

Consumers can gain significant value from comprehensive information on sustainable cooling appliances and solutions. In addition to affecting purchasing decisions, awareness can influence and reinforce positive behaviors—such as practicing part-time and part-space cooling, and setting thermostats based on adaptive thermal comfort—thus strengthening the drive for sustainable cooling.

Online channels can be very effective in enabling widespread access to information on sustainable cooling practices. Particularly in the case of cooling technologies, which are many and diverse in nature, easy-to-access and easy-to-understand product information available online can be very helpful in guiding purchasing decisions for consumers and other buyers, such as procurement officers.

Social and digital media have expanded avenues for consumer outreach and communication and can be effectively leveraged. Market surveys in China, India, and Europe show that consumers use their smartphones to inform purchasing decisions, including for appliances, and hence efforts are being made to offer digital tools to consumers to enable on-demand access to information about efficient appliances.¹³⁷

For example, the Energy Star website includes basic information on cooling appliances that are Energy Star certified.¹³⁸ It includes room air conditioners, split air conditioners, central air conditioners, light commercial heating and cooling, and even smart thermostats. For each product, it lists similar information that would be found on an energy label, such as SEER, cooling capacity, and expected energy use per year. Users can filter based on cooling capacity, price, brand, or additional features. In addition, consumers can access information on available rebates right from the same website.

The National Environment Agency of Singapore maintains a similar website for all air conditioners that are labeled under the Energy Labeling Scheme.¹³⁹ It provides similar information and filtering capabilities at the Energy Star website; however, it also includes the option for consumers to enter their anticipated hours of usage per day and electricity price per kWh to see an estimated annual electricity cost specific to their use case.

Independent third parties may also provide appliance information. For example, Topten is a consumer-oriented online search tool for appliances (including air conditioners), building components, and cars that selects products based on their energy efficiency and energy consumption.¹⁴⁰ Topten is run by Topten International Group, which is a nonprofit organization.

- **Reinforce messages that reference social norms, and make the benefits of sustainable space cooling relatable**

Traditional messages of “save money” and “save the planet” can be strengthened by referring to social norms, or what others commonly do in the same situation. For example, a hotel that was encouraging guests to reuse their towels saw a 34 percent increase in reuse when they asked guests to “Join your fellow guests” and informed them that the majority of hotel guests reuse their towels.¹⁴¹

In the United States, Opower by Oracle provides utility customers reports of their energy use compared to that of their neighbors with similar-sized homes. Initially, Opower began with paper reports, and now it offers digital platforms. Opower customers reduced their energy consumption by 2 percent, or 0.62 kWh per day.¹⁴² Since its founding, Opower has saved 20 terawatt-hours (TWh) of electricity.¹⁴³

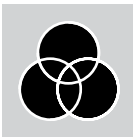

Benefits of sustainable cooling, and energy efficiency at large, are generally expressed in terms of positive impacts on the electricity grids, emissions reduction, and climate change mitigation. These terms often may not be relatable to the common person. To better appeal to the layperson, the messaging around the benefits of sustainable space cooling should be modified—while keeping the local and cultural context in mind—to make the benefits relatable and attractive (for example, “savings in your pocket every year,” “a healthier and more comfortable workplace,” “ensuring a healthier planet for your children”).

RESOURCES

- Rivas, Silvia, Barbara Cuniberti, and Paolo Bertoldi, 2016, *Effective Information Measures to Promote Energy Use Reduction in EU Member States*, Joint Research Center of the European Commission, Brussels, Belgium, http://publications.europa.eu/resource/cellar/05ffd175-f97e-4237-9061-8f9689298dff.0001.03/DOC_1.
- Bureau of Energy Efficiency, 2015, *Strategy for Energy Efficiency Campaign*, Government of India, New Delhi, <https://cdkn.org/wp-content/uploads/2017/07/Up-EE-communications-campaign-strategy-1.pdf>.
- *Energy Star Guide to Energy & Water Efficiency Competitions in Buildings & Plants*, 2016, US Department of Energy and US Environmental Protection Agency, Washington, DC, <https://www.energystar.gov/buildings/tools-and-resources/energy-efficiency-competition-guide>.
- Energy Sector Management Assistance Program, 2020, “Integrating Behavior Change in Energy Efficiency Programs in Developing Countries—A Practitioner’s Guide,” Washington, DC.

S2. BUILD CAPACITY IN CRITICAL INSTITUTIONS AS WELL AS AMONG TRADE PROFESSIONALS AND THE HEATING, VENTILATION, AND AIR-CONDITIONING SERVICE SECTOR

At-a-Glance

	<p>What capacity building is and why it is important</p> <p>The term “capacity building” in this context refers to ensuring adequately skilled resources in regulatory and policy bodies and other critical institutions; developing technical capacity within the trade institutions, including upskilling in the HVAC service sector, and complementing capacity building with adequate supporting infrastructure to effectively advance sustainable space cooling. Capacity building is a critical aspect to ensure appropriate enforcement and implementation of policy measures, as well as adequate delivery of sustainable space cooling solutions and services. This is a cross-cutting intervention that can increase the effectiveness and impact of other interventions, and it can be applied in multiple phases per local context.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Build and sustain adequate capacity in regulatory and policy bodies and other critical institutions • Complement capacity building with adequate supporting infrastructure • Leverage third-party service providers to meet immediate capacity needs and to enable the sharing of knowledge and best practices across countries • Facilitate technical capacity building within the trade institutions, including upskilling in the HVAC service sector
	<p>Barrier addressed: Lack of Awareness</p>

What Capacity Building Is and Why It Is Important

Capacity building—that is, ensuring the training and appointment of appropriately skilled resources among policy makers, regulators, financiers, and private sectors—is key to effectively scaling up enforcement, implementation, and delivery of sustainable space cooling practices and solutions. Capacity building thus can be viewed as a cross-cutting intervention that can enhance the effectiveness of every other intervention.

Lack of institutional and professional capacity can present barriers to scaling sustainable space cooling at macro- and micro-levels, including, but not limited to, the following:

- Lack of robust and cohesive policies that support sustainable space cooling,
- Lack of implementation and enforcement of policy initiatives,
- Limited knowledge within financial institutions about financing sustainable space cooling projects,
- Limited awareness among building design and construction professionals, and
- Limited capacity of local technology suppliers and installers.

Collectively, these barriers can lower the effectiveness of other interventions in this publication and significantly impede the development and scaling up of sustainable space cooling projects and solutions.

Key Factors to Consider for Implementation of Capacity Building

- **Build and sustain adequate capacity in regulatory and policy bodies and other critical institutions**

To create a robust policy environment to promote sustainable space cooling, it is critical to provide training, resources, and ongoing support to officials in regulatory and policy bodies, such as national energy agencies. It's also important to develop systems that can be self-sustaining (for example, train individuals who can go on to train others) and survive changes in political leadership (for example, storing and maintaining training resources that can be passed on to future officials). Given the cross-cutting nature of cooling—which includes aspects of building energy efficiency, cooling technologies, and refrigerants—capacity-building efforts should cover multiple entities at both national and subnational levels, as per a country's regulatory setup. These could typically include ministries and agencies dealing with energy (or power), climate change, environment, urban development, and energy efficiency.

The Berlin Energy Agency in Germany is a public entity that advises both public and private sector clients on energy-efficiency projects, mainly involving energy services performance contracting. The agency brings experience from the thousands of projects that it has been involved with to individuals who may only undertake a large energy-efficiency project one time in their career. It also consults for organizations outside Germany, to transfer experiences and lessons learned in Germany to other markets.

Training and capacity-building efforts should extend to critical institutions along the entire value chain for sustainable space cooling, such as utilities, lending institutions, building design and construction professionals, and energy service providers. Adequate awareness and skill-building among such institutions can create supporting market conditions to promote and scale up the adoption of sustainable space cooling solutions and services.

For example, a key aspect of EESL's success in advancing bulk procurement of energy-efficient appliances in India (discussed in F2) is the broad support EESL receives from multiple organizations—such as Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and the World Bank, among others—to strengthen institutional capacities. The institutional strengthening activities for EESL under the World Bank's India Energy Efficiency Scale-Up Program include establishment of a sustainable development unit to oversee the environmental and social management of EESL programs, development of financial-planning capacity with support from external advisors, robust procurement guidelines and standard bidding documents, and hiring and training of internal staff, as well as undertaking independent third-party evaluation of EESL's programs to identify challenges and feedback to improve the programs. The development of requisite institutional capacity will allow EESL to enhance its access to commercial financing and help scale up the deployment of energy-saving measures—including efficient ceiling fans and air conditioners—in residential and public sectors. Through this project, EESL is creating greater levels of awareness and acceptance by the market, attracting otherwise scarce commercial financing for energy efficiency, and initiating momentum within an otherwise nascent ESCO market in India.^{xlv}

In another example, to support the success of the Philippines Efficient Lighting Market Transformation Project (PELMATP), the Philippines' Department of Energy undertook a capacity-building program targeted at consumer cooperatives, a sector noted to be an effective distribution channel of consumer products in the country. Supported by UNDP, the training program focused on a microfinancing model, with an aim to address the financing barrier and leverage this model to facilitate procurement and distribution of energy-efficient lighting products through consumer cooperatives.

xlv Another aspect of this project—EESL's bulk-procurement model—is discussed in detail in F2, Aggregate demand to drive down the acquisition cost of sustainable cooling equipment, build market confidence, and spur greater adoption.

- **Complement capacity building with adequate supporting infrastructure**

While capacity-building efforts are key in ensuring not only the formulation but also the enforcement of policy measures to advance sustainable space cooling, it is equally important to complement capacity building with adequate support mechanisms, such as infrastructure for technology testing and certification.

When Pakistan initiated its labeling program for energy-efficient fans, the World Bank, in partnership with CLASP, helped establish the Punjab Energy Efficiency and Conservation Agency (PEECA) and ensured that it has a detailed framework for monitoring, verifying, and enforcing the labeling program.^{xlv} In parallel with the newly appointed agencies, testing laboratories were also set up to ensure verification and accountability, leading to public trust in the labeling program.

- **Leverage third-party service providers to meet immediate capacity needs and to enable the sharing of knowledge and best practices across countries**

Training and capacity-building efforts at scale will take time. In the meantime, credible third-party service providers can be leveraged to meet immediate capacity needs and make progress toward sustainable space cooling. Many capacity-building and training organizations also provide either secondments or project implementation support services.

One such example is the International Institute for Energy Conservation (IIEC), which facilitates the mainstreaming of successful energy policies and projects through project development, project implementation, and capacity-building services.¹⁴⁴ Because IIEC works across several countries, they enable the sharing of good practices while customizing their services to suit local contexts.

In a multiyear program covering Brazil, South Africa, Chile, the Philippines, Thailand, India, and Argentina, IIEC supported the identification and implementation of sustainable energy projects that qualified under the US Initiative on Joint Implementation program. In 2013, IIEC designed and implemented a training course on energy performance standards and labels in Kenya to build capacity among policy makers (including the Kenya Bureau of Standards, Ministry of Energy, and National Environment Management Authority), implementers, and distributors/importers.

The International Energy Agency (IEA) has been offering capacity-building programs across several countries for over 40 years, including a variety of formats from group training to secondments.¹⁴⁵ Covering a diverse range of topics ranging from energy-efficiency policy design to energy technology road maps, IEA training is targeted at central government officials and key national stakeholders, such as civil society agencies and private sector organizations.

- **Facilitate technical capacity building within the trade institutions, including upskilling in the HVAC service sector**

Development of a robust workforce that understands the importance and technical know-how of efficient cooling practices is very important and should be promoted through energy auditors/manager training and certification programs, training for building sector professionals (architects, developers, engineers), and private sector training programs.

