TRANSFORMATIONAL CLIMATE FINANCE: AN EXPLORATION OF LOW-CARBON ENERGY

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EXECUTIVE SUMMARY

Limiting global warming to below 2°C above pre-industrial levels will require massive reductions in greenhouse gas (GHG) emissions from business-as-usual—on the order of 40 percent to 70 percent in 2050 compared to 2010, and near net zero emissions by 2100. At the same time, new investments will be needed to shift the world to a low-carbon economy. Responding to the scale of the climate change challenge will require a fundamental transformation in our political, economic, energy, and socio-technical systems.

This working paper examines how climate finance can be transformational by gleaning insights from nine low-carbon energy case studies, selected to cover a variety of geographies, energy sources, and degrees of transformation. We provide a series of recommendations for development finance institutions/contributor governments and recipient governments on how to catalyze transformational change, and a planning framework that lays out a sequence of steps for recipient governments.

Nature of Transformation

A transformation is a long-term fundamental shift in a system, whether political, economic, social, or biological. Transformations are typically viewed as multi-actor, multi-scale processes, where the change is highly non-linear.

We consider low-carbon energy transformation to have three characteristics or criteria:

- **Large magnitude impact.** There is a profound change in the energy sector in terms of the shift to low-carbon energy (e.g. installed capacity and/or net generation) that may also have economy-wide impacts.

- **Non-linear change.** While the change might begin slowly, the scaling up of low-carbon energy has a non-linear trajectory.

- **Sustained and long term.** Transformations typically occur over years and perhaps decades, and there should be no fundamental backsliding.

### Case Studies of Low-Carbon Energy Transformation

Although transformation can occur in other sectors (e.g. transportation, agriculture), we focus here on low-carbon energy, which we define to include renewable energy and energy-efficient technologies. We analyzed the most critical elements for transformation by reviewing 20 case studies from both developed and developing countries and across all regions. We then sorted the case studies into one of three categories:

- **Transformational:** cases where finance has been used for truly path-breaking, low-carbon energy development; where there has been a non-linear growth in renewable energy or energy efficiency; and/or where successes have been scaled up and replicated.

- **Potentially transformational:** cases where finance has shown promise or early successes in catalyzing low-carbon development; where there has been positive change, but not yet in a dramatic non-linear, sector-wide fashion; where there is potential scalability and replicability.

- **Missed opportunities or early stage development:** cases where initial promise has not led to transformational success, or cases where an initial failure has been turned around, but development is ongoing.

From the 20 cases, we selected three from each category for in-depth analysis, trying to maintain a balance between developed and developing country experiences, across regions, and among types of low-carbon energy development. The transformational cases include wind in Uruguay and Denmark, and renewable energy more broadly in Portugal. The potentially transformational cases include solar household systems in Bangladesh, energy efficiency in Thailand, and solar water heaters in Tunisia. Lastly, the missed opportunities or early stage development case studies include geothermal in Indonesia, renewable energy in South Africa, and solar in Spain.

Among the transformational cases, Uruguay illustrates how addressing regulatory barriers and creating a well-designed auction system for renewable energy development can have a catalytic effect on private sector investment. In Denmark, transformation came about through a confluence of factors, including substantial investment in research and development, clear targets, stable financial incentives, community ownership of wind development, and policies to enhance grid access and management for increasingly high shares of renewable energy. Portugal illustrates the successful use of an innovative feed-in tariff design with variable components to encourage the expansion of renewable energy and the importance of government policies and intervention to ensure that the electricity grid is modernized to handle variable renewable energy generation.

Thailand has used a petroleum tax to create a revolving fund and provide a sustainable source of financing for energy efficiency. However, the Thai economy has been unable to decouple GDP growth from energy consumption; transformational success in energy efficiency thus remains elusive. Bangladesh has effectively combined consumer subsidies and concessional microloans to make small-scale solar installations affordable for millions of rural households, but the challenge remains as to whether the program can continue to expand, while making it more sustainable, maintaining affordability for the poorest, and increasing the quality and reliability of hardware. Tunisia’s Prosol scheme for solar water heaters shows that targeted subsidies can effectively scale up renewable energy adoption and support sustainable financing models, but it remains to be seen whether the past success in solar water heater deployment can be continued in post-revolution Tunisia.

The missed opportunities or early stage development case studies are characterized by some combination of policy uncertainty (South Africa), poor policy design (Spain), lack of government leadership (South Africa, Indonesia), and the continued “headwinds” of fossil-fuel subsidies, which make renewable energy less competitive.
(Indonesia), although both South Africa and Indonesia have made progress in recent years.

Our case studies point to eight factors that can help facilitate transformational change in low-carbon energy development:

- National ownership
- Stakeholder engagement and participation
- Establishment of a stable enabling environment for investment
- Alignment of financial incentives to address market distortions
- Strategic use of public resources to mobilize investment
- Investment in technology and innovation
- Use of innovative financial instruments and arrangements to catalyze investments
- Continuous learning and improvement

**Recommendations for Recipient Governments and Development Finance Institutions/Contributor Governments**

Low-carbon transformation will require action across many scales. While private sector technology providers, commercial banks, utilities, technical institutions, and community organizations are all vital actors, this paper focuses on recipient governments and development finance institutions/contributor governments. These recommendations can guide both sets of actors on catalyzing low-carbon energy transformation.

**Recipient governments**

- Take ownership of the process.
- Organize government to facilitate low-carbon transformation, including creating incentives for government agencies to work together to implement plans and targets and designating a government champion to coordinate the process.
- Formulate national plans and targets in an inclusive, multi-stakeholder process.
- Adopt consistent policies and regulations.

- Identify barriers to climate investment and gaps in enabling conditions and provide financial resources to address them.
- Support enabling infrastructure.
- If resources allow, invest in research and development to adapt technology to local conditions.
- Use international public finance strategically, for example, to address key capacity gaps and provide training and awareness-raising.
- Get the prices right—remove fossil-fuel subsidies and internalize externalities through carbon pricing or other instruments.
- Level the playing field in terms of competitive procurement and focus on developing the private sector.
- Adopt a dynamic approach and continually update and iterate policies, targets, and public financial support in line with evaluations of progress and lessons learned.

**Development Finance Institutions and Contributor Governments**

- Make sure that international support is well aligned with local country plans and priorities and provides long-term sustained assistance.
- In conjunction with recipient governments, identify gaps in enabling factors (e.g. institutional capacity, laws, policies, and regulations) and provide support to address them.
- Move beyond thinking of transformation at the project level; adopt a portfolio or programmatic approach, and coordinate with other contributors.
- Identify the barriers and risks to private sector investment and tailor instruments to “crowd in, not crowd out” the private sector.

**A Planning Framework for Transformational Climate Finance for Recipient Governments**

Our framework for transformational climate finance (Figure 1) builds upon the critical elements for transformation identified in the case studies and lays out a sequence of steps for recipient governments:
1. Formulate the problem. This includes articulating the long-term goal and vision, identifying metrics for transformation, and examining barriers and potential drivers at different scales.

2. Engage with a wide array of stakeholders (government, private sector, and communities) and define the roles and responsibilities of the key actors.

3. Establish a stable enabling environment. While there should be flexibility to increase the ambition of policies to reflect advances in technology, costs, and scientific urgency, the enabling environment should remain stable to ensure investor confidence.

4. Align incentives by establishing low-carbon energy policy/regulatory and fiscal incentives, supporting research and development, and cutting fossil-fuel subsidies.

5. Develop pilot projects and test new financial arrangements, partnerships, and innovative instruments.

6. Build monitoring, evaluation, learning, and feedback into the problem formulation and strategic vision. By adopting a cyclical process, low-carbon energy deployment can scale up over time.

**Figure 1 | Planning Framework for Transformational Climate Finance for Recipient Governments**
I. INTRODUCTION: DEFINING LOW-CARBON TRANSFORMATION

According to the Intergovernmental Panel on Climate Change, the world must limit global warming to 2 °C relative to pre-industrial levels (IPCC 2014a) to avoid the worst impacts of climate change (World Bank 2012a). Realizing this limit will require massive reductions in GHG emissions, on the order of 40 percent to 70 percent below 2010 levels by 2050, and near net zero emissions by 2100 (IPCC 2014a). If the world is to have a likely chance of staying below 2°C warming, emissions in 2020 should not be higher than 44 GtCO₂e. Based on current trajectories, however, they are expected to be 52–54 GtCO₂e (median estimates) (UNEP 2014). Responding to the urgency and huge scale of the climate change challenge will require a fundamental transformation in our political, economic, social, and energy systems, in order to transition to a low-carbon energy world.