^{xlv} This is also discussed in P2, Leverage labeling as an effective, low-cost way to orient consumers toward sustainable purchasing decisions.

Upskilling programs for cooling equipment technicians are also critically important. The HVAC service sector—that is, the installation and servicing technicians—tends to be largely informal in many developing countries, leading to rampant operational inefficiencies (degradation of up to 30 to 40 percent in efficiency) and leakage of refrigerants, and thus a significant source of GHG emissions. Driving skill-building of the service sector through training and certification is an important step toward addressing these operational inefficiencies. In response to such issues, the India Cooling Action Plan establishes a target of training and certification of 100,000 HVAC service technicians in India by 2022–23. This training drive would address equipment operational inefficiencies and provide opportunity to integrate safe handling, installation, and operation of equipment with flammable refrigerants. At the same time, this presents an immediate opportunity for providing increased employment, better livelihoods, and safer working practices for the HVAC service sector. Leveraging the flagship scheme of the Ministry of Skill Development and Entrepreneurship (Pradhan Mantri Kaushal Vikas Yojana), registering industry training centers under the National Skills Qualifications Framework, and drawing linkages with micro- and small-to-medium-sized enterprises are some recommended ways forward in progressing toward this target. Training and skill development are critical when it comes to creating long-term employment in the sector.



Institutional strengthening and capacity-building opportunities should also be extended to academic programs for building sector professions—such as architecture and mechanical engineering—incorporating building sciences, thermal efficiency strategies, and design for climate adaptations within their curriculums.

RESOURCES

- “GIZ Proklima Cool Training,” Green Cooling Initiative (accessed September 25, 2019), <https://www.green-cooling-initiative.org/cool-training/>.
- “IEA Training,” International Energy Agency (accessed September 25, 2019), <https://www.iea.org/areas-of-work/training#d.en.8409>.
- United Nations Environment Program, 2015, *Good Servicing Practices: Phasing Out HCFCs in the Refrigeration and Air-Conditioning Servicing Sector*, Paris, https://www.ecacool.com/upload/files/7/7723_e_good_servicing_practices_phasing_out_hcfc_in_rac_servicing_sector_training_guide.pdf.

S3. LEVERAGE ONGOING REFRIGERANT TECHNOLOGY TRANSITION ACTIVITY (AS REQUIRED UNDER THE KIGALI AMENDMENT) TO INTEGRATE ENERGY EFFICIENCY IN COOLING EQUIPMENT AND MAXIMIZE BENEFITS

At-a-Glance

	<p>Why integration of energy efficiency with the ongoing refrigerant transition is important</p> <p>This intervention targets the manufacturing sector and is thus most relevant in countries with a sizable manufacturing base for cooling equipment. Such countries should create a policy push to drive the industry toward harmonizing refrigerant transition with energy efficiency of sustainable cooling equipment. Studies suggest that integrating the ongoing refrigerant transition—HCFC phaseout and HFC phasedown efforts under the Kigali Amendment to the Montreal Protocol—with efficiency improvements in cooling technologies could make the most impact for the lowest cost, potentially doubling the climate benefits of the Kigali Amendment.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Create a policy “push” to drive the industry toward harmonizing refrigerant transition with energy efficiency of sustainable cooling equipment • Identify funding sources to dovetail energy-efficiency efforts with the Multilateral Fund-funded refrigerant transition efforts • Supplement technology transfer initiatives with adequate capacity building and training
	<p>Barriers addressed: Lack of Awareness, Complexity of Choice</p>

Why Integration of Energy Efficiency with the Ongoing Refrigerant Transition Efforts Is Important

As the different nations advance their HCFC phaseout and HFC phasedown efforts under the Kigali Amendment to the Montreal Protocol, ensuring improvements in energy efficiency in next-generation technology innovation could have a significant impact for a small marginal cost. Manufacturing air conditioners to use new refrigerants requires a complete redesign of the air conditioner and retooling of all the machinery to manufacture it. While this complete redesign is happening, there is an opportunity for manufacturers to focus on the energy efficiency of the air conditioners and to maximize climate benefits.

The 2018 Technology and Economic Assessment Panel (TEAP) report found that approximately 80 percent of the emissions from an RAC are from grid-electricity consumption, and about 20 percent are from the refrigerant’s global warming potential.¹⁴⁶ Based on these findings, the report makes a strong case for an integrated strategy of redesigning refrigeration, air-conditioning, and heat pump equipment to replace current refrigerants with climate-friendly alternatives while improving the equipment’s energy efficiency. Improving the energy efficiency of air conditioners and other cooling equipment can double the climate benefits of the Kigali Amendment.¹⁴⁷ IGSD’s *Primer on Energy Efficiency* explains that integrating energy efficiency into refrigerant transitions can reduce costs to governments, increase manufacturer competitiveness, save consumers money, and reduce emissions.¹⁴⁸

The Mutilateral Fund (MLF) for the Implementation of the Montreal Protocol provides funds to help developing countries comply with their obligations under the Montreal Protocol and the Kigali Amendment.

During this process, complementary energy-efficiency improvements can be systematically targeted and achieved. However, the availability of additional funding, such as that required by manufacturers for advancing energy efficiency, can be a challenge in leveraging this opportunity.

Key Factors to Consider for Enabling Integration of Energy Efficiency in Cooling Equipment with Refrigerant Transition Efforts

- **Create a policy “push” to drive the industry toward harmonizing refrigerant transition with energy efficiency of sustainable cooling equipment**

In the context of a transition to more climate-friendly alternatives in the air-conditioning sector, both for new equipment and replacement of old equipment containing high GWP refrigerants, there is an opportunity for policy and regulations to encourage the integration of refrigerant transition efforts with energy-efficiency improvements. For example, the India Cooling Action Plan strongly underscores the need for integration of energy-efficiency and refrigerant transitioning efforts, aligning with the linkage recognized by the Kigali Amendment to the Montreal Protocol.

Taking it one step further, policy makers should set ambitious efficiency requirements several years in the future and announce them as soon as possible (for example, a country could state their MEPS will be twice as stringent by 2028). While this has not been put into practice yet, these major, long-term signals would drive behavior in the industry and encourage manufacturers to integrate efficiency with the first HFC freeze date.

- **Identify funding sources to dovetail energy-efficiency efforts with Multilateral Fund-funded refrigerant transition efforts**

Manufacturers may face challenges obtaining the necessary financing to improve the energy efficiency of air conditioners while they are transitioning to more sustainable refrigerants. Governments should look for funding sources and technical support that they can use to complement existing funds for the refrigerant transition. K-CEP, for example, has provided such technical assistance support.

One example where additional funding sources have been used to support energy efficiency alongside the refrigerant transition is Walton Hi-Tech Industries Ltd. in Bangladesh.¹⁴⁹ Walton produces almost 80 percent of refrigerators in Bangladesh and many of its air conditioners. While phasing out HFCs, Walton is also working to manufacture more efficient appliances. K-CEP, the MLF, and UNDP launched a program in December 2017 to support Walton's efforts. With the funds, Walton is developing and testing a new compressor that could reduce energy demand by one-third.

Another program that was designed but has not been implemented at the time of publication is Indonesia's Promoting Energy Efficiency for Non-HCFC Refrigeration and Air Conditioning (PENHRA) project.¹⁵⁰ Leveraging the HCFC phaseout activities under the Montreal Protocol's Multilateral Fund, the project brings in additional funding from the GEF to support manufacturers to simultaneously upgrade their facilities to produce more efficient air conditioners. The GEF provided \$5 million, and \$19 million in cofinancing was expected to be raised.¹⁵¹ The Indonesia Ministry of Energy and Mineral Resources and UNDP would implement the program by providing upstream grants to manufacturers. The grants were expected to cover the manufacturers' incremental costs to produce more energy-efficient air conditioners at the same time MLF grants were provided to them to phase out HCFCs. As of 2020, the program has not yet been implemented and was waiting for final GEF approval.

- **Supplement technology transfer initiatives with adequate capacity building and training**

With technology advancements and new technologies, there comes a parallel need for adequately skilled technicians to service and maintain these technologies.

Thailand, the second-largest manufacturer of residential air conditioners, predominantly uses HCFC-22 and exports approximately 90 percent of its production. As part of the HCFC phaseout management project funded by the MLF, the World Bank helped 12 AC manufacturers in Thailand leapfrog and convert their production lines from HCFC-22 to HFC-32. Financing was also made available for installation of equipment related to testing, certification, and safety requirements of HFC-32 refrigerant. The World Bank also offered technical assistance to the manufacturers and technicians through workshops and awareness campaigns to train them on servicing and installation of HFC-32 air conditioners.

Through its Green Cooling Initiative, GIZ cooperated with China's largest manufacturer of split ACs, Gree, to introduce the first natural refrigerant production line. In a similar project, GIZ cooperated with Godrej to introduce a hydrocarbon refrigerant-based RAC to the Indian market. In Eswatini, GIZ collaborated with Palfridge to convert the annual production of about 60,000 refrigerators to natural refrigerants.

While the natural refrigerants have an extremely low GWP, there are concerns about the flammability risk of these refrigerants. GIZ incorporated relevant procedures as well as safety measures for manufacturing, handling, and servicing equipment with flammable refrigerants in training programs in China, India, and Eswatini.

In 2014, GIZ Proklima also began a Cool Training program, which offers one-week courses for National Ozone Unit policy makers and two-week classes for RAC technicians.¹⁵² The courses focus on natural refrigerants, including propane (R-290), CO₂ (R-744), and ammonia (R-717).

RESOURCES

- “TEAP Decision XXVIII/3: Working Group Report on Energy Efficiency,” 2017, UN Environmental Program, <https://ozone.unep.org/science/assessment/teap?page=1>.
- Dreyfus, Gabrielle B., Stephen O. Andersen, Ana M. Kleymayer, and Durwood Zaelke, 2017, *Primer on Energy Efficiency*, Institute for Governance & Sustainable Development Working Paper, Washington, DC, <http://www.igsd.org/wp-content/uploads/2019/10/EE-Primer-11.13.17.pdf>.

S4. SUPPORT AND LEVERAGE A RESEARCH AND DEVELOPMENT, AND INNOVATION ECOSYSTEM THAT ENABLES TECHNOLOGY ADVANCEMENT

At-a-Glance

	<p>Why a research and development (R&D) and innovation ecosystem is important</p> <p>An R&D and innovation ecosystem that involves all cooling stakeholders is important to promote technology advancement, which in turn allows policies and financial programs to have a greater impact. Given the global context of cooling, international collaborations are important to leverage globally dispersed centers of excellence. In-country efforts should consider alignment with best practices across national borders while being cognizant of domestic market readiness.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Engage in international collaboration • Develop an integrated framework to promote an R&D ecosystem • Ensure signals of future demand to catalyze innovation in sustainable cooling equipment • Leverage innovation challenges to catalyze step change
	<p>Barrier addressed: Lack of Awareness</p>

Why Leveraging a Research and Development (R&D), and Innovation Ecosystem Is Important

Technology advancement is a key component to the transition to more sustainable space cooling. Policies and financial programs work to enable the adoption of sustainable technologies, so the better the available technologies are, the greater impact the programs will have.

To advance technology innovation, a robust R&D ecosystem that involves all the cooling stakeholders is critical. This can be achieved through effective government support, collaboration between the public and private sectors and academia, and adequate funding support. Given the global context of cooling, international collaborations and partnerships are important to leverage the globally dispersed centers of excellence and good practices.

Key Factors to Consider for Creating an R&D and Innovation Ecosystem

▪ Engage in international collaboration

Space cooling is a global industry, with a few manufacturing centers of excellence across the globe and with broad impacts that cascade to the environment at large. As such, cooling can be most effectively addressed through international collaborations and partnerships to share learnings, broaden the positive impacts, and thus accomplish more with fewer resources. This collaboration can take the form of coalitions, events, and regional partnerships.

For example, the Mission Innovation launched in 2015 is a global initiative of 24 countries and the European Commission enabling multi-country collaboration to accelerate clean energy innovation. Accelerating low-carbon heating and cooling solutions is among the eight key focus areas (“Innovation

Challenges”) identified by Mission Innovation, named as Innovation Challenge 7: Affordable Heating and Cooling of Buildings (IC:7).¹⁵³ IC:7 provides a platform for international collaboration, with the objective to significantly accelerate innovation in the heating and cooling areas. Energy efficiency and affordability are both essential considerations within this innovation challenge.

▪ **Develop an integrated framework to promote an R&D ecosystem**

To make the best use of resources, government-funded research efforts should be coordinated as part of an integrated framework—an R&D road map—rather than conducted as piecemeal research projects. The R&D road map should consider alignment with best practices across national borders while also being cognizant of domestic market readiness. The framework should establish priorities and expected timeframes. Monitoring and evaluation should be built into the framework to understand successes and build on them.

As an example, the government of India’s Department of Science and Technology has been planning its initiatives in alignment with the goals and focus areas identified under Mission Innovation.

The Engineering and Physical Sciences Research Council of the United Kingdom invests in long-term, fundamental research to advance knowledge and technology in engineering and the physical sciences. It develops a strategic plan every five years as well as an annual delivery plan. The annual delivery plan outlines the areas of focus and the key activities to deliver against the vision, goals, and objectives set out in the five-year strategic plan.

Similarly, the US Department of Energy issues strategic plans every four to five years that include a few overarching goals, each with additional strategic objectives nested below them. This provides a road map and sets priorities that are then reflected in individual program plans.¹⁵⁴

The US Department of Energy’s Energy Savings Potential and RD&D Opportunities for Commercial Building HVAC Systems points to the following steps to developing an R&D road map:¹⁵⁵

1. Develop initial list of technology options that show potential to reduce energy use.
2. Eliminate technologies that do not meet the project goals (low energy savings, limited applicability).
3. Evaluate the remaining technologies based on their energy reduction potential.
4. Score technology options based on their energy savings potential, first cost, operational complexity, non-energy benefits, and peak-demand reduction potential.
5. Characterize each technology based on where it is in development.

Ideally, an R&D road map should establish short-, medium-, and long-term strategies and align funded projects with these strategies. For example, for their next-generation heating and cooling funding, the US Department of Energy lists its short-, medium-, and long-term strategies and includes a list of funded projects that correspond to each strategy.¹⁵⁶

▪ **Ensure signals of future demand to catalyze innovation in sustainable cooling equipment**

Another strategy to foster an R&D ecosystem is to aggregate demand for sustainable products, which gives manufacturers certainty of demand and encourages them to develop and mass-produce such products. See F2 for more discussion on demand aggregation.

Gavi, the Vaccine Alliance, uses this strategy to drive forward cold chain technologies for vaccine storage.¹⁵⁷ Gavi has committed US\$250 million from 2017 through 2021 to jointly invest with countries to purchase equipment that meets certain standards.¹⁵⁸ Gavi pools demand from the countries it works with to procure technologies that exceed World Health Organization performance quality safety standards at lower costs. Gavi's model of demand aggregation through advanced market commitments can be applied to the space cooling sector to create certainty of demand in the market for higher-efficiency sustainable cooling equipment and to accelerate their commercialization and deployment.

■ Leverage innovation challenges to catalyze step change

Innovation challenges and prizes often represent the best way to bridge the wide gap between commercially available technologies and realizable potential. Prizes democratize innovation, encourage new ideas, and disrupt markets. Furthermore, prizes are an efficient use of funding because the prize money is typically only awarded if there is a technology that meets the set goal. In addition, the funding is effectively leveraged to encourage prize applicants to invest their own resources into the competition. It's good practice for prizes to expand their scope to ensure adoption of the winning technologies as well, through policy and market preparation activities.

In a recent example, a global coalition of partners, led by Rocky Mountain Institute (US), Mission Innovation, and the government of India, launched the Global Cooling Prize, an innovation challenge that aims to spur breakthrough innovation in residential cooling. Launched in New Delhi in November 2018, the Global Cooling Prize is an important Mission Innovation initiative under India's leadership, aligned with one of the key Mission Innovation objectives of making low-carbon heating and cooling affordable for everyone. The Global Cooling Prize seeks to identify a technology solution that has one-fifth of the climate impact—to offset the projected fivefold increase in RAC cooling demand in emerging economies—taking into account both grid-supplied electricity and refrigerant GWP of today's standard RAC units. Scaling up such a solution can achieve cumulative emissions reductions of over 75 gigatons by 2050, help mitigate up to 0.5°C in global warming impact by 2100,¹⁵⁹ and bring multiple socioeconomic and environmental co-benefits. The Global Cooling Prize also includes an investment and scaling committee that will help raise investments in some of the most promising technologies and create demand for such technologies, starting with the Indian market.



Advanced Cooling Challenge, a campaign launched in 2016 by the Clean Energy Ministerial (CEM), is focused on innovation and energy efficiency of air conditioners, with the objective to bring together governments, manufacturers, policy makers, and other stakeholders for promoting the development and adoption of super-efficient and climate-friendly air conditioners. Since its launch, Advanced Cooling Challenge has mobilized over 30 participants—including governments, NGOs, manufacturers, distributors, retailers, and consumer organizations—to make commitments that will leverage \$1.4 billion to advance efficient cooling globally.¹⁶⁰ Policy development and technical assistance projects have been mobilized in nearly 20 countries across four regions (Southern Africa, Southeast Asia, the Pacific Islands, and Central America).¹⁶¹

RESOURCES

- Mission Innovation, <http://mission-innovation.net/our-work-2/>.
- US Department of Energy, 2017, *Energy Savings Potential and RD&D Opportunities for Commercial Building HVAC Systems*, Washington, DC, <https://www.energy.gov/sites/prod/files/2017/12/f46/bto-DOE-Comm-HVAC-Report-12-21-17.pdf>.
- “The Road to Zero: DOE’s Next-Generation Heating and Cooling R&D Strategy,” US Department of Energy (accessed September 26, 2019), <https://www.energy.gov/eere/buildings/road-zero-does-next-generation-heating-and-cooling-rd-strategy>.
- Engineering and Physical Sciences Research Council, 2015, *Strategic Plan 2015* (accessed September 26, 2019), <https://epsrc.ukri.org/newsevents/pubs/strategic-plan-2015/>.
- “Advanced Cooling Challenge,” Clean Energy Ministerial (accessed September 11, 2019), <http://www.cleanenergyministerial.org/campaign-clean-energy-ministerial/advanced-cooling-challenge>.
- Global Cooling Prize homepage (accessed September 26, 2019), <https://globalcoolingprize.org/>.
- “Immunization Supply Chain,” Gavi, <https://www.gavi.org/support/hss/immunisation-supply-chain/>.

S5. INCORPORATE STRATEGIES TO ENABLE ACCESS TO COOLING IN OFF-GRID OR WEAK-GRID LOCATIONS

At-a-Glance

	<p>Why off-grid cooling solutions are important</p> <p>This intervention is applicable in areas where a sizable portion of the population is in off-grid or weak-grid locations, to ensure adequate access to cooling for this population. An estimated 16 percent of the world's population has little or no access to electricity,¹⁶² and a sizable share of this population lives in hot and tropical climates. In view of rising temperatures and the growing need for cooling, exploring viable off-grid options for cooling is important to expand cooling access to such communities.</p>
	<p>Key factors to consider for implementation</p> <ul style="list-style-type: none"> • Address knowledge gaps for promoting market growth of off-grid cooling appliances • Develop comprehensive solutions that meet consumers' ability and willingness to pay, through low-cost cooling technologies coupled with innovative business models or programs • Accelerate research and development for off-grid cooling solutions • Leverage the concept of community cooling centers for off-grid/weak-grid locations
	<p>Barriers addressed: Lack of Awareness, Complexity of Choice</p>

What Off-Grid Cooling Solutions Are and Why They Are Important

Significant progress has been made on energy access in recent years. The report published annually by the custodian agencies of Sustainable Development Goal (SDG) 7 notes that the share of the world's population having access to electricity grew from 83% in 2010 to 90% in 2018, an increase of more than one billion people. However, the report also estimates that, under policies that were either in place or planned before the start of the COVID-19 crisis, an estimated 620 million people would still lack access in 2030, with 85 percent of them in Sub-Saharan Africa.¹⁶³ In addition, as of 2015, approximately 1 billion people globally had unreliable energy access.¹⁶⁴ In view of rising temperatures and the growing need for cooling, exploring viable off-grid options to enable cooling access for such communities is important.

For the purpose of this publication, “off-grid” is used to describe any of the following situations:

- Communities that do not have a main grid or any sort of mini-grid electricity, though individual homes and businesses may have solar home systems or diesel or petrol generators to meet their energy needs;
- Communities that are not connected to the main grid but have a mini-grid providing basic power;^{xlvii} or
- Communities where one or a few buildings are connected to the main electricity grid, but the majority are not connected.

In addition, “weak-grid” describes communities that are largely or entirely connected to the main electricity grid but suffer from poor-quality power supply.

Clean energy technologies like solar home systems and renewable mini-grids are making it possible for households and businesses in off-grid or weak-grid locations to access modern energy services,

^{xlvii} Mini-grids (also called microgrids and nanogrids) are becoming more common in off-grid areas such as India and Africa. They can provide alternating current or direct current power. They are usually solar powered with batteries and often also integrate a generator for backup or peak loads, though pure generator mini-grids exist in many places. Mini-grids generally have strict limits on power consumption, but renewable energy mini-grids often have excess energy at certain times of the day.

including cooling, for the first time.¹⁶⁵ Some pay-as-you-go solar home systems include fans, such as the M-Kopa systems available in Nigeria.¹⁶⁶ However, high energy efficiency and cost-effectiveness are key to delivering such energy services at the lowest cost and to scaling and accelerating access to cooling. Efficient off-grid appliance technologies can reduce total energy supply costs and maximize energy access, helping maximize social and health benefits.

Key Factors to Consider for Enabling Access to Cooling in Off- or Weak-Grid Locations

- **Address knowledge gaps for promoting market growth of off-grid cooling appliances**

Key stakeholders such as manufacturers, policy makers, distributors, and investors lack critical information about off-grid appliances and the broader market, thus inhibiting market growth. Efficiency for Access is a coalition that aims to tackle this challenge for off-grid appliances more broadly. One of their initiatives is the Equip Data platform, which is an online interactive database of off-grid appliances, including fans and refrigerators, and their performance data.¹⁶⁷ Efficiency for Access does its own product testing according to international best practices, posts the data on the platform, and also works with policy makers, investors, companies, and others to understand and use the data. Its goals are to make the off-grid appliance market more transparent, which in turn will increase appliance quality and enable stakeholders to make data-backed decisions about off-grid appliances.