In economics, transformation typically refers to structural change in the relative importance of economic sectors as a country’s economy, society, and institutions modernize and as resources shift to more productive sectors and activities (Breisinger and Diao 2008). More broadly, transformation is generally considered a long-term fundamental shift in a system, whether political, economic, social, or biological (see Table 1). Transformations are typically viewed as multi-actor, multi-scale processes, where the change is highly non-linear (Box 1).

The word “transformation” is frequently used in the climate change context. For example, the Clean Technology Fund of the Climate Investment Funds seeks to “finance transformational actions” through a set of “transformational investments” in the power sector, transportation, and energy efficiency (CIFs 2008). The Green Climate Fund’s (GCF) Governing Instrument states that “the Fund will promote the paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change (GCF 2011).” The GCF defines the paradigm shift potential as the degree to which the proposed activity can catalyze impact beyond a one-off project or program investment. In this sense, paradigm shift is synonymous with transformation.

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**Table 1 | Some Definitions of Transformation**

<table>
<thead>
<tr>
<th>Definition</th>
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<tr>
<td>“A long-term process of change during which a society or subsystem of society fundamentally changes.”</td>
<td>Rotmans (2000)</td>
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<tr>
<td>“The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems)”</td>
<td>IPCC Special Report on Extreme Weather Events (2012)</td>
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<td>“(An) irreversible, persistent adjustment in societal values, outlooks and behaviors of sufficient ‘width and depth’ to alter any preceding situation.”</td>
<td>TRANsformative Social Innovation Theory (TRANSIT) project (2014)</td>
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<td>“A structural change that alters the interplay of institutional, cultural, technological, economic, and ecological dimensions of a given system. It will unlock new development paths, including social practices and worldviews.”</td>
<td>Wuppertal Institute (2014)</td>
</tr>
<tr>
<td>“Transformation is change that is profound, radical, and sustainable; change that fundamentally and indelibly alters the very nature of something.”</td>
<td>Robert Gass (2014)</td>
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We consider low-carbon energy transformation to have three characteristics or criteria:

- **Large magnitude impact.** There is a profound change in the energy sector in terms of the shift to low-carbon energy (as measured by installed capacity and/or net generation, for example) that may also have economy-wide impacts.

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MULTIPLE SCALES AND ACTORS

Transformations require not only shifts in technologies, but changes in policy and culture. Transformations are multi-level and occur at multiple scales. According to O’Brien and Sygna, transformation takes place in three nested spheres (Figure 2). At the center is the practical sphere, where technological innovation and behavioral change lead to measurable outcomes. In the middle is the political sphere, where financial, political, legal, social, economic, ecological, and cultural systems are changed. The outermost sphere is the personal, where deep-seated change in worldviews and values occurs. The nesting of these spheres is important—goals and targets are set in the practical sphere, enabling conditions are set in the political sphere, and individual and collective views of viable systems and solutions are set in the personal sphere. Changes in one sphere influence changes in others. By examining these interactions, it is possible to analyze the breadth and depth of transformations, and identify ways to influence transformations to ensure that they deliver the necessary goals.

Another framework for transformation, the multi-level perspective, distinguishes three levels in societal transitions:

- **Landscape (macro-level),** which includes political culture and coalitions, social values, worldviews and paradigms, demography, macroeconomic drivers, and the natural environment

- **Regimes (meso-level),** which include the social norms, interests, rules, and belief systems that underlie dominant organizations, institutions, and practices

- **Niches (micro-level),** which are protected spaces, and include R&D laboratories, subsidized pilot projects, and technology innovations

Transformation can occur when niche-innovations build momentum, through learning processes, price/performance improvements, and support from powerful groups, and interact with landscape-level drivers to put pressure on and destabilize the regime, creating windows of opportunity for further niche innovations.

Source: IPCC (2014b).
Three points merit emphasis. First, transformation is not the result of a single project; rather, it is the accreting effect of a portfolio of projects and actions over long periods of time that brings about transformation. Second, we are not speaking narrowly of a transformation in financial innovations for low-carbon energy, but how to use climate finance to catalyze transformational change.

Third, while large sums might be needed to catalyze low-carbon energy transformation, and international and domestic finance is needed at many stages in the process—from establishing enabling conditions to actual deployment of low-carbon energy technologies—transformation is a function of more than the quantity of finance.
II. LOW-CARBON ENERGY CASE STUDIES: WHERE HAS TRANSFORMATION OCCURRED AND WHY?

Globally, there are compelling early indicators of a societal shift toward low-carbon energy, which we define to include both renewable energy and energy-efficient technologies. Over the last decade, global installed capacity of solar photovoltaic (PV) and wind has increased almost exponentially (Figure 4). Investment in renewable energy increased sixfold between 2004 and 2014, and 2014 saw the installation of a record 95 GW in new wind and solar capacity (Frankfurt School-UNEP Centre 2015). In several countries, including some without compensatory support schemes, the cost of new onshore wind generation is now at cost parity with new coal- or gas-fired generation. This is the case in Australia, Brazil, Chile, Mexico, New Zealand, South Africa, Turkey, and much of the European Union, as well as in some Indian and U.S. states. For the last four years, investment in new renewable energy capacity has outpaced investment in new fossil-fuel capacity (REN21 2015). Some developing countries are installing renewable energy at almost twice the rate of developed countries (BNEF et al. 2014).

Figure 4  |  Solar PV and Wind: Total Global Capacity

In this section, we examine low-carbon energy case studies from nine countries. We initially conducted a literature review, drawing together 20 cases from developed and developing countries across all regions (Figure 5). We then sorted each case study into one of three categories:

- **Transformational**: cases where finance has been used for truly path-breaking, low-carbon energy development; where there has been a non-linear growth in low-carbon energy; and/or where successes have been scaled up and replicated.

- **Potentially transformational**: cases where finance has shown promise or early successes in catalyzing low-carbon energy development; where there has been positive change, but not in a dramatic non-linear sector-wide fashion; where there is potential scalability and replicability.

- **Missed opportunities or early stage development**: cases where initial promise has not led to transformational success, or cases where an initial failure has been turned around, but development is ongoing.

From the initial 20 case studies, we selected three from each category to analyze in depth (Table 2). We sought a balance between developed and developing country experiences, among regions, and among types of low-carbon energy development. Some of the case studies build on an earlier World Resources Institute (WRI) report, *Mobilizing Climate Investment* (Polycarp et al. 2013e). In selecting the cases for in-depth analysis, we have tried to showcase examples that have not received as much public attention as more prominent cases, such as Germany, China, and India.

Nine case studies cannot capture the full array of experience with low-carbon energy development; nonetheless, the cases presented here highlight key insights and important elements for transformational climate finance. For each case, we identify the interventions and analyze the drivers of transformation. We also consider the internal and external factors for success (or lack thereof), and any challenges for further transformational development.
Over the past eight years, Uruguay has seen a rapid transformation in its wind sector. The country had virtually no wind generation in 2007 but, by the end of 2014, nearly 500 MW of wind capacity had been installed, accounting for over 10 percent of electricity generation (Figure 6). Wind energy is now cost competitive and will displace the most expensive fossil-fuel generation. One GW of capacity is set to come online by the end of 2015 (Uruguay’s total installed power capacity across all sources is currently 3 GW) (BNEF et al. 2014). An initial $1 million grant from the Global Environment Facility (GEF), along with $6 million in national public co-financing, has laid the foundation for a wind energy market that is on track to reach $2 billion in private investment by the end of 2015 (Glemarec et al. 2012). Across all clean energy sources, Uruguay received $1.3 billion in investment in 2013 (BNEF et al. 2014), the largest share as a percentage of GDP of any country in the
world (REN21 2014), and it is adding the most wind capacity per capita globally (REN21 2015).

Uruguay’s wind development was driven by a desire to increase energy security. The country had relied heavily on hydropower, but with dry years between 1997 and 2007, hydro’s share of total electricity generation fell from over 90 percent to around 50 percent, necessitating an increase in fossil-fuel imports. By 2007, imported fossil fuels provided a third of generation (BNEF et al. 2014). In addition to import costs, the increased reliance on fossil fuels added to the fiscal burden of providing residential subsidies. Given the steadily rising electricity demand, diversifying energy sources was a prudent policy (Glemarec et al. 2012).

Regulatory reform created an enabling environment for renewable energy development. The GEF provided a $1 million grant to the UN Development Programme (UNDP) for the Uruguay Wind Energy Programme, which ran from 2007 to 2012 and focused on policy reform in Uruguay’s energy markets. The Wind Energy Programme supported the Government of Uruguay in creating a national policy on renewable energy that includes a reverse auctioning mechanism for large-scale renewable energy development and a feed-in tariff for small-scale systems. Regulatory reform allowed independent power producers to feed into the grid at a standardized price under the auction contracts, and introduced a “must-take” requirement for the state utility company, Usinas y Trasmisiones Eléctricas (UTE), to buy all wind power produced (Glemarec et al. 2012). Such requirements may be controversial among utilities but, as a publicly owned company, UTE aligned its business model with the government’s renewable energy policy priorities (GEF 2007). To encourage early development, generators received a higher price per MWh for projects that came online before 2015. By offering higher prices to early innovators, UTE was able to counteract one of the drawbacks of auctioning processes compared to feed-in tariffs: once contracts are won, incentives for speedy connection diminish (Glemarec et al. 2012). Uruguay’s regulatory reforms succeeded in bringing a large amount of wind online in 2014 (see Figure 6). The government established a 300 MW target for installed wind capacity by 2015, which was later increased to 500 MW, then increased again to 1.3 GW as the sector’s development exceeded expectations (Glemarec et al. 2012; REN21 2015).

Figure 6  |  Wind Power in Uruguay

Institutional capacity building helped to ensure effective policy design and implementation. UTE had no experience with variable generation; the GEF-UNDP project assisted UTE in developing a demonstration wind farm as a way of building technical expertise in the sector. Working with Universidad de la República, the project developed a renewable energy technology curriculum to train UTE staff (Glemarec et al. 2012).

The project included outreach to private sector stakeholders to address knowledge gaps and risk perceptions about the wind sector. UTE conducted workshops on wind assessments and facilitated meetings among industry leaders, developers, and financiers (Glemarec et al. 2012). Dialogues among stakeholders helped promote energy-market linkages between Uruguay, Brazil, and Argentina (Glemarec et al. 2012), with UTE working with the Brazilian state-owned utility Electrobras to develop wind projects along the shared border (BNEF et al. 2014).

The Uruguay case demonstrates how addressing regulatory barriers and creating a well-designed auction system can have a catalytic effect on investment in low-carbon energy development. Once these policies were in place, private investment in wind power flowed without further public finance.

Denmark – Wind

From 1995 to 2013, total installed wind-power capacity in Denmark increased by over 700 percent, with wind’s share in domestic generation rising from 3.5 percent to 32 percent (Figure 7) (Danish Energy Agency 2014). As of August 2015, Denmark had over 5,500 operating wind turbines with a total capacity of 5.0 GW (Danish Energy Agency 2015), and wind generation has exceeded 100 percent of Denmark’s electricity consumption on several occasions, breaking world records (Energinet.dk 2014). Denmark has the highest renewable energy capacity per capita in the world, and was also the first country in the world to install wind turbines offshore in 1991 (Danish Energy Agency 2009). The country remains a world leader in offshore wind, with 1.3 GW of capacity, second only to the United Kingdom (REN21 2015).

Denmark’s program to develop wind power originated in response to the 1970s global oil crisis. The government invested significantly in wind research and development (R&D); an Energy Research Programme was launched in 1976 and allocated around US$24.2 million over the subsequent decade for wind power. By 2009, government funding for wind R&D had reached US$25 million a year (Danish Energy Agency 2011). Today, Denmark has the sixth highest ratio of gross expenditure for wind R&D to GDP in the world, at 3.1 percent (National Science Board 2010).

Alongside R&D spending, Denmark embarked on a policy program that included energy-market reform and financial incentives for wind development. The government introduced a feed-in tariff in the 1980s, providing a guaranteed subsidy per kilowatt-hour of wind electricity generated. It also introduced renewable energy obligations in the late 1990s, mandating that electricity utilities develop over 1.6 GW of wind capacity. The 2004 Energy Policy Agreement cut subsidies, which stalled wind development for the next five years. However, after assessing the impacts of the cuts, the government increased the feed-in tariff in its 2008 Energy Policy Agreement, reinvigorating wind development. Since the 2008 policy shift, Denmark has added 250–300 MW of capacity each year (Figure 7) (Danish Energy Agency 2011). Since 2001, the feed-in tariff has been funded by a price supplement added to all electricity bills, known as the public service obligation. In 2009, the public service obligation raised $630 million, of which around a third went to wind subsidies (Danish Energy Agency 2011). While Danish household electricity prices are the highest in the European Union, Danish industrial electricity prices are below the EU average (Eurostat 2014).

The Danish government has accompanied price incentives with policy targets. The 2008 Energy Policy Agreement set a goal of renewable energy providing 20 percent of Denmark’s gross energy consumption by 2011. This aligned with the EU-wide target requiring 20 percent of energy consumption in 2020 to come from renewable sources; this target is shared differently among member states, with Denmark’s specific target being 30 percent by 2020 (Danish Energy Agency 2009). See Box 3 for more on EU member states’ varying progress on meeting their renewable energy targets. Denmark surpassed the 2011 target, with 23.6 percent of energy consumption coming from renewable energy (Danish Energy Agency 2009) and, in 2012, the new government announced a more ambitious target of 35 percent of final energy, with 50 percent of electricity consumption to be supplied by renewable energy by 2020 (Energinet.dk 2014). The government has also set a long-term goal of becoming completely independent of fossil fuels by 2050 (KEBMIN 2011).
Strong institutions and streamlined planning processes have helped to create a favorable environment for wind development. Starting in 1994, the government required all municipalities to technically map and designate land where wind development would be permitted and, in 2008, required each municipality to set aside areas to accommodate 150 MW of wind capacity. Planning decisions for smaller wind turbines up to 150 meters high are devolved to municipal governments and, since 2010, a Wind Turbine Secretariat has supported municipalities with the planning process. Offshore wind is the responsibility of the Danish Energy Agency, which publishes technical maps designating sites suitable for offshore development, and liaises with other authorities to streamline the process for attaining approvals and licenses. This has reduced transaction costs for developers and removed many barriers to offshore wind development (Danish Energy Agency 2009).

Denmark has taken decisive steps to ensure grid access for wind. The transmission grid is entirely owned by Energinet.dk, a public company controlled by the Ministry of Climate and Energy. This has allowed grid expansion and upgrades to align with the national energy policy to promote wind. Most onshore wind is connected directly to the local distribution grid, with distribution system operators required to share the costs with developers. Grid connection of offshore wind is entirely financed by Energinet.dk and passed on to the consumer through electricity bills (Cochran et al. 2012). Denmark has one of the fastest grid connection procedures for wind in Europe, with an average lead-time of 2.1 months compared to the EU-wide average of 25.8 months (EWEA 2010).

Denmark’s experience with wind has not been without problems, some of which are unique to a country with an unprecedentedly high share of renewable generation. As the size and cost of wind turbines have increased, so too has public opposition, although such voices remain a minority. In response, the 2008 Renewable Energy Act included provisions to address community concerns and to encourage local participation and ownership in the wind-development process. The reforms mandate that local citizens are offered at least 20 percent equity in new
wind developments, require commercial developments to channel a portion of the revenues into funds that invest in community projects, and provide government grants for community groups wishing to conduct initial scoping work for renewable energy development (Danish Energy Agency 2009). Community ownership of renewable energy projects has been found to yield strong economic benefits, with operations-period employment impacts that are 1.5 to 3.4 times higher for community-owned wind projects compared to absentee projects (Lantz and Tegen 2009). An estimated 15 percent of Danish wind turbines are now owned by co-operatives (Energinet.dk 2009).

Another challenge for countries in an advanced stage of wind development, such as Denmark, is the need to replace old and inefficient turbines, which can take up land with prime wind conditions. In 2001, the Danish government introduced a scrapping scheme to encourage modernization. Small, older wind turbines with a capacity of up to 150 kW were eligible for a scrapping certificate guaranteeing an additional subsidy for replacement turbines installed within an eligible period. The scheme covers 174 MW-worth of turbine capacity, providing certificates for up to 350 MW in new wind development (Danish Energy Agency 2009).

Lastly, integration of wind energy becomes more technically difficult and costly at higher shares. Grid integration involves three types of costs: extending and reinforcing transmission lines, balancing the increased volatility of supply, and maintaining enough residual generation to cover peak demand times (Cochran et al. 2012). So far, Denmark has been able to keep integration costs low, between €1.4–€2.6 ($1.8–$3.4) per MWh in western Denmark, the area with the greatest concentration of wind generation (24 percent) (Holttinen et al. 2009). These costs are small as a proportion of overall wholesale price, and subtract less than 5 percent from the assessed benefits of adding wind generation. Integration is made possible by strong grid interconnections and electricity market integration with neighboring countries, which allows Denmark to export electricity during high wind output and to import during periods of low output. The use of combined heat and power plants fitted to generate heat with electricity when wind generation is high, and the introduction of negative pricing in 2009 as an incentive for generators to control oversupply, also enhance integration (Cochran et al. 2012). With Denmark looking to reach 50 percent renewable-electricity generation by 2020, and with neighboring countries increasing their shares of variable renewable energy, grid integration remains a challenge. Energinet.dk is investigating additional means to cost-effectively integrate greater wind penetration, including through additional interconnections, use of storage and electric vehicles, and deployment of smart grids to better match supply and demand (Cochran et al. 2012; Eriksen and Orths 2008).