- **Develop comprehensive solutions that meet consumers' ability and willingness to pay through low-cost cooling technologies, coupled with innovative business models or programs**

Because off-grid communities are commonly also economically vulnerable and very price sensitive, mechanisms to make cooling solutions extremely affordable while avoiding high one-time payments are key to ensure wider access to cooling. In providing access to off-grid cooling, lessons can be learned from experiences providing electricity or other energy services, such as solar home systems and mini-grids, to off-grid communities. Comprehensive program designs that combine supply of appropriate cooling solutions with parallel mechanisms to ensure and support customer demand (such as access to finance and enhanced consumer awareness) are important in this context.

The solar home system model has been most successful when the systems are provided to customers on a pay-as-you-go basis. M-Kopa, one of the largest solar home system providers in Africa, has connected over 750,000 homes and businesses in Kenya, Nigeria, and Uganda.¹⁶⁸ M-Kopa's product range includes different solar home system bundles to suit different pockets and needs—typically including lights and phone-charging abilities, and expanding to include fans, televisions, and, in the case of Uganda, small refrigerators. Customers buy the solar home system on a payment plan, with an initial deposit followed by small daily payments for one to two years. Customers are able to make payments easily through their mobile phones or a local M-Kopa agent. After completing payments, customers own the product and continue to use the solar-powered devices without additional operational costs. M-Kopa has established a professional call center to help customers and retailers with any problems. When considering cooling for off-grid areas, these lessons in different product offerings, pay-as-you-go options, and strong customer service should be kept in mind.

Mini-grids are another effective way to provide energy access to off-grid communities using the pay-as-you-go model. Mini-grids in Africa already serve more than 11,000 connections with 20 hours of power

or more per day.¹⁶⁹ Mini-grid customers commonly run fans and refrigerators using mini-grid electricity. In mini-grids, customers generally pay a small up-front fee to be connected to the mini-grid and then pay for the electricity as they use it. Because the mini-grid developers often continue to own the mini-grids, their profitability depends largely on their customers' electricity use and satisfaction. As such, mini-grid companies put a large focus on understanding their customers and their needs, and providing customer service. These practices should be kept in mind when considering cooling for off-grid areas.

An example of effective program design for off-grid communities is the World Bank Group's Lighting Africa program, which has an ambitious goal of providing clean, affordable, quality-verified, off-grid lighting to more than 250 million people across Sub-Saharan Africa by 2030. The program design addresses both supply and demand through a market-tested combination of policy development, quality assurance, market intelligence, access to finance, business support, and consumer awareness. The program has provided electricity to over 32 million people.¹⁷⁰ Such innovative program design could be potentially emulated to bring low-energy cooling options—such as direct current (DC) fans—to off-grid or weak-grid communities. In fact, efforts are underway to broaden this program to address cooling (initially refrigerators).

▪ **Accelerate research and development (R&D) for off-grid cooling solutions**

An important consideration in off-grid/weak-grid situations is whether to use highly energy-efficient and low-power appliances, since power supplies are at a premium. For example, high-efficiency fans are a viable option for such situations; in scenarios where solar PV or battery storage is available, DC or inverter-fed cooling appliances can be considered, as they can run directly as long as the cooling appliance has an integrated variable-speed inverter to manage fluctuations in supply. However, many off-grid solar companies struggle to identify and source outstanding appliances. Many appliance manufacturers are unaware of the off-grid market's commercial opportunities, and those that are aware often struggle to find clear and timely paths to market. Efforts are needed to align research efforts to bring super-efficient cooling appliances to market.

Efficiency for Access Coalition's Low-Energy Inclusive Appliances (LEIA) program is a research and innovation program with the objective to double the efficiency and halve the cost of a range of electrical appliances suited for off- and weak-grid customers.¹⁷¹ The LEIA program's research focus includes the off-grid appliance market, consumers, socioeconomic impacts, and technology to address the gaps in market intelligence. Its methodology involves technical working groups, composed of market stake-holders, that develop technology road maps to identify and prioritize R&D initiatives that will provide the best opportunities for accelerating the development and commercialization of emerging off- and weak-grid technologies.

Two recent examples of instruments to catalyze innovative products for serving off-grid and weak-grid communities are the Global Lighting and Energy Access Partnership (LEAP) Awards and the Global LEAP Off-Grid Appliance Procurement Incentives program. Both programs are implemented through the Efficiency for Access Coalition,¹⁷² and they are managed by CLASP. The Global LEAP Awards is an international competition to identify and promote the world's best off-grid appliances,¹⁷³ accelerating market development and innovation. Inaugurated in 2013, the program has included fans and refrigerators, among other appliances, to serve cooling needs. This program has evolved into a trustworthy brand that provides information about the quality and energy performance of off-grid appliances.

The Global LEAP Off-Grid Appliance Procurement Incentives program provides incentives to appliance manufacturers and off-grid solar distributors who partner to distribute large quantities of best-in-class off-grid/weak-grid appliances. The incentives program was launched as a pilot in Bangladesh in 2016 and expanded to East Africa in late 2017. As of December 2019, the Global LEAP Off-Grid Appliance Procurement Incentives program has catalyzed the procurement of over 230,000 best-in-class off-grid TVs, fans, and refrigerators across Kenya, Uganda, Tanzania, Rwanda, and Bangladesh.¹⁷⁴ These include the first-ever large-scale procurements of off-grid refrigerators by two of the leading pay-as-you-go

companies in East Africa. Participating companies take surveys as part of the sales verification process, enabling the assessment of the impacts of these products on people's lives. Global LEAP sales verification surveys are generating unique off-grid appliance market intelligence and consumer insights for continuous program improvement, and facilitating entry into new markets.

Another example of promoting R&D in off-grid appliances specifically is the Engineers Without Borders Chill Challenge.¹⁷⁵ This challenge is specifically for off-grid small commercial refrigerators and ice makers, and specifies cooling capacities, costs to operate, and refrigerant limitations. Furthermore, to ensure usability in off-grid situations, the parameters specify transportability in a pickup truck and simple operation by a nontechnical user. A challenge with similar parameters could be designed for off-grid space cooling appliances as well.

- **Leverage the concept of community cooling centers for off-grid/weak-grid locations**

Community cooling centers are typically air-conditioned public buildings that are available to the public for use for recreational purposes and also help to protect the populations during extreme heat events. While this concept is applicable to any heat-vulnerable community—community cooling centers already exist in several urban centers in the United States to serve the public during extreme heat events—community cooling centers can be particularly relevant in off- or weak-grid communities where personal cooling options are limited.

For communities where a few buildings do have main grid electricity access, community cooling centers could be an affordable way to provide cooling access to all. For communities with mini-grids, the mini-grid operators could consider providing additional cooling services such as community cooling centers. This could work particularly well on solar mini-grids, which often have excess energy during the sunniest afternoon hours of the day.

RESOURCES

- Efficiency for Access Coalition, 2018, *Off-Grid Appliance Market Survey: Perceived Demand and Impact Potential of Household, Productive Use and Healthcare Technologies*, <https://storage.googleapis.com/clasp-siteattachments/Market-Survey-2018.pdf>.
- “Donor & Partner Programmes,” Efficiency for Access (accessed December 19, 2019), <https://efficiencyforaccess.org/programmes>.
- “Fans,” Global LEAP Awards (accessed September 26, 2019), <https://globalleapawards.org/fans>.
- Lighting Global, <https://www.lightingglobal.org/>.
- Lighting Africa, <https://www.lightingafrica.org/>.
- “Super-efficient Equipment and Appliance Deployment Initiative,” Clean Energy Ministerial, <http://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/super-efficient-equipment-and-appliance-deployment>.
- Energy Sector Management Assistance Program, 2019, *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers*, World Bank, Washington, DC, <https://openknowledge.worldbank.org/bitstream/handle/10986/31926/Mini-Grids-for-Half-a-Billion-People-Market-Outlook-and-Handbook-for-Decision-Makers-Executive-Summary.pdf?sequence=1&isAllowed=y>.



Santorini Island Oia Greece Europe: sunset at the white village of Oia Santorini with old blue and white Greek churches at dusk Santorini Greece.
Credit: Fokke baarsen/shutterstock.

ANNEX 1. SUMMARY OF INTERVENTION EXAMPLES

COUNTRY	NAME	COMPONENTS OF THE PROJECT/PROGRAM																	OFF-GRID TECHNOLOGIES		
		P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1	S2	S3	S4	S5
Armenia	Armenia Energy Efficiency Project, World Bank													X							
	Australia Energy Labels	X																			
Australia	Policy on Energy Efficiency in Government Operations				X																
	National Australian Built Environment Rating System (NABERS)						X														
	Environmental Upgrade Financing (EUF)														X						
Bangladesh	Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling (BRESL)*		X	X																	
	Walton Hi-Tech Industries Ltd.																		X		
Brazil	Energy-Efficiency Testing with Daikin									X											
Canada	Canadian Provinces' PACE														X						

*Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling.

		COMPONENTS OF THE PROJECT/PROGRAM																					
COUNTRY	NAME	COOLING ASSESSMENT		APPLIANCE LABELING		MEPS	GOVERNMENT LEAD-BY-EXAMPLE	NATIONAL COOLING ACTION PLANS	BUILDING ENERGY VISIBILITY	BUILDING ENERGY CODES	INCENTIVE MECHANISMS	DEMAND AGGREGATION	DEBT SUBSIDY	CaaS	ESCOs	ESAs	PACE AND EUF	UTILITY-LED DSM	AWARENESS	CAPACITY BUILDING	INTEGRATE EE AND REFRIGERANT TRANSITION	R&D ECOSYSTEM	OFF-GRID TECHNOLOGIES
		P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1	S2	S3	S4	S5		
China	Appliance Energy Label	X		X															X				
	MEPS																						
	Green and High-Efficiency Cooling Action Plan					X																	
	BRESL *	X		X																			
	Building Energy Label						X												X				
	Building Energy Codes							X															
	Promoting Energy-Efficient Products for the Benefit of the People								X														
Czech Republic	China's ESCO Market													X	X								
	Program EFEKT														X								
	Paris District Cooling Project																						
France	Berlin Energy Agency																			X			
Germany	Demand Analysis for Cooling by Sector in India in 2027	X																					
	Bureau of Energy Efficiency (BEE) Standards & Labeling Program		X																X				
India	BEE—Strategy for Energy Efficiency Campaigns																		X				
	India MEPS			X																			
	Central Government Directive on Procurement of Energy-Efficiency Appliances				X																		

*Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling.

		COMPONENTS OF THE PROJECT/PROGRAM																			
		COOLING ASSESSMENT	APPLIANCE LABELING	MEPS	GOVERNMENT LEAD-BY-EXAMPLE	NATIONAL COOLING ACTION PLANS	BUILDING ENERGY VISIBILITY	BUILDING ENERGY CODES	INCENTIVE MECHANISMS	DEMAND AGGREGATION	DEBT SUBSIDY	CaaS	ESCOs	ESAs	PACE AND EUF	UTILITY-LED DSM	AWARENESS	CAPACITY BUILDING	INTEGRATE EE AND REFRIGERANT TRANSITION	R&D ECOSYSTEM	OFF-GRID TECHNOLOGIES
COUNTRY	NAME	P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1	S2	S3	S4	S5
	GREENSHIP						X										X				
Indonesia	BRESL*		X	X																	
	Promoting Energy Efficiency for Non-HCFC Refrigeration and Air Conditioning (PENHRA)																		X		
Japan	Top Runner Program	X		X																	
	Green Purchasing Network				X																
	Japan's Eco-Point System								X												
Kenya	Kenya MEPS			X														X			
	Community Solar Nano-Grid (SONGs)																				X
Mexico	Efficient Lighting and Appliances Project								X							X					
	EcoCasa Green Mortgages										X										
Nigeria	M-Kopa																				X
Pakistan	BRESL*		X	X																	
	Punjab—Standardization and Labeling		X																		
	Punjab Energy Efficiency and Conservation Agency (PEECA)		X															X			
Philippines	Philippines Efficient Lighting Market Transformation Project (PELMATP)																	X			
Republic of Korea	Republic of Korea Government Purchasing				X																
	Republic of Korea Carbon Cashbag Program									X											

*Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling.