**Substantial investment enabled Denmark’s wind transformation.** This included investment in research and development; policies to establish clear targets, provide financial incentives, and empower local communities to have ownership of wind development; and enhancing the grid system to manage increasingly high shares of renewable energy. The price certainty of the feed-in tariff provides developers with stable revenue for long-term investments in wind power. Mandatory mapping and designation of wind-development areas and streamlined planning processes have removed investment barriers. Incentives for community ownership have helped to increase local support for wind development and ensure that benefits are more equitably shared. By demonstrating the technical and economic feasibility of high levels of renewable energy integration, Denmark has helped pave the way for other countries.

### Portugal — Renewable Energy

Portugal has seen a massive scale-up in renewable energy over the past decade. In 2000, the percentage of non-hydro renewable energy generation in the electricity mix was less than 5 percent; by 2012, it had increased to more than 30 percent (Figure 8). In 2014, all renewable energy sources (including large hydro) provided 49 percent of total electricity consumption (REN21 2015).

Portugal has few domestic fossil-fuel reserves; its desire for energy independence and reduced reliance on expensive fuel imports provides an impetus for renewable energy growth (Reiche and Bechberger 2004). To guide development, the government set successive targets for renewable energy. A 2003 resolution established a target of 3.7 GW of wind capacity by 2010, with a further target set in 2005 for 5.1 GW by 2013, both of which were exceeded. The 2009 EU Renewable Energy Directive mandates that 31 percent of Portugal’s final energy consumption comes from renewable sources by 2020 (EU 2009). Portugal’s National Renewable Energy Action Plan,
required by the EU directive, set a complementary renewable electricity target of 60 percent of total consumption by 2020 (Government of Portugal 2010).

Portugal introduced a feed-in tariff for renewable energy in 1988. The government has continually assessed its effects and modified it as needed. It has increased the tariff rate several times, adjusted the price guarantee period, and differentiated by renewable energy type (Proença and St. Aubyn 2013). The feed-in tariff design is an innovative combination of a fixed component to reflect the avoided investment in conventional capacity, a variable component per kWh of electricity generated to reflect the avoided power generation costs of conventional power plants, and a component to support the environmental benefits based on the costs of CO₂ emissions avoided by substituting renewable energy for conventional generation, as well as different tariff levels for day and night generation. Tariffs for existing renewable energy plants are updated every year to account for inflation, and tariffs for new developments are revised when national technology-specific capacity targets are met (Klein et al. 2010).

To limit the government’s fiscal obligation, payments to renewable energy owners are limited based on production of energy, as well as a temporal restriction of 15 years. The feed-in tariff has been successful as an incentive for wind development. In 2001, the increase in the feed-in tariff for wind led to development applications for 7 GW of capacity, exceeding targets not only for renewable energy development, but also for grid capacity, so not all proposals could be approved. In an effort to ensure community support for renewable energy, 2.5 percent of income from wind production must go to the local municipality (Government of Sweden 2008).

Government modernization of the grid has been instrumental to the success of renewable energy in Portugal. In 2000, after longstanding underinvestment, the Government bought out all the private transmission line owners, creating a single national grid and investing in transmission infrastructure upgrades to enable large-scale renewable energy. Since 2007, the grid has been owned by a publicly traded company, subject to ownership regulations that prevent private utilities from regaining a controlling

Figure 8  |  Renewable Energy in Portugal

share (Rosenthal 2010; IEA 2009a). Grid development plans are issued every two years. Grid expansion and upgrade have been assisted by a law that allows expropriation of land for grid infrastructure if public benefit can be proved. Project developers are required to pay all costs for grid connection, while the cost of upgrading the transmission grid is financed through the standard electricity tariffs paid by consumers (Government of Sweden 2008). This has avoided a situation where grid infrastructure is an underfunded public good, which has been the constraining factor for utility-scale renewable energy development in a number of countries, such as Brazil and China (Barua et al. 2012; REN21 2015). Portugal’s transition to renewable energy has been possible without tax increases or public debt thanks to the fuel cost savings, and both household and industry electricity prices remain around the European weighted average (Eurostat 2014).

**Portugal illustrates the successful use of an innovative feed-in tariff design to encourage the expansion of renewable energy. It also demonstrates the importance of accompanying policies to ensure that transmission and distribution are also upgraded to handle variable renewable energy capacity, given that private grid operators may lack sufficient incentives to invest in modernization.**

**Potentially Transformational**

**Thailand – Energy Efficiency**

Over the past two decades, Thailand has made progress in its energy efficiency (Figure 9). Between 1993 and 2000, the country reduced peak demand by 566 MW and achieved cumulative annual energy savings of 3,140 GWh—more than double the government’s initial target (Mulholland and Singh 2000). By 2012, peak demand had been reduced by an estimated 2.6 GW, with 15,700 GWh of cumulative energy savings, equivalent to about 11 percent of net electricity consumption in 2011. At the same time, the population with access to electricity has increased from 93 percent in 1990 to almost 100 percent by 2010 (World Bank 2014). Energy intensity, measured as the amount of energy used per unit of GDP, has remained at roughly the same level for more than two decades.

In the face of rapidly rising energy demand in the early 1990s, the Thai government prioritized energy conservation as the lowest-cost approach to addressing energy needs. In 1991, the government launched a Demand Side Management (DSM) Plan to control growth in electricity consumption and promote energy-efficient technologies and services. The program was supported by a $9.5 million grant from the GEF, a $6 million grant from Australia, and $25 million in concessional loans from the Overseas Economic Cooperation Fund of Japan. The plan originally intended to mirror U.S. DSM approaches by using rebates, but was adapted to fit the national context after early assessments found that, in Thai culture, financial incentives might be perceived as inequitable. As a result, the plan focused on voluntary negotiations with manufacturers to improve efficiency, consumer marketing campaigns, and bulk purchase and distribution of high-efficiency products (Mulholland and Singh 2000).

The government passed an Energy Conservation Promotion Act in 1992, mandating energy efficiency requirements for industry and creating the Energy Conservation Promotion Fund (UNEP 2006). This fund is responsible for financing energy efficiency programs in factories and buildings, and is funded through a dedicated sales tax on petroleum products that raises around $50 million a year (Grüning et al. 2012). The tax has a dual benefit: it discourages fossil-fuel use and encourages emissions reductions through energy-saving measures. Thailand exceeded the targets of the first phase of the DSM plan—to reduce peak demand by 238 MW and achieve cumulative energy savings of 1,427 GWh by 1998—and by the year 2000 it had achieved more than double these goals (Mulholland and Singh 2000). The second phase, from 2000 onward, was funded by the Energy Conservation Promotion Fund and the national Electricity Generating Authority, without international support, illustrating the initiative’s financial sustainability (UNESCAP 2010).

In 2002, the Department of Energy was promoted to a full Ministry, further emphasizing the political importance of energy efficiency policies (Polycarp et al. 2013). The same year, the government set up an Energy Efficiency Revolving Fund, financed by the Energy Conservation Promotion Fund, to provide credit to banks for concessional loans to energy efficiency projects for industry and buildings. By 2012, the Energy Efficiency Revolving Fund had provided $220 million to 294 projects, with estimated annual energy cost savings of $165 million. The Energy Efficiency Revolving Fund has reduced private banks’ risk perceptions for financing energy efficiency, leading to their increased willingness to take on more of the financing costs (Grüning et al. 2012). As a result, the fund is now able to leverage two dollars of private investment for every dollar of Energy...
Efficiency Revolving Fund finance (Wang et al. 2013; Polycarp at al. 2013). Following these successes, in 2011, the government published a 20-year energy efficiency development plan, committing $560 million in investment from the Energy Conservation Promotion Fund over five years and aiming to reduce energy consumption by 20 percent by 2030 (Polycarp et al. 2013).

To support these energy efficiency programs, which are largely domestically financed, Thailand has made strategic use of international support for institutional capacity building, technical assistance, and readiness activities (Polycarp et al. 2013). After publishing the DSM plan in 1991, the government created a designated office in the Electricity Generating Authority to develop, implement, and evaluate national DSM measures. In 1992, the government embarked on intensive staff and management training programs to strengthen the capacity of the Department of Energy Development and Promotion (Meyer et al. 2009; Polycarp et al. 2013). The government used long-term expert advisors to provide technical support in specific areas where there was a dearth of expertise, rather than relying on short-term consultants, resulting in cost savings and more effective knowledge transfer (World Bank 2000).

Thailand’s petroleum tax is an elegant financing solution because it not only raises capital for energy efficiency measures, but also helps to address price distortions that encourage high energy use. The Energy Efficiency Revolving Fund has also provided a sustainable source of financing, yielding annual energy savings by an order of magnitude greater than the initial investment. Thailand has channeled international support to institutional capacity building, which has helped to ensure that energy efficiency programs are implemented in an effective and sustainable way. However, while energy intensity has held level, the Thai economy has been unable to decouple GDP growth from energy consumption.

Figure 9  |  Energy Efficiency in Thailand

Bangladesh – Solar Home Systems

Bangladesh has the fastest growing off-grid solar PV home system program in the world. Launched in 2003, with a target of installing 50,000 systems over five years, it was soon installing this number each month. From 2012 to 2013, three quarters of a million units were installed (Figure 10) and, by early 2014, the program had installed a cumulative three million systems. Uptake of solar home systems has increased per capita income by 9 to 12 percent, per capita expenditure by 4 to 5 percent, and household ownership of durable goods by 23 to 27 percent. The estimated nationwide reduction in carbon emissions due to switching from kerosene lamps to solar home systems is 160,000 metric tons a year (Khandker et al. 2014).

Bangladesh embarked on the solar home system program to help achieve its Millennium Development Goals by expanding energy access. Only 42.5 percent of rural households are grid-connected and, even with connectivity, peak demand often exceeds supply, leading to frequent and lengthy power outages. Bangladesh’s national strategy includes a goal of ensuring universal access to electricity by 2021 (Khandker et al. 2014).

Figure 10  |  Solar Home System Installations in Bangladesh

The household solar PV systems are small—between 20 and 120 watts peak (Wp) capacity. A 50 Wp system can power four lights, a mobile phone charger, and a television. With a market price of $400 for a 50 Wp system, they are also relatively inexpensive. The systems have been made affordable to low-income rural households through a unique combination of subsidies and concessional loans offered through local microfinance institutions, such as Grameen Shakti. This has addressed credit risk and affordability, allowing the program to scale up rapidly. The subsidy is fixed at $25, meaning that poorer households, in effect, receive greater proportional support because they tend to opt for smaller systems where the subsidy covers a greater portion of the cost. A refinancing facility allows the microfinance institutions to refinance 70–80 percent of the loans made to consumers from a Ministry of Finance-owned company, Infrastructure Development Company Ltd., at favorable rates. This provides long-term access to finance and liquidity to the lenders, while reducing consumers’ monthly payment and the risk of default (Khandker et al. 2014).

The current phase of the program, running from 2012 to 2018, costs $386 million. Around half of this comes from domestic resources: the Government of Bangladesh, local microfinance institutions, and household down payments for the systems (World Bank 2012). External funding has come from the World Bank’s Global Partnership on Output-Based Aid, the Asian Development Bank, Islamic Development Bank, the Global Environment Facility, and several bilateral contributors (Khandker et al. 2014).

The ownership model has resulted in better upkeep by participating households compared to leasing, and the affordable loan terms mean average collection efficiency is 94 percent (World Bank 2012). The program has been cost-effective: the subsidy cost is small compared to grid extension and is gradually decreasing, falling from 25 percent of the average unit price in 2004 to 10 percent in 2012. Cost-benefit analysis has shown the social benefits far exceed the subsidy cost (Khandker et al. 2014). In 2010 the program was also adapted to promote energy efficiency by supplying over 10 million compact fluorescent lamp bulbs across the country, which had the effect of stimulating the domestic manufacturing industry, although the quality of initial production was poor (World Bank 2012).

The welfare effects of solar home system adoption compare favorably with grid-based electrification initiatives. They have helped to meet rural electricity needs.
needs for lighting, fans, televisions, mobile phones, and other electrical equipment. By replacing kerosene lamps, solar home systems have reduced indoor air pollution, providing associated health benefits, especially for women. Other lifestyle improvements include extending waking and working hours, which has increased the evening study time of schoolchildren, as well as improving access to information through TV and radio, and enhancing security (Khandker et al. 2014). The rollout of the solar home system program is estimated to have created 115,000 jobs in sales, installations, and maintenance (REN21 2015).

Though it exceeds initial expectations, the solar home system program covers only 10 percent of off-grid households in Bangladesh, leaving scope for expansion. Indeed, Infrastructure Development Company Ltd. has set a target to install a further three million systems, to bring the total to six million systems by 2016. In addition to phasing down the subsidy, it is working to promote a more competitive market by differentiating refinancing terms for the implementing microfinance institutions so that smaller organizations benefit from more favorable conditions. Over time, the aim is to transition the program toward full commercial financing by increasing refinancing interest rates and reducing tenures. In addition, there is a need to ensure that, as the program expands, growth does not compromise quality, which could negatively impact market sustainability. Enforcing regulations on hardware standards, better training of end users, and improving customer service can all help build confidence in and demand for solar (Khandker et al. 2014).

Bangladesh has effectively combined consumer subsidies and concessional microloans to make small-scale solar installations affordable for millions of rural households. Providing off-grid electricity access has been far quicker and cheaper than grid expansion, and is demonstrating a new, potentially transformational model of energy ownership. With many households still lacking electricity, the challenge is to continue expanding the program while making it more sustainable (reducing international support, reducing subsidies, and moving toward commercial financing), maintaining affordability for the poorest, and increasing the quality and reliability of hardware.

Tunisia – Solar Water Heaters

Tunisia’s Programme Solaire (Prosol) scheme transitions households away from fossil-fuel powered water heaters to solar water heaters. Since launching in 2005, Prosol has scaled up installations from 7,000 square meters (m²)/year to 80,000 m²/year by 2008 (Figure 11) (Baccouche 2013). By 2010, over 119,000 solar water heater systems had been installed, covering around 355,350 m². The reduced energy demand over the lifetime of the heaters installed between 2005 and 2010 is expected to be more than 250 kilotonnes of oil equivalent (ktoe). The associated fall in demand for fossil-fuel subsidies will result in a net gain for the public budget of $101 million—five times the government’s investment of $21.8 million. The Prosol scheme has created 3,000 direct jobs in installation and maintenance (Trabacchi 2012). Annual avoided carbon dioxide emissions from Prosol were estimated at 90,000 metric tons in 2010, and projected to reach 185,000 metric tons by 2016 (Baccouche 2013).

Figure 11  |  Solar Water Heater Installations in the Tunisian Residential Sector

Source: Adapted from Baccouche (2013).
Tunisia has been exploring the potential of renewable energy technologies to reduce its dependence on fossil fuels since the 1980s. It developed a solar thermal strategy in 1984 and established the National Energy Management Agency in 1985. In the 1990s, the government introduced laws and fiscal incentives for solar thermal deployment, but equipment quality and maintenance issues limited uptake (Polycarp et al. 2013b). In 1996, with support from the World Bank, the National Energy Management Agency introduced a 35 percent capital cost subsidy for solar water heaters, first for commercial users, then for households. The project successfully spurred adoption, with 50,000 m² of new solar water heaters installed, but the growth was not financially sustainable. When project funding ended in 2002, demand collapsed (World Bank 2004).

In 2005, informed by lessons learned from previous efforts to stimulate the solar water heater market, the Tunisian government launched Prosol. Targeting residential customers, Prosol provided a 20 percent capital cost subsidy for solar water heaters. Lack of consumer credit had hampered previous solar water heater initiatives; Prosol overcame this barrier by authorizing the state utility to collect loans through electricity bills. This arrangement allowed for longer repayment times and softer credit conditions for households, and reduced transaction costs for lenders. The program included a temporary interest rate subsidy designed to encourage households to apply for credit, creating a critical mass of loans to demonstrate to banks that solar water heaters were a viable credit prospect. The interest rate subsidy was phased out over 18 months (Polycarp et al. 2013b).

In the second phase of Prosol, launched in 2007, the state utility provided loans directly to households, replacing the solar water suppliers who had provided loans in the first phase. This arrangement was a more suitable way to apportion risk given the electricity utility’s power to enforce repayments. Prosol has a near-zero default rate, helping to ensure profitability. In 2009, the government reformed the subsidy to make the scheme more affordable for low-income households: rather than a percentage-based subsidy, Prosol offered consumers a $150–300 payment, depending on the size of the system. The National Energy Management Agency successfully addressed implementation challenges by coordinating and engaging local and international stakeholders. A training program and accreditation scheme for suppliers and installers, certification and performance labeling for solar water heaters, supplier component guarantees, and after-sale maintenance contracts have helped reduce technology failure rates to approximately 1 percent (Trabacchi et al. 2012).