		COMPONENTS OF THE PROJECT/PROGRAM																
		COOLING ASSESSMENT	P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1
COUNTRY	NAME	COOLING ASSESSMENT	P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1
		COOLING ASSESSMENT	P1	P2	P3	P4	P5	P6	P7	F1	F2	F3	F4	F5	F6	F7	F8	S1
United States (cont.)	The United States ESCO Market																	
	Metrus Energy ESA Provider																	
	Home Energy Reports (HERs)																	
	Opower by Oracle																	
	United States Department of Energy Strategic Plans																	
Vietnam	BRESL*																	
REGION	NAME																	
Africa	World Bank Group's Lighting Africa Program																	
	Association of Southeast Asian Nations Harmonization of Test Standards																	
Southeast Asia	ASEAN Regional Policy Roadmap for Harmonization of Energy Performance Standards for Air Conditioners																	
	European Union Energy Labels																	
European Union	European Union MEPS (Ecodesign Directive)																	
	Energy Performance of Buildings Directive																	
	Energy-Efficient Mortgages Action Plan																	
	EuroPACE																	

*Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficiency Standards and Labeling.

[illegible]

ANNEX 2. ACCOUNTING CONSIDERATIONS

In structuring and evaluating the potential efficacy of financing and enabling mechanisms against different sectors of the market, it is critical to understand the impact of accounting considerations—especially in relation to the private sector, where the impact is the greatest.

This is highlighted where relevant throughout the handbook, but to fully appreciate the importance of this topic, it is helpful to understand what drives companies and corporations to care about accounting considerations.

It starts with an established strong correlation between the financial measure of return on invested capital (ROIC),¹⁷⁶ which together with expectations of future growth drives overall company valuations, and overall company debt capacity. This correlation drives internal company metrics, which in turn drive market behavior and focus.

The first of these metrics, the numerator, is to maximize near-term return (profit), and profit is recognized when revenue (sales) are recorded. The recognition of revenue does not necessarily correlate to cash in the short term, and it is important to recognize the difference, as while a transaction can be cash neutral (or even positive) for a company, if it results in a deferral of revenue recognition, the return is deferred and the transaction will be viewed internally as less attractive.

The other primary metric flowing from ROIC is invested capital, which comprises equity and debt. Together they are the denominator of ROIC, and a smaller denominator is desired for driving internal metrics toward this outcome. As a result, transactions that create debt for a company will be viewed less favorably and may even be prohibited under internal guidelines or restricted by a requirement for higher returns associated with such transactions. Further, in some jurisdictions there are statutory debt constraints in the form of maximum permissible debt to equity ratios, where increased debt can result in a requirement to raise additional equity.

Whereas if the return or revenue recognition component is a consideration unique to the implementing party (that is, an energy service company [ESCO]), the desire to minimize invested capital will lie with both the implementing party and the facility owner, with the facility owner typically seeing a solution with off-balance sheet potential as considerably more attractive.

In reviewing the efficacy of any financial intervention, understanding the timing of revenue recognition (sales treatment) and debt characterization for each of the parties involved is a critical consideration.

ANNEX 3. FINANCING STRUCTURES COMPARISON OF ASSET OWNERSHIP AND RISK AND SAVINGS ALLOTMENT

	ESCO AS BORROWER		FACILITY OWNER AS BORROWER		ESA	MESA	COOLING AS A SERVICE
	GUARANTEED SAVINGS	SHARED SAVINGS	GUARANTEED SAVINGS	SHARED SAVINGS			
Balance sheet ownership of deployed assets*	ESCO	ESCO	Facility owner	Facility owner	ESA provider (typically held in Special Purpose Vehicle)	MESA provider (typically held in Special Purpose Vehicle)	Cooling service provider
Performance risk	ESCO	ESCO	ESCO	ESCO	ESA provider (they may have a guarantee from the implementing ESCO contractor)	MESA provider (they may have a guarantee from the implementing ESCO contractor)	Cooling service provider
Credit risk	ESCO	ESCO	Finance provider	Finance provider	ESA provider	MESA provider	Cooling service provider
Savings above contractually agreed	Facility owner	ESCO and facility owner (shared)	Facility owner	ESCO and facility owner (shared)	ESA provider and facility owner (shared)	MESA provider	Cooling service provider

Note: The nature of the assets can overrule whose balance sheet they go on.



A bird's eye view of the terraces of the Principality of Monaco.
Credit: FineBoken.nl

ENDNOTES

- ¹ ANSI/ASHRAE, 2013, *Thermal Environmental Conditions for Human Occupancy*, standard 55-2013, ANSI/ASHRAE, Atlanta, GA, <https://www.ashrae.org/technical-resources/bookstore/thermal-environmental-conditions-for-human-occupancy>.
- ² Kumar, Satish, Sneha Sachar, Sandeep Kachhawa, Akash Goenka, Saikiran Kasamsetty, and Gerry George, 2018, *Demand Analysis for Cooling by Sector in India in 2027*, Alliance for an Energy Efficient Economy, New Delhi, India, <https://www.aeee.in/wp-content/uploads/2018/10/Demand-Analysis-for-Cooling-by-Sector-in-India-in-20271.pdf>.
- ³ ESMAP, Regulatory Indicators for Sustainable Energy homepage (accessed October 18, 2019), <https://rise.esmap.org/>.
- ⁴ Harrington, Lloyd, Jack Brown, and Marg Caithness, 2014, *Energy Standards and Labeling Programs throughout the World in 2013*, Australian Department of Industry, Victoria, Australia, <https://www.iea-4e.org/document/343/energy-standards-labelling-programs-throughout-the-world-in-2013>.
- ⁵ "Barrier Removal to the Cost-Effective Development and Implementation of Energy Standards and Labeling Project (BRESL)," Global Environment Facility (accessed December 1, 2019), <https://www.thegef.org/project/barrier-removal-cost-effective-development-and-implementation-energy-standards-and-labeling>.
- ⁶ Bureau of Energy Efficiency, 2015, *Strategy for Energy Efficiency Campaign*, Government of India and British High Commission, New Delhi, <https://cdkn.org/wp-content/uploads/2017/07/Up-EE-communications-campaign-strategy-1.pdf>.
- ⁷ "China Launches Digital Energy Label & App," 2017, CLASP, March 30, 2017, <https://clasp.ngo/updates/2017/china-launches-digital-energy-label-app>.
- ⁸ Global Environment Facility and United for Efficiency, 2017, *Energy-Efficient and Climate-Friendly Air Conditioners*, United Nations Environment Program, Paris, <https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-Final.pdf>.
- ⁹ Sulyma, Iris M., F. K. H. Chin, P. T. du Pont, D. Ference, J. Martin, N. Phumaraphand, K. H. Tiedemann, G. Wikler, and S. Zariffa, 2000, *Taking the Pulse of Thailand's DSM Market Transformation Programs*, European Council for an Energy Efficient Economy, Stockholm, https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/ACEEE_buildings/2000/Panel_8/p8_31/paper.pdf.
- ¹⁰ "EGAT Cooperates with 4 Financial Institutions for Latest Campaign," 2018, German International Cooperation, February, 20, 2018, <http://aiz.thai-german-cooperation.info/news/content/395/116>.
- ¹¹ De la Rue du Can, Stephane, Greg Leventis, Nihar K. Shah, and Michael A. McNeil, 2015, *Cooling the Growth of Air Conditioners Energy Consumption*, Lawrence Berkeley National Laboratory, Berkeley, CA, <http://eta-publications.lbl.gov/sites/default/files/lbnl-184253.pdf>.
- ¹² De la Rue du Can, Leventis, Shah, and McNeil, *Cooling the Growth of Air Conditioners Energy Consumption*.
- ¹³ "Standardization and Labeling," Punjab Energy Efficiency and Conservation Agency, Government of the Punjab (accessed September 18, 2019), https://peeca.punjab.gov.pk/standardization_and_labeling.
- ¹⁴ World Bank Group, 2017, *Punjab Energy Efficiency Project Standards & Labeling of Fans*, Washington, DC, <https://storage.googleapis.com/clasp-siteattachments/WB-SL-Progress-update-5Oct17.pdf>.
- ¹⁵ "Compliance, Testing, & Quality Assurance," CLASP (accessed September 18, 2019), <https://clasp.ngo/how-we-work/compliance-testing-quality-assurance>.
- ¹⁶ Bureau of Energy Efficiency homepage (accessed September 18, 2019), <https://www.beestarlabel.com/>.
- ¹⁷ Waide, Paul, and Rowan Watson, 2013, *The New European Energy Label: Assessing Consumer Comprehension and Effectiveness as a Market Transformation Tool*, CLASP, Washington, DC, https://storage.googleapis.com/clasp-siteattachments/2013_05_EU-Energy-Labeling-Comprehension-Study.pdf.
- ¹⁸ *Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 Setting a Framework for Energy Labelling and Repealing Directive 2010/30/EU (Text with EEA Relevance)*, EUR-Lex (accessed September 18, 2019), <https://eur-lex.europa.eu/eli/reg/2017/1369/oj>.
- ¹⁹ "Regional Standards Enforcement," US Department of Energy (accessed October 17, 2019), <https://www.energy.gov/gc/legal-resources/office-assistant-general-counsel-enforcement/regional-standards-enforcement>.
- ²⁰ Park, Won Young, Nihar Shah, and Brian Gerke, 2017, *Assessment of Commercially Available Energy-Efficient Room Air Conditioners Including Models with Low Global Warming Potential (GWP) Refrigerants*, Lawrence Berkeley National Laboratory, Berkeley, CA.
- ²¹ Abhyankar, Nikit, Nihar Shah, Won Young Park, and Amol Phadke, 2017, *Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies*, Lawrence Berkeley National Laboratory, Berkeley, CA, <https://ies.lbl.gov/sites/default/files/lbnl-1005798.pdf>.