The success of Prosol Residential led to the launch of solar water heater programs for the tertiary and industrial sectors in 2008 and 2009, respectively, and Prosol Elec for small-scale household solar PV systems in 2010 (Trabacchi et al. 2012). In 2009, the government launched the Tunisian Solar Plan 2010–2016, a public-private partnership to promote renewable energy through 40 projects representing over $2.2 billion in investment, including scaling up Prosol. The plan included targets for generating 16 percent of electricity from renewable energy and reducing energy consumption by 25 percent, as well as a target for installing a total of 900,000 m² of solar water heaters, by 2016 (Trabacchi et al. 2012).

Prosol was supported by a $2.2 million loan from the Italian Ministry of the Environment and Protection of Land and Sea and technical support from UNEP’s Mediterranean Renewable Energy Program Finance Initiative. The Tunisian government created a National Fund for Energy Conservation in 2005 to provide a steady stream of domestic funding for renewable energy and energy efficiency, funded by revenues from motor vehicle registrations and customs duties. Through the fund, the government provided $21.8 million in grants to cover the capital cost subsidy for the solar water heaters. Between 2005 and 2010, investment in Prosol totaled $134 million, of which public funding accounted for 18 percent—a leverage rate of $5 of private investment for every $1 of public money. Analysis by the Climate Policy Initiative suggests that in a Tunisian energy market absent all subsidies—for renewable energy or fossil fuels—investments in solar water heaters would offer higher returns than investments in fossil fuels. Efforts to reduce the fossil-fuel subsidies would therefore also enhance the financial viability of Prosol (Trabacchi et al. 2012).

Tunisia’s Prosol scheme shows that targeted subsidies can effectively scale up renewable energy adoption and support sustainable financing models. By shifting demand away from fossil fuels, it can result in net savings for the public budget. However, persistent use of fossil-fuel subsidies continues to stack the deck against renewable energy, and means that solar water heaters still require subsidy support; efforts to reduce fossil-fuel subsidies would therefore reduce the public financing burden on two fronts. Solar water heater installations dropped in the wake of the 2011 revolution, and it remains to be seen whether past success in deployment will continue in post-revolution Tunisia.
**Missed Opportunities or Early Stage Development**

**South Africa – Renewable Energy**

South Africa struggled for many years to develop a coherent policy to promote renewable energy. Its 2003 White Paper on renewable energy set a goal of 10,000 GWh of renewable energy generation by 2013, but policy implementation was slow and poorly coordinated, and development stagnated throughout the 2000s (Polycarp et al. 2013a). By 2012, non-hydro renewable electricity generation stood at just 446 GWh (Figure 12). Renewable electricity capacity is just 511 MW out of a total installed power capacity of 43 GW (BNEF et al. 2014).

South Africa is one of the leading global producers of coal, and coal dominates the domestic electricity market, keeping prices low and making it difficult for renewable energy to gain a competitive foothold. In addition, the South African state-owned utility company, Eskom, has a monopoly on electricity generation and transmission and little incentive to develop renewable energy itself or allow other developers into the market. Lastly, the regulatory environment did not encourage renewable energy development, and the government had limited technical capacity in designing and implementing renewable energy policies.

The 10,000 GWh target in the 2003 White Paper set an overarching goal for renewable energy development, but whether the target was annual or cumulative was unclear and supporting policies were inconsistent (Eberland et al. 2014). In 2009, the National Energy Regulator of South Africa approved guidelines for a feed-in tariff for renewable energy but, soon after, the newly formed Department of Energy announced that new renewable energy generation would be procured through an auction process, sending mixed signals about the government’s preferred approach (Trollip and Marquard 2014).

In an effort to limit Eskom and the National Energy Regulator’s roles in electricity planning, and to open development to new actors, the government proposed an inte-

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**Figure 12 | Renewable Energy in South Africa**

![Graph showing renewable energy in South Africa from 1995 to 2011](image)

- Non-hydro renewable electricity generation
- Renewable energy percentage of total electricity generation

*Source: EIA (2014).*
grated resource planning process for the power sector. The Department of Energy published the Integrated Resource Plan in December 2009. Rather than elaborating how South Africa could meet its climate mitigation goals, the plan focused on commissioning new coal generation and failed to account for the falling cost of renewable energy technologies. Following negative reaction and pressure from civil society and the private sector, the Department of Energy launched a broader stakeholder consultation, leading to the release of a “Policy Adjusted Integrated Resource Plan” in 2011 (Pienaar and Nakhooda 2014). The updated Integrated Resource Plan 2010–2030 included a more ambitious renewable energy capacity target of 17.8 GW by 2030, equivalent to 9 percent of projected energy generation, compared to 11.4 GW in the previous version, and provided technology-specific targets (Government of South Africa 2011). The total estimated investment required to meet these targets is $36 billion, of which $8–8.9 billion would be the incremental costs of pursuing renewable energy instead of conventional sources (SARI 2011). The Integrated Resource Plan is intended to be a living document, with updates due every two years.

In order to meet the Integrated Resource Plan targets, the government officially abandoned the feed-in tariff approach and, in 2011, launched the Renewable Energy Independent Power Producer Procurement Program, which established reverse auctions with a goal of installing 3.7 GW in new renewable electricity capacity over seven rounds of tenders. A specialist Independent Power Producer (IPP) Unit was established, bringing together technical staff from the Department of Energy and the National Treasury’s Public Private Partnership Unit, to manage the process (Bouille et al. 2015). The new approach has galvanized investment in renewable energy, with $14 billion committed since 2012, compared to only $600 million in the preceding six years (Eberland et al. 2014; BNEF et al. 2014). Sixty-four projects have been awarded and will add 3.9 GW in renewable electricity capacity by 2016 and 6.3 GW by 2017. Auction prices have fallen across the three bidding phases so far, with the average solar PV tariff falling by 68 percent and the average wind tariff decreasing by 42 percent (Eberland et al. 2014). In light of the rapid success of the auction process, the 2013 Integrated Resource Plan update recommends continuing procurement with additional annual auction rounds of 1 GW photovoltaic capacity, 1 GW wind capacity, and 2 GW Concentrated Solar Power (CSP) capacity (Eberland et al. 2014; BNEF et al. 2014).

International support has assisted with capacity building and implementation of the Independent Power Producer program. The World Bank and the GEF provided a $6 million grant for advice on policy reform and the design of financing mechanisms as part of its Renewable Energy Market Transformation project, as well as supporting renewable energy resource mapping and feasibility studies. Domestic support was also vital, with the National Treasury providing sovereign guarantees to the program, and the Development Bank of South Africa supplying $5 million for consultants and staff training (Martin and Winkler 2014; SARI 2011).

South Africa illustrates how policy uncertainty and lack of institutional leadership can hinder the development of renewable energy early on. However, over the past five years, institutional and policy changes, in particular the adoption of the IPP auctioning system and the creation of a specialized IPP Unit in the Government, have changed the situation dramatically and have helped to scale up private sector investment in, and deployment of, renewable energy in the country.

Spain – Solar Photovoltaic

Spain’s feed-in tariff system successfully drove rapid and large-scale renewable energy development. This generous subsidy support, combined with falling global solar technology costs, caused solar PV capacity to jump from just over 600 MW in 2007 to more than 3.3 GW in 2008 (Figure 13) (IEA PVPS 2014). Concentrated solar power has also seen rapid growth, with 2.3 GW installed since 2007. However, since 2013, growth of both technologies has slowed almost to a complete standstill, with only 6 MW of solar PV capacity installed in 2014, and no new installation of concentrated solar power (EIA 2014; REE 2014).