- ²² CLASP, 2019, *Cooling in a Warming World: Global Markets and Policy Trends*, Washington, DC, https://issuu.com/clasngo/docs/clasp_-_cooling_in_warming_world?e=36662569/67350091.
- ²³ “China Subsidy Program Spurs 342 Bln Yuan in Home Appliance Sales,” 2011, Embassy of the People's Republic of China in the Republic of Zimbabwe, December 31, 2011 (accessed September 18, 2019), <http://www.chinaembassy.org.zw/eng/xwdt/t892363.htm>; and Yu, Yang, and All China Marketing Research, 2013, *Impacts of China's Energy Efficient Appliance Subsidy Program on Customer Behavior*, CLASP, Washington, DC, https://storage.googleapis.com/clasp-siteattachments/11_2013_Impacts_of_Chinas_EE_Appliance_Subsidy_Program_on_Consumer_Behavior_EXECUTIVE_SUMMARY.pdf.
- ²⁴ De la Rue du Can, Leventis, Shah, and McNeil, *Cooling the Growth of Air Conditioners Energy Consumption*.
- ²⁵ Park, Shah, and Gerke, *Assessment of Commercially Available Energy-Efficient Room Air Conditioners*.
- ²⁶ International Energy Agency and Super-efficient Equipment and Appliance Deployment Initiative, 2015, *Achievements of Appliance Energy Efficiency Standards and Labeling Programs*, Paris, <https://www.iea-4e.org/document/363/achievements-of-appliance-energy-efficiency-standardsand-labelling-programs-a-global-assessmentmtr>.
- ²⁷ “What Is SEER? EER? HSPF?” Energy Star (accessed December 19, 2019), <https://energystar.zendesk.com/hc/en-us/articles/212111387-What-is-SEER-EER-HSPF->.
- ²⁸ United Nations Development Program, 2013, “BRESL—Overview,” presented at Seventh Regional Meeting of lites.asia, Jakarta, Indonesia, April 22–23, http://www.lites.asia/files/otherfiles/0000/0217/Day_2_Session_1.3_BRESL_overview_Asep_Suwarna.pdf.
- ²⁹ CLASP and RenCon Associates, 2019, *Kenya Room Air Conditioner Market Assessment and Policy Options Analysis*, Washington, DC, and Verona, WI, <https://storage.googleapis.com/clasp-siteattachments/2019-Kenya-Room-Air-Conditioner-Market-Assessment-and-Policy-Options-Analysis.pdf>.
- ³⁰ Singh, Jas, Alicia Culver, and Melis Bitlis, 2012, *Public Procurement of Energy Efficient Products: Lessons from around the World*, ESMAP, Washington, DC, <https://openknowledge.worldbank.org/bitstream/handle/10986/17485/735070ESMOP12700EEProducts0TR003012.pdf?sequence=1&isAllowed=y>.
- ³¹ Department of Resources, Energy and Tourism, 2013, *Energy Use in the Australian Government's Operations 2011–12*, Australian Government, Canberra, https://www.energy.gov.au/sites/default/files/energy-use-in-australian-govt-ops_2011-12-report-2013_0.pdf.
- ³² Vyawahare, Malavika, 2018, “One Lakh Old ACs to Be Replaced in Govt Buildings in Bid to Conserve Energy,” *Hindustan Times*, January 24, 2018, <https://www.hindustantimes.com/india-news/one-lakh-old-ac-s-to-be-replaced-in-govt-buildings-in-bid-to-conserve-energy/story-wVv76qwlBCKUIMmxxpLM5O.html>.
- ³³ “Part 23—Environment, Energy and Water Efficiency, Renewable Energy Technologies, Occupational Safety, and Drug-Free Workplace,” Acquisition.gov (accessed December 19, 2019), <https://www.acquisition.gov/content/part-23-environment-energy-and-water-efficiency-renewable-energy-technologies-occupational>.
- ³⁴ “About GPN,” Green Purchasing Network (accessed December 19, 2019), <https://www.gpn.jp/english/>.
- ³⁵ Singh, Culver, and Bitlis, *Public Procurement of Energy Efficient Products*.
- ³⁶ OECD, 2015, *Going Green: Best Practices for Sustainable Procurement*, Paris, https://www.oecd.org/gov/public-procurement/Going_Green_Best_Practices_for_Sustainable_Procurement.pdf.
- ³⁷ “Standard Energy Efficiency Data (SEED) Platform,” US Department of Energy (accessed December 19, 2019), <https://www.energy.gov/eere/buildings/standard-energy-efficiency-data-seed-platform>.
- ³⁸ “Rwanda's New Cool Endeavour,” 2018, UN Environment Program, July 20, 2018, <https://www.unenvironment.org/news-and-stories/story/rwandas-new-cool-endeavour>.
- ³⁹ Institute for Governance & Sustainable Development, 2019, *Green and High-Efficiency Cooling Action Plan: English Translation*, Washington, DC, <http://www.igsd.org/wp-content/uploads/2019/07/ENG-China-Cooling-Action-Plan.pdf>.
- ⁴⁰ Roberts, Vivienne, 2015, “The Demand for Cooling in Singapore's Buildings,” *Energy Ramblings*, September 5, 2015.
- ⁴¹ “Air Conditioner Use Emerges as One of the Key Drivers of Global Electricity-Demand Growth,” 2018, International Energy Agency, May 15, 2018, <https://www.iea.org/news/air-conditioning-use-emerges-as-one-of-the-key-drivers-of-global-electricity-demand-growth>.
- ⁴² “LEED Rating System,” U.S. Green Building Council (accessed December 19, 2019), <https://new.usgbc.org/leed>.
- ⁴³ “Energy Star Portfolio Manager,” Energy Star (accessed December 19, 2019), <https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/new-energy-star-portfolio-manager>.
- ⁴⁴ NABERS homepage (accessed December 19, 2019), <https://www.nabers.gov.au/>.
- ⁴⁵ Goldstein, David B., and Charles Eley, 2014, “A Classification of Building Energy Performance Indices,” *Energy Efficiency* 7: 353–75, <https://doi.org/10.1007/s12053-013-9248-0>.

- ⁴⁶ *Directive 2010/31/EU*, EUR-Lex, May 19, 2010, https://eur-lex.europa.eu/legal-content/EN/ALL/ELX_SESSIONID=FZMJThLLzfxmmMCQGp2Y1s2d3TjwTD8QS3pqdkhXZbwqGwlgY9KN%212064651424?uri=CELEX:32010L0031; and *Directive 2012/27/EU*, EUR-Lex, October 25, 2012, <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027>.
- ⁴⁷ Roberts, "The Demand for Cooling in Singapore's Buildings."
- ⁴⁸ "Building Energy & Water Efficiency Strategy," City of Orlando (accessed December 19, 2019), <https://www.orlando.gov/Initiatives/Building-Energy-Water-Efficiency-Strategy>.
- ⁴⁹ "Data Disclosure and Reports," NYC Mayor's Office of Sustainability, Green Buildings and Energy Efficiency (accessed September 16, 2019), https://www1.nyc.gov/html/gbee/html/plan/ll84_scores.shtml.
- ⁵⁰ "LEED Green Rater," U.S. Green Building Council (accessed December 19, 2019), <https://new.usgbc.org/leed-green-rater>.
- ⁵¹ Levine, Mark, Stephane de la Rue de Can, Nina Zheng, Christopher Williams, Jennifer Thorne Amann, and Dan Staniaszek, 2012, *Building Energy-Efficiency Best Practice Policies and Policy Packages*, US Department of Energy, Washington, DC, <https://doi.org/10.2172/1168594>.
- ⁵² Levine, de la Rue de Can, Zheng, Williams, Amann, and Staniaszek, *Building Energy-Efficiency Best Practice Policies and Policy Packages*.
- ⁵³ "Home Energy Score," US Department of Energy (accessed December 19, 2019), <https://www.energy.gov/eere/buildings/downloads/home-energy-score>.
- ⁵⁴ "NYC to Become First US City to Require Building Energy Grades," 2017, Sierra Club, December 22, 2017, <http://nyc.sierraclub.org/new-york-become-first-u-s-city-require-energy-grades-publicly-posted-commercial-residential-buildings/>.
- ⁵⁵ Cox, Sadie, 2016, *Building Energy Codes: Policy Overview and Good Practices*, Clean Energy Solutions Center, Paris, <https://www.nrel.gov/docs/fy16osti/65542.pdf>.
- ⁵⁶ "India," Global Buildings Performance Network (accessed December 19, 2019), <http://www.gbpn.org/beet-3/country-infosheets/india>.
- ⁵⁷ "Building Energy Code," Commonwealth of Massachusetts (accessed December 19, 2019), <https://www.mass.gov/info-details/building-energy-code>.
- ⁵⁸ US Department of Energy, 2011, *Going Beyond Code*, Washington DC, <https://www.energycodes.gov/sites/default/files/documents/GoingBeyondCode.pdf>.
- ⁵⁹ Yu, Sha, Jiyong Eom, Meredydd Evans, and Leon Clarke, 2014, "A Long-Term, Integrated Impact Assessment of Alternative Building Energy Code Scenarios in China," *Energy Policy* 67: 626–39, <https://doi.org/10.1016/j.enpol.2013.11.009>.
- ⁶⁰ Ministry of Environment, Forest and Climate Change, 2019, *India Cooling Action Plan*, Government of India, New Delhi.
- ⁶¹ ESMAP, Regulatory Indicators for Sustainable Energy homepage (accessed December 19, 2019), <https://rise.worldbank.org/>.
- ⁶² Levine, de la Rue de Can, Zheng, Williams, Amann, and Staniaszek, *Building Energy-Efficiency Best Practice Policies and Policy Packages*.
- ⁶³ Sun, Xiaojing, Marilyn A. Brown, Matt Cox, and Roderick Jackson, 2015, "Mandating Better Buildings: A Global Review of Building Codes and Prospects for Improvement in the United States," *Wires Energy and Environment*, March 11, 2015, <https://doi.org/10.1002/wene.168>.
- ⁶⁴ Bin, Shui, and Jun Li, 2012, *Building Energy Efficiency Policies in China: Status Report*, American Council for an Energy-Efficient Economy, Washington, DC, <http://www.aceee.org/research-report/e129>.
- ⁶⁵ "Building Standards Code," California Air Resources Board (accessed December 19, 2019), <https://ww3.arb.ca.gov/cc/greenbuildings/standards.htm>.
- ⁶⁶ Dillon, Heather, and Mingjie Zhao, 2015, *Energy and Carbon Enhancements to the City of Seattle Code Requirements*, Pacific Northwest National Laboratory, Richland, WA, <https://pdfs.semanticscholar.org/10bb/938e53004e14300dd65a96b318ac859bf3cb.pdf>.
- ⁶⁷ "Energy Compliance through the Target Performance or Total Building Performance Paths," 2018, Seattle Department of Construction and Inspections, June 29, 2018, <http://www.seattle.gov/DPD/Publications/CAM/Tip423.pdf>.
- ⁶⁸ Traube, Caroline, and Michael Frank, 2017, "Get Ready for the New Year—and New Energy Codes," *Daily Journal of Commerce*, October 26, 2017, <https://www.djc.com/news/ae/12105487.html>.
- ⁶⁹ De la Rue du Can, Stephane, Greg Leventis, and Nihar Shah, 2015, *Lessons Learned from Incentive Programs for Efficient Air Conditioners: A Review*, LBNL-191145, Lawrence Berkeley National Laboratory, Berkeley, CA, <https://eta.lbl.gov/publications/lessons-learned-incentive-programs>.

- ⁷⁰ “More Ways to Save: Rebates, Incentives, Assessments and More,” The RCS Network (accessed December 19, 2019), <https://www.masssave.com/en/saving/>.
- ⁷¹ World Bank Group, 2016, *Mexico—Efficient Lighting and Appliances Project (English)*, Washington, DC, <http://documents.worldbank.org/curated/en/770671469672145946/Mexico-Efficient-Lighting-and-Appliances-Project>.
- ⁷² De la Rue du Can, Leventis, Shah, and McNeil, *Cooling the Growth of Air Conditioners Energy Consumption*.
- ⁷³ “Commercial and Industrial Upstream HVAC and Heat Pump Program,” 2019, National Grid, August 2019, <https://www.nationalgridus.com/media/pdfs/bus-ways-to-save/ee7078-ci-upstream-hvac.pdf>.
- ⁷⁴ “Income Eligible Programs,” The RCS Network (accessed December 19, 2019), <https://www.masssave.com/saving/income-based-offers/income-eligible-programs>.
- ⁷⁵ “About the Number of Home Electronics Eco Points,” Government of Japan (accessed December 19, 2019, translated by Google), http://www.env.go.jp/policy/ep_kaden/buy/point.html.
- ⁷⁶ “Case Study: Japan’s Housing Eco-Point System,” Low Carbon Green Growth Roadmap for Asia and the Pacific, <https://www.unescap.org/sites/default/files/28.%20CS-Japan-housing-eco-point-system.pdf>.
- ⁷⁷ Wakabayashi, Daisuke, 2010, “Japan Seeks an ‘Eco-Points’ Boost,” *The Wall Street Journal*, August 31, 2010, <https://www.wsj.com/articles/SB10001424052748704421104575463183518640958>.
- ⁷⁸ Fairey, Philip, and David B. Goldstein, 2006, *Getting It Right Matters: Why Efficiency Incentives Should Be Based on Performance and Not Cost*, American Council for an Energy-Efficient Economy, Washington, DC, https://www.aceee.org/files/proceedings/2006/data/papers/SS06_Panel8_Paper06.pdf.
- ⁷⁹ De la Rue du Can, Leventis, and Shah, *Lessons Learned from Incentive Programs for Efficient Air Conditioners*.
- ⁸⁰ “Carbon Cashbag,” KEMCO (accessed September 2019), http://www.kemco.or.kr/new_eng/pg02/pg02020510.asp.
- ⁸¹ De la Rue du Can, Stephane, Greg Leventis, Amol Phadke, and Anand Gopal, 2014, “Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances,” *Energy Policy* 72 (September 2014): 56–66, <https://www.sciencedirect.com/science/article/pii/S0301421514002705?via%3Dihub>.
- ⁸² Abhyankar, Shah, Park, and Phadke, *Accelerating Energy Efficiency Improvements in Room Air Conditioners in India*.
- ⁸³ Singh, Manjeet, and Gurprasad Gurumurthy, 2019, *Bulk Procurement in Room Air Conditioning: A Critical Analysis of the EESL Programme*, The Energy and Resources Institute, New Delhi, India, <https://www.teriin.org/sites/default/files/2018-11/1558347541ESEA-PolicyBrief.pdf>.
- ⁸⁴ “Super-efficient Air Conditioning Programme Launched by EESL,” 2019, Press Information Bureau, Ministry of Power, Government of India, February 22, 2019, <https://pib.gov.in/Pressreleaseshare.aspx?PRID=1566015>.
- ⁸⁵ “EESL to Sell 1.5 Tonne 7-Star ACs at Rs 41,300,” *The Economic Times*, July 8, 2019, <https://economictimes.indiatimes.com/eestl-to-sell-1-5-tonne-7-star-ac-s-at-rs-41300/articleshow/70128053.cms?from=mdr>.
- ⁸⁶ Aun Abdullah, from Lodha Groups, e-mail to Seth Coan, from RMI, August 22, 2019.
- ⁸⁷ Advanced RTU Campaign homepage (accessed October 14, 2019), <http://www.advancedrtu.org/>.
- ⁸⁸ Gabrielle Dreyfus, from IGSD, e-mail to Sneha Sachar and Elizabeth O’Grady, from RMI, August 16, 2019.
- ⁸⁹ Anderson, Stephen O., and Sueli Carvalho, 2018, “Morocco Buyers Club Seeking Affordable Super-efficient Low-GWP ACs,” IGSD, presented as an update to the World Bank, November 28, 2018, https://esmap.org/sites/default/files/events-files/Int%20Conf%20Sust%20Cooling/Buyers%20Club_Optimized.pdf.
- ⁹⁰ Energy Efficiency Services Limited homepage, <https://www.eeslindia.org/content/raj/eestl/en/home.html>.
- ⁹¹ Sarkar, Ashok, and Sarah Moin, 2018, “Transforming Energy Efficiency Markets in Developing Countries: The Emerging Possibilities of Super ESCOs” *World Bank Live Wire*, <https://openknowledge.worldbank.org/bitstream/handle/10986/30385/129781-BRI-PUBLIC-VC-ADD-SERIES-6-9-2018-12-9-31-LWLJfinalOKR.pdf?sequence=1&isAllowed=y>.
- ⁹² Singh and Gurumurthy, *Bulk Procurement in Room Air Conditioning*.
- ⁹³ *Buyers Club Handbook—January 2020 Update*, Institute for Governance and Sustainable Development and OzonAction/United Nations Environment Program, Washington, DC, and Paris, <http://www.igsd.org/wp-content/uploads/2018/01/Buyers-Club-Handbook-Jan2020.pdf>.
- ⁹⁴ Aditya, Lukas, “Financing Energy Efficiency, Part 1: Revolving Funds,” *Live Wire* (2018/88), World Bank, <https://openknowledge.worldbank.org/handle/10986/30388> License: CC BY 3.0 IGO.
- ⁹⁵ “Pioneers,” Energy Efficient Mortgages Initiative (accessed December 5, 2019), <http://eemap.energyefficientmortgages.eu/pioneers-2/#tab-id-1>.
- ⁹⁶ Monge, Camilo, 2018, “EcoCasa Program Outperforms Its Green Building Goals,” Clean Energy Finance Forum, February 20, 2018, <https://cleanenergyfinanceforum.com/2018/02/20/ecocasa-program-outperforms-its-green-building-goals>.

- ⁹⁷ World Bank, 2018, *Green Bond Impact Report 2018*, Washington, DC, <http://pubdocs.worldbank.org/en/632251542641579226/report-impact-green-bond-2018.pdf>.
- ⁹⁸ “Unlocking the Potential of District Cooling,” Strategy& (accessed December 19, 2019), <https://www.strategyand.pwc.com/m1/en/reports/unlocking-potential-district-cooling.html>.
- ⁹⁹ “UAE’s Tabreed to Build India’s First District Cooling System in Amaravati,” *The Times of India*, February 14, 2019, <https://timesofindia.indiatimes.com/india/uaes-tabreed-to-build-indias-first-district-cooling-system-in-amaravati/articleshow/67992502.cms>.
- ¹⁰⁰ Riahi, Lily, 2015, *District Energy in Cities: Paris Case Study*, United Nations Environment Program, Paris (accessed December 19, 2019), <https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=b7d8029e-fb30-d023-a362-50f251a39458&forceDialog=1>.
- ¹⁰¹ Riahi, *District Energy in Cities*.
- ¹⁰² “Concept,” Gujarat International (accessed December 19, 2019), <http://www.giftgujarat.in/concept>.
- ¹⁰³ Patel, Guarankumar, 2018, “India’s First District Cooling System at GIFT City,” REHVA Federation of European Heating, Ventilation and Air Conditioning Association (accessed December 19, 2019), <https://www.rehva.eu/rehva-journal/chapter/indias-first-district-cooling-system-at-gift-city>.
- ¹⁰⁴ Riahi, *District Energy in Cities*.
- ¹⁰⁵ Di Cecca, A., F. Benassiss, and P. Poeuf, “Energy Storage: The Parisian District Cooling System,” Energy Learning (accessed December 19, 2019), <https://www.energy-learning.com/index.php/archive/94-energy-storage-the-parisian-district-cooling-system>.
- ¹⁰⁶ Kigali Cooling Efficiency Program, 2018, *Cooling as a Service (CaaS)*, San Francisco, CA, https://www.k-cep.org/wp-content/uploads/2018/07/Cooling-as-a-service-Knowledge-brief-6.7.2018_Final_online_v1.pdf.
- ¹⁰⁷ “Everything You Need to Know about the Rwanda Cooling Initiative Coolease Financial Mechanism,” 2019, FONERWA (accessed December 19, 2019), <http://fonerwa.org/blog/rwanda-cooling-initiative-coolease-financial-mechanism>.
- ¹⁰⁸ Roberts, “The Demand for Cooling in Singapore’s Buildings.”
- ¹⁰⁹ Stuart, Elizabeth, Peter H. Larsen, Juan Pablo Carvallo, Charles A. Goldman, and Donald Gilligan, 2016, *U.S. Energy Service Company (ESCO) Industry: Recent Market Trends*, Lawrence Berkeley National Laboratory, Berkeley, CA, <http://www.osti.gov/servlets/purl/1342939>.
- ¹¹⁰ International Finance Corporation, 2017, *China Energy Service Company (ESCO) Market Study*, Washington, DC, <https://www.ifc.org/wps/wcm/connect/5d1cfd04-36fc-4f80-9900-c419940bd69b/IFC+final+ESCO+report-EN+.pdf?MOD=AJPERES&CVID=jZVnBBO>.
- ¹¹¹ International Finance Corporation, *China Energy Service Company (ESCO) Market Study*.
- ¹¹² Boza-Kiss, Benigna, Paolo Bertoldi, and Marina Economidou, 2017, *Energy Service Companies in the EU*, Joint Research Center of the European Commission, Brussels, Belgium, <http://doi.org/10.2760/12258>.
- ¹¹³ Metrus Energy homepage (accessed December 13, 2019), <https://www.metrusenergy.com/>.
- ¹¹⁴ “Efficiency Services Agreement (ESA) in BAE Facilities Nationwide,” Better Buildings, US Department of Energy (accessed December 13, 2019), <https://betterbuildingsinitiative.energy.gov/implementation-models/efficiency-services-agreement-esa-bae-facilities-nationwide>.
- ¹¹⁵ Better Building Finance homepage (accessed December 19, 2019), <https://betterbuildingfinance.com.au/>; and “FAQ: PACE for Homes,” Rocky Mountain Institute (accessed December 19, 2019), <https://rmi.org/our-work/buildings/residential-energy-performance/faq-pace-for-homes/>.
- ¹¹⁶ Gose, Joe, 2019, “To Meet Demand for Green Buildings, Developers Get a Leg Up,” *The New York Times*, August 27, 2019, <https://www.nytimes.com/2019/08/27/business/green-buildings-pace-loans.html>.
- ¹¹⁷ “Case Studies: 460 Collins Street Melbourne VIC,” Better Building Finance (accessed December 19, 2019), <https://betterbuildingfinance.com.au/case-studies/460-collins-street-melbourne-vic/>.
- ¹¹⁸ “Our Council Partners,” Better Building Finance (accessed December 19, 2019), <https://betterbuildingfinance.com.au/councils/>.
- ¹¹⁹ Sustainable Australia Fund homepage (accessed December 19, 2019), <https://sustainableaustraliafund.com.au/>.
- ¹²⁰ PACECanada homepage (accessed December 19, 2019), <https://www.paceab.ca/>.
- ¹²¹ Gabrielson, David, 2017, “PACE: Property Assessed Clean Energy,” PACENation, https://ec.europa.eu/energy/sites/ener/files/documents/007_1a_david_gabrielson_seif_paris_11-12-17.pdf.
- ¹²² GNE Finance homepage (accessed September 2019), <https://www.gnefinance.com/press>.
- ¹²³ EuroPACE homepage (accessed December 19, 2019), <https://www.europace2020.eu/>.