Spain began promoting renewable energy in 1997, with the introduction of the Electricity Sector Law, which set up a regime providing a preferential price and tax incentives for renewable energy and cogeneration. Solar developers could choose between a fixed feed-in tariff, adjusted annually, or a fixed feed-in premium. Solar deployment was low and, in response to criticisms from developers that annual revisions meant that the system did not provide sufficient predictability, reforms in 2004 and 2007 attempted to provide more favorable incentives and greater certainty. Tariff rates were set for four years, a medium-term Renewable Energy Plan for 2011–2020 was developed, and the feed-in premium for solar PV was scrapped so that all installations received the more stable feed-in tariff.
While there was a cap on support for solar installations, and eligibility limits for installations above annual targets, the system failed to include mechanisms to reduce the tariff in line with changing costs and efficiency of technology. Moreover, it did not compensate for fluctuations in exchange rates, which made imported hardware cheaper, or other market shifts that increased access to credit. Because solar PV, unlike wind and concentrated solar power, is a modular technology that can be installed quickly, developers were able to respond to changing market conditions (e.g., falling cost of PV panels, cost of capital, currency fluctuations) faster than policymakers could make necessary reforms. Developers also exploited loopholes in the law, pushing tariff payouts much higher than anticipated. For example, the 2007 reform increased the tariff by 82 percent for installations between 100 kW and 10 MW, with the aim of encouraging investment in mid-sized facilities, which were more expensive to operate. However, developers quickly disaggregated larger planned projects into medium ones grouped close together in order to benefit from the higher rate, undermining the policy objective of encouraging smaller facilities. When it became clear that installations would exceed the annual target and trigger a review of tariff rates, investors rushed to complete installations, exaggerating the boom in installations in 2008. Tariffs were indeed revised downwards, causing installations to crash in 2009, with less than 50 MW installed (del Rio and Mir-Antigues 2014).

Beyond poor feed-in tariff design, electricity utilities were challenged by a broader problem of limited ability to finance investment in new generation capacity—renewable energy or otherwise—due to restrictions on consumer rate rises. Price regulation can be an important way of ensuring equitable energy access in liberalized energy markets. But, by 2011, prices in real terms had remained unchanged since 1996, despite the rising costs of generation. Unable to pass on these costs to consumers, utilities resorted to debt financing to plug the so-called “tariff deficit,” but this became unsustainable with the onset of the global financial crisis. By 2012, the tariff deficit stood
at €29 billion, around 3 percent of Spain’s GDP. The financial crisis also compounded the problem by causing a drop in electricity demand, meaning there was excess capacity still legally entitled to subsidy support (del Rio and Mir-Antigues 2014).

In an attempt to reassure markets and bring costs under control, the government provided sovereign guarantees for electricity utilities’ debt and took measures to prevent it from increasing. Reforms in 2008 limited support for new solar installations, and in 2010 the government introduced changes for existing developments, including capping the annual number of hours eligible for feed-in tariffs and limiting feed-in tariff payments to 25 years rather than the life of the project. Such retroactive changes threatened the financial viability of existing installations, and have been subject to legal challenges (del Rio and Mir-Antigues 2014). In 2012, the government introduced a moratorium on support for all new renewable energy developments while new regulations were developed. This curtailed even the modest growth in solar PV after 2009 and halted concentrated solar power development, which had continued despite earlier reforms thanks in part to a premium on top of feed-in tariff rates. No new concentrated solar power plants have been announced in Spain since 2010, and there has been no new investment in the sector since 2012 (Frisari and Feás 2014). In 2013, the feed-in tariff was replaced altogether with a dual subsidy scheme providing a return on investment, calculated on the basis of installed capacity, to cover “the investment costs of a typical installation that cannot be recovered from the sale of energy,” and a return on operation, calculated on the basis of the average interest of a 10-year sovereign bond plus 3 percentage points (KPMG 2014).

Spain is a stark example of the problems associated with poor subsidy design. Solar power price incentives did not include gradual phase-down mechanisms, and did not identify sustainable financing. The retroactive changes that attempted to bring costs under control hurt the financial performance of many existing solar projects and caused investment in new developments to dry up. Though a new support system was introduced in 2013, the methodology for calculating the investment costs subsidy remains unclear, and appears unlikely to restore certainty to a market suffering from severe lack of investor confidence.

Indonesia – Geothermal Energy

Located in the “Ring of Fire,” a region of high tectonic activity, Indonesia has the world’s largest geothermal power potential, estimated at approximately 27 GW (IEA 2008). This is equivalent to over half the country’s total power capacity, which currently stands at 46.8 GW (BNEF et al. 2014). However, progress in developing geothermal resources has been slow, with only 1.4 GW installed capacity in 2014, less than 5 percent of the total potential (REN21 2015). Geothermal energy provided 9.42 TWh of energy in 2013, around 5 percent of the electricity mix (Figure 14) (BNEF et al. 2014).

Indonesia began exploring geothermal power in the 1970s, using support from the United States, Italy, Japan, and New Zealand to conduct a resource assessment, which found significant potential. New government policy enabled the state-owned oil company, Pertamina, to partner with private companies to develop geothermal facilities. By the 1990s, 527 MW of capacity had been installed, with contracts for a further 3 GW of development. However, this nascent development was set back by the 1997 Asian financial crisis, which led to the suspension and cancellation of several geothermal contracts.

The government passed a law on geothermal energy in 2003 in an attempt to revive the sector. It set a target of 6 GW of installed capacity by 2020, and allowed private developers to bid competitively for geothermal contracts without having to operate jointly with Pertamina. However, implementing regulations were not passed until several years later. Furthermore, the law failed to set an overarching framework for pricing, so power-purchase agreements had to be negotiated on a case-by-case basis with Perusahaan Listrik Negara, the national utility, which had no obligation to buy renewable energy. These problems were compounded by a lack of specific information on geothermal resource potential, creating risks for both private developers and Perusahaan Listrik Negara, because the law required both to commit before knowing whether the project would deliver sufficient power (Polycarp et al. 2013c). Entry requirements for companies to participate in the tender process were too lenient and many bids for geothermal development set unrealistically low prices, resulting in many projects getting stalled (World Bank 2015).
One of the major market distortions holding back geothermal development in Indonesia is the use of fossil-fuel subsidies (Box 2). Given low fossil-fuel prices throughout the 2000s, the government looked to conventional energy, primarily coal, to meet rising demand for electricity. In 2006, it introduced a fast-track electricity procurement program for 10 GW of coal power. However, in 2008, a second fast-track program aimed for a further 10 GW electricity capacity, but with 60 percent coming from renewable energy, including 4.8 GW of geothermal (Polycarp et al. 2013c). A new Energy Law was passed in 2007, establishing a target of 17 percent of primary energy consumption from renewable energy by 2025, of which 5 percent should come from geothermal (ARES 2013).

In the last five years, the government has shown greater leadership in promoting geothermal. In 2009, it established a ceiling price for geothermal electricity, providing increased price certainty for developers—a critical requirement given the high upfront capital required for geothermal development. In 2011, the government introduced a power-purchase obligation that required the national utility to buy power produced from geothermal plants. Further revisions in 2012 allowed the feed-in tariff to vary depending on the region, with the aim of better tailoring support to the local cost of production (Polycarp et al. 2013c).

In another effort to mitigate risk for geothermal developers, the Ministry of Finance, with technical support from KfW (German Development Bank), ADB (Asian Development Bank) and JICA (Japan International Cooperation Agency), established a Geothermal Fund Facility in 2012, with $200 million in public funding for initial geothermal exploration work. The aim is to encourage developers to undertake exploratory drilling, which will increase the information available to government and developers so they can negotiate more effective geothermal contracts (Polycarp et al. 2013c). However, after three years of operation, the Fund has yet to disburse money to any projects.8

Lack of cooperation among government institutions has impeded development. The Ministry of Energy and Mineral Resources is responsible for implementing the Geothermal Law and setting tariffs, but the Ministry of Finance, which lacks technical expertise in geothermal power, controls the Geothermal Fund, and is primarily

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focused on minimizing the fiscal impact of electricity subsidies for geothermal. Perusahaan Listrik Negara and Pertamina are both overseen by the Ministry of State-Owned Enterprises (World Bank 2015). There have been some efforts to prioritize geothermal, with the Ministry of Energy and Mineral Resources being reorganized in 2011 to create a Directorate-General for New and Renewable Energy (Polycarp et al. 2013c).

International support has helped to build national capacity for geothermal development, but readiness programs have been slow in showing results, illustrating the need for long-term support (Polycarp et al. 2013c). In 2008, the GEF began financing a $4 million readiness program to support the government in policy development to implement the 2003 geothermal law, and institutional capacity building (World Bank 2008). In 2010, the Clean Technology Fund (CTF) approved $300 million in concessional loans, as part of its national investment plan for Indonesia, to support over 800 MW of public and private sector geothermal developments (CIFs 2010). Bilateral agencies have also been active in geothermal development, with JICA, ADB, KfW, the Netherlands, and New Zealand providing readiness and technical support for resource assessments, feasibility studies, and environmental and social impact assessments. KfW has also provided directed project finance to geothermal plants (Polycarp et al. 2013c).

Reforms have encouraged an increase in geothermal generation since 2012 yet, of 58 areas with geothermal concessions, only nine are in production (Cahyafitri 2014). In August 2014, the government passed a law reclassifying geothermal activities so they are no longer defined as mining, which had precluded development in forest conservation areas. While this is likely to aid geothermal development, it may have negative implications for biodiversity. The law also grants authority for tendering to the central government instead of local authorities, simplifying the development process; it also increases the variable feed-in tariff (Cahyafitri 2014).