- ¹²⁴ "Property Assessed Clean Energy (PACE)," American Council for an Energy-Efficient Economy (accessed December 19, 2019), <https://www.aceee.org/toolkit/2020/02/property-assessed-clean-energy-pace>.
- ¹²⁵ "First Pilot Demand Response Program in India: Development, Execution and Way Forward," Energy Alternatives India (accessed December 19, 2019), <http://www.eai.in/news-and-media/pr/first-pilot-demand-response-program-in-india-development-execution-and-way-forward>.
- ¹²⁶ Khadilkar, Shekhar, "Tata Power Demand Response Program," The Tata Power Company Ltd. Mumbai Distribution (accessed December 19, 2019), <https://beeindia.gov.in/sites/default/files/ctools/Shekhar%20Khadilkar%20Tata%20Power%20DR.pdf>.
- ¹²⁷ "Technology Enabling Demand Response," Mitsubishi Heavy Industries, Ltd. (accessed December 19, 2019), <https://beeindia.gov.in/sites/default/files/ctools/Mr%20takaya.pdf>.
- ¹²⁸ "Discover the Benefits of SmartAC," PG&E (accessed December 19, 2019), https://www.pge.com/en_US/residential/save-energy-money/savings-solutions-and-rebates/smart-ac/smart-ac.page?WT.mc_id=Vanity_smartac.
- ¹²⁹ World Bank Group, 2016, *Mexico—Efficient Lighting and Appliances Project (English)*, Washington, DC, <http://documents.worldbank.org/curated/en/770671469672145946/Mexico-Efficient-Lighting-and-Appliances-Project>.
- ¹³⁰ State of California, 2016, *Decision Providing Guidance for Initial Energy Efficiency Rolling Portfolio Business Plan Filings*, https://docs.wixstatic.com/ugd/0c9650_9afbd868952646bba5ea5b687499fd4b.pdf.
- ¹³¹ Sachar, Sneha, Shyamasis Das, and Akash Goenka, 2019, *Behavioural Energy Efficiency Potential for India*, Alliance for an Energy Efficient Economy, New Delhi, India, <https://www.oracle.com/a/ocom/docs/industries/utilities/behavioural-energy-efficiency-wp.pdf>.
- ¹³² International Energy Agency, 2018, *Behavior Change for Energy Efficiency: Opportunities for International Cooperation*.
- ¹³³ Gray, Kathleen, 2009, "Appliances Get Their Own Recycled Clunkers Program," ABC News, August 25, 2009, <https://abcnews.go.com/Business/appliances-recycled-clunkers-programs/story?id=8413345>.
- ¹³⁴ Gheorghiu, Iulia, 2018, "Oracle Utilities Boasts Industry-Leading 20 TWh of Savings for Consumers," Utility Dive, October 22, 2018, <https://www.utilitydive.com/news/oracle-utilities-opower-boasts-industry-leading-20-twh-of-savings-for-cons/540202/>.
- ¹³⁵ Rivas, Silvia, Barbara Cuniberti, and Paolo Bertoldi, 2016, *Effective Information Measures to Promote Energy Use Reduction in EU Member States*, Joint Research Center of the European Commission, Brussels, Belgium, http://publications.europa.eu/resource/cellar/05ffd175-f97e-4237-9061-8f9689298dff.0001.03/DOC_1.
- ¹³⁶ Bureau of Energy Efficiency, *Strategy for Energy Efficiency Campaign*.
- ¹³⁷ "Labeling & Buyer Education," CLASP (accessed December 19, 2019), <https://clasp.ngo/how-we-work/labeling-buyer-education>.
- ¹³⁸ "Heating & Cooling," Energy Star (accessed December 19, 2019), https://www.energystar.gov/products/heating_cooling.
- ¹³⁹ "Product Search Section," National Environment Agency (accessed December 19, 2019), <https://e-services.nea.gov.sg/els/Pages/Search/PublicSearchProduct.aspx?param=goods&type=p>.
- ¹⁴⁰ Topten.eu homepage (accessed December 19, 2019), <https://www.topten.eu/private>.
- ¹⁴¹ Griskevicius, Vladas, Robert B. Cialdini, and Noah J. Goldstein, 2008, "Social Norms: An Underestimated and Underemployed Lever for Managing Climate Change," *IJSC* 3 (2008): 5–13, <https://pdfs.semanticscholar.org/8791/b3ce170ee1328adb2df83d75c36fdad326e9.pdf>.
- ¹⁴² Allcott, Hunt, and Todd Rogers, "Opower: Evaluating the Impact of Home Energy Reports on Energy Conservation in the United States," Abdul Latif Jameel Poverty Action Lab (accessed December 19, 2019), <https://www.povertyactionlab.org/evaluation/opower-evaluating-impact-home-energy-reports-energy-conservation-united-states>.
- ¹⁴³ "What Is Opower?" Oracle (accessed December 19, 2019), <https://www.oracle.com/industries/utilities/products/what-is-opower.html>.
- ¹⁴⁴ "IIEC's Experience in Training & Capacity Building," International Institute for Energy Conservation (accessed December 19, 2019), <https://www.iiec.org/key-activities/training-capacity-building>.
- ¹⁴⁵ "Training: Establishing Ongoing Working Relationships with Participating Countries for Continual Capacity Building," International Energy Agency (accessed December 19, 2019), <https://www.iea.org/training/trainingthemesandmodules/#d.en.8409>.
- ¹⁴⁶ Technology and Economic Assessment Panel, 2017, *Decision XXVIII/3 Working Group Report on Energy Efficiency*, United Nations Environment Program, Paris, <http://conf.montreal-protocol.org/meeting/mop/cop11-mop29/presession/Background-Documents/TEAP-EEWG-Report-october2017.docx>.

- ¹⁴⁷ Dreyfus, G., N. Borgford-Parnell, J. Christensen, D. W. Fahey, B. Motherway, T. Peters, R. Piccolotti, N. Shah, and Y. Xu, 2020, *Assessment of Climate and Development Benefits of Efficient and Climate-Friendly Cooling*, Climate & Clean Air Coalition, Paris, <https://ccacoalition.org/en/resources/assessmentclimate-and-development-benefits-efficient-and-climate-friendly-cooling>.
- ¹⁴⁸ Dreyfus, Gabrielle B., Stephen O. Andersen, Ana M. Kleymayer, and Durwood Zaelke, 2017, *Primer on Energy Efficiency*, Institute for Governance & Sustainable Development Working Paper, Washington, DC, <http://www.igsd.org/wp-content/uploads/2019/10/EE-Primer-11.13.17.pdf>.
- ¹⁴⁹ Kigali Cooling Efficiency Program, *Year 2 Report*.
- ¹⁵⁰ De la Rue du Can, Stephane, 2015, "ACs: Cooling Growth in Energy Demand," Super-efficient Equipment and Appliance Deployment Initiative, http://eta-publications.lbl.gov/sites/default/files/2015-_ac_cooling_the_demand.pdf.
- ¹⁵¹ De la Rue du Can, Leventis, and Shah, *Lessons Learned from Incentives Programs for Efficient Air Conditioners*.
- ¹⁵² "GIZ Proklima Cool Training," Green Cooling Initiative (accessed December 19, 2019), <https://www.green-cooling-initiative.org/cool-training/>.
- ¹⁵³ "IC7: Affordable Heating and Cooling of Buildings," Mission Innovation (accessed December 19, 2019), <http://mission-innovation.net/our-work/innovation-challenges/affordable-heating-and-cooling-of-buildings/>.
- ¹⁵⁴ US. Department of Energy, 2014, *Strategic Plan 2014–2018*, Washington, DC, https://www.energy.gov/sites/prod/files/2014/04/f14/2014_dept_energy_strategic_plan.pdf.
- ¹⁵⁵ US Department of Energy, 2017, *Energy Savings Potential and RD&D Opportunities for Commercial Building HVAC Systems*, Washington, DC, <https://www.energy.gov/sites/prod/files/2017/12/f46/bto-DOE-Comm-HVAC-Report-12-21-17.pdf>.
- ¹⁵⁶ "The Road to Zero: DOE's Next-Generation Heating and Cooling R&D Strategy," United States Department of Energy (accessed September 26, 2019), <https://www.energy.gov/eere/buildings/road-zero-does-next-generation-heating-and-cooling-rd-strategy>.
- ¹⁵⁷ Sushila Maharjan, from Gavi, in interview with Radhika Lalit and Sneha Sachar, from RMI, July 5, 2019.
- ¹⁵⁸ "Immunization Supply Chain," Gavi, <https://www.gavi.org/support/hss/immunisation-supply-chain/>.
- ¹⁵⁹ Sachar, Sneha, Iain Campbell, and Ankit Kalanki, 2018, *Solving the Global Cooling Challenge: How to Counter the Climate Threat from Room Air Conditioners*, Rocky Mountain Institute, Boulder, CO.
- ¹⁶⁰ "Advanced Cooling Challenge," Super-efficient Equipment and Appliance Deployment Initiative (accessed September 11, 2019), <https://superefficient.org/about-us/campaigns/advanced-cooling-challenge>.
- ¹⁶¹ "Advanced Cooling Challenge," Clean Energy Ministerial (accessed September 11, 2019), <http://www.cleanenergyministerial.org/campaign-clean-energy-ministerial/advanced-cooling-challenge>.
- ¹⁶² "World Energy Outlook," International Energy Agency, <https://www.iea.org/reports/world-energy-outlook-2019>.
- ¹⁶³ "Tracking SDG 7: The Energy Progress Report," 2020, <https://irena.org/publications/2020/May/Tracking-SDG7-The-Energy-Progress-Report-2020>.
- ¹⁶⁴ Arlet, Jean, 2017, *Electricity Tariffs, Power Outages and Firm Performance: A Comparative Analysis*, World Bank Group, Washington, DC, <http://pubdocs.worldbank.org/en/444681490076354657/Electricity-Tariffs-Power-Outages-and-Firm-Performance.pdf>.
- ¹⁶⁵ "More People Have Access to Electricity, but World Is Falling Short of Sustainable Energy Goals," International Renewable Energy Agency, May 22, 2019, <https://www.irena.org/newsroom/pressreleases/2019/May/More-People-Have-Access-to-Electricity-Than-Ever-Before>.
- ¹⁶⁶ "Products," M-Kopa (accessed October 14, 2019), <http://www.m-kopa.com/products/>.
- ¹⁶⁷ "Equip Data," Efficiency for Access (accessed December 19, 2019), <https://efficiencyforaccess.org/equip-data-programme>.
- ¹⁶⁸ "Our Impact," M-Kopa (accessed December 19, 2019), <http://solar.m-kopa.com/about/our-impact/>.
- ¹⁶⁹ Kidenda, John, 2018, *Mini-Grids on the Trajectory of Rural Electrification in Africa*, African Mini-Grid Developers Association, <http://africamda.org/wp-content/uploads/2018/10/WHITE-PAPER-Mini-Grids-on-the-Trajectory-of-Rural-Electrification-in-Africa.pdf>.
- ¹⁷⁰ Lighting Africa homepage (accessed December 19, 2019), <https://www.lightingafrica.org/>.
- ¹⁷¹ "Low Energy Inclusive Appliances (LEIA) Programme," Efficiency for Access (accessed December 19, 2019), <https://efficiencyforaccess.org/leia>.

¹⁷² "About Efficiency for Access," Efficiency for Access (accessed December 19, 2019), <https://efficiencyforaccess.org/about-the-coalition>.

¹⁷³ "About," Global Leap Awards (accessed December 19, 2019), <https://globalleapawards.org/about>.

¹⁷⁴ "Global Leap Awards," Efficiency for Access (accessed December 19, 2019), <https://efficiencyforaccess.org/global-leap-awards>.

¹⁷⁵ "Chill Challenge: Affordable, Off-Grid Refrigeration," Engineers Without Borders USA (accessed December 19, 2019), <https://www.ewb-usa.org/chill-challenge/>.

¹⁷⁶ Cao, Bing, Bin Jiang, and Timothy Koller, 2006, "Balancing ROIC and Growth to Build Value," McKinsey & Company, March 1, 2006, <https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/balancing-roic-and-growth-to-build-value>.

ESMAP MISSION

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by The World Bank. It assists low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Canada, ClimateWorks Foundation, Denmark, the European Commission, Finland, France, Germany, Iceland, Italy, Japan, Lithuania, Luxembourg, the Netherlands, Norway, the Rockefeller Foundation, Sweden, Switzerland, the United Kingdom, and the World Bank.





Energy Sector Management Assistance Program
The World Bank

1818 H Street NW
Washington, DC 20433 USA
esmap.org | esmap@worldbank.org