The lack of strong leadership inhibited the development of geothermal power in Indonesia for many years. Reforms of regulation and pricing structures, as well as government funding for initial exploratory activities, has helped to encourage development more recently. However, further improvements in tariff-setting and review, the processes for negotiating power-purchase agreements, and reforming fossil-fuel subsidies could help spur geothermal development.

**Box 2 | Fossil-Fuel Subsidies in Indonesia**

The Indonesian government sets electricity prices at a fixed rate, meaning they do not reflect their true market (or environmental) cost. In FY2013, electricity subsidies amounted to $9 billion, 8 percent of the national budget. Fuel subsidies also have a distorting effect on Indonesia’s electricity market, because oil and diesel provide 15 percent of the country’s electricity generation. Initial efforts in 2002 and 2003 to reform subsidies were abandoned when they met with widespread protests and a successful constitutional challenge on the grounds that electricity is a public good. Attempts at reform in 2005 and 2008 included greater consultation and communication with stakeholders and various compensatory mechanisms to mitigate the negative impacts. From May 2008, industrial electricity consumers were required to pay the full market costs for their electricity and other categories of end users were subject to phased price increases. By 2014, the largest household consumers and medium-sized businesses were paying market or above-market rates for electricity.

However, the overall policy of energy prices being set by government continues. President Joko Widodo, elected in July 2014, pledged to phase out fuel subsidies completely over four years. In November 2014, fuel prices were increased with immediate effect; the increase was accompanied by cash transfer schemes to assist the poorest with the adjustment. Despite these compensation measures, the reforms sparked violent protests. On December 31st, 2014, the government announced that it would remove subsidies from gasoline and introduced a fixed subsidy on diesel (with the price lower than market value, but fluctuating according to market conditions). Due to the fall in world oil prices, the effect of these reforms was to reduce fuel prices to pre-November 2014 levels, which was popular with the public. The reduction in the government subsidy bill will amount to about $15.5 billion, with the savings reallocated to support state-owned enterprises. The economy was resilient to these subsidy reforms and Standard and Poor’s improved Indonesia’s B+ credit rating from stable to positive. The reforms have been made easier by low global oil prices and their resilience, once prices start rising again, remains to be seen.

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* Beaton and Lontoh (2010).
* GSI (2014).
* BNEF et al. (2014).
* Beaton and Lontoh (2010).
* Reuters (2014); GSI (2015); GSI (2015a).
Insights from Case Studies

From the nine case studies, it is possible to gain insights into the factors that can help to ensure that climate finance is used to catalyze low-carbon energy transformation (Table 3).

National Ownership

In all the case studies that fall into the transformational category, the national government took ownership of the programs and demonstrated political leadership. This entailed developing laws, regulations, plans, and targets (see the discussion of enabling environments, below), as well as providing targeted, strategic financial support and coordinating, or even creating new ministries or agencies. In the 1970s, Denmark set a clear long-term vision to develop wind power and reduce dependence on fossil fuels, which has been key to driving and coordinating its low-carbon transformation. Indonesia and South Africa are instructive cases where the lack of leadership stunted development of renewable energy until recent years, when governments have seized the initiative and actively encouraged renewable energy.

National government financing has been instrumental in ensuring that low-carbon energy development is financially sustainable. The Energy Conservation Promotion Fund in Thailand has largely financed its energy efficiency program. Tunisia created a National Fund for Energy Conservation to provide a steady stream of public support for renewable energy and energy efficiency, funded by revenues from motor vehicle registrations and custom duties. Public ownership of utilities or grid operators can help to align national policy priorities with investments in low-carbon generation infrastructure. Publicly owned transmission-system operators in Denmark and Portugal were able to invest in grid upgrades to handle new generation. In Uruguay, the state-owned utility supported the sometimes-controversial “must-take” requirement for utilities to buy all wind energy connected; the utility also provided technical support for private

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<th>STAKEHOLDER ENGAGEMENT AND PARTICIPATION</th>
<th>A STABLE ENABLING ENVIRONMENT</th>
<th>FINANCIAL INCENTIVES ALIGNED TO ADDRESS MARKET DISTORTIONS</th>
<th>STRATEGIC USE OF RESOURCES TO MOBILIZE PRIVATE INVESTMENT</th>
<th>TECHNOLOGY AND INNOVATION INVESTMENTS</th>
<th>INNOVATIVE FINANCIAL INSTRUMENTS AND ARRANGEMENTS</th>
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<td>MISSED OPPORTUNITIES OR EARLY STAGE DEVELOPMENT</td>
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▲ Present  ● Partially present  ■ Not present
developers connecting wind turbines to the grid. Portugal demonstrated political leadership by buying out private transmission-system operators when they failed to upgrade the grid to handle renewable electricity development.

One important determinant for transformational potential seems to be the designation of one government department or agency to lead, which ensures coherence across government and provides a focal point for stakeholder engagement. The Tunisian Government established the National Agency for Energy Conservation to coordinate and engage local and international stakeholders. Thailand created a Demand-Side Management Office in the Electricity Generating Authority to develop, implement, and evaluate national demand-side management measures, and upgraded the Department of Energy to a full ministry. The Danish Energy Agency acts as the “one-stop shop” for all offshore wind development in Denmark, liaising with relevant authorities for approvals and licenses. In South Africa, splitting the Department of Minerals and Energy into two agencies helped to reduce conflicts of interest between the mining and energy sectors, allowing the Department of Energy to better support renewable energy. The creation of a specialized Independent Power Producer Unit drawing on expertise from a variety of government departments helped to prioritize and coordinate the renewable energy auctioning process. Similarly, in Indonesia, the Ministry of Energy and Mineral Resources was reorganized to create a new Directorate General for New and Renewable Energy.

Stakeholder Engagement and Participation

Participatory processes better ensure that the public interest is protected and, by making trade-offs more apparent, can boost support for eventual decisions. Allowing a broad range of actors to have input can lead to innovative ideas and approaches being considered, increasing policy effectiveness. Lastly, allowing participation of other stakeholders can build technical capacity beyond government bodies (Nakhooda et al. 2007).

Engaging stakeholders should not be used merely to confirm pre-determined decisions. Publishing the results of consultations, including responses from policymakers, and outlining how feedback has been incorporated can ensure confidence that participation has had a tangible impact. Efforts should be made to expand participatory processes beyond sector experts and industry insiders to include impacted groups and more critical stakeholders. Special mechanisms to include marginalized groups—encouraging pro-active engagement, appointing a consumer representa-

tive, or requiring regulators to make submissions on behalf of specific groups—could be considered. In the energy sector, where discussions can quickly become “technical,” governments need to ensure that the public can understand and substantively engage with the issues. Consultation processes should be clear and well communicated, making use of mass media and allowing a reasonable time for input. Access to documentation related to the policy process can be enhanced through legal disclosure requirements, minimizing costs for document access, and clear criteria for determining which documents are confidential. Training programs that forge ties between government agencies, advocacy groups, and technical experts can also broaden participation (Nakhooda et al. 2007). The Electricity Governance Initiative provides a toolkit with additional best practice indicators for enhancing participation and good governance more broadly in policymaking in the electricity sector (Dixit et al. 2007).

South Africa provides an example of the problems that can occur when policymaking processes fail to adequately consult stakeholders, and how impediments can be overcome by taking a more participatory approach. The government’s revised Integrated Resources Plan, the result of a consultative process with both civil society and the private sector, is more reflective of the public interest than the previous plan, and includes more ambitious renewable energy targets, which have helped to boost the sector’s development.

Denmark is a model for stakeholder engagement. Among other policies, it requires that communities have the option to buy into local wind development projects as investors. This model of citizens as “prosumers”—producers (or owners) of energy as well as consumers—has increased community support for wind farms and mobilized new pools of capital.

Thailand has seen significant progress in improving governance and participation in policymaking for its electricity sector. Using the Electricity Governance Initiative Toolkit, civil society groups have pushed for greater transparency and participation in the power development planning process, and advocated for greater emphasis on demand-side management and renewable energy sources to meet electricity needs, achieving both procedural and substantive reforms (Weischer et al. 2011). Following a successful legal challenge by NGOs to an attempt to privatize the national electricity utility, the government established an independent electricity regulator to improve oversight and accountability (Nakhooda et al. 2007).
A Stable Enabling Environment

In *Mobilizing Climate Investment* (Polycarp et al. 2013e), WRI identified enabling conditions in both the public and private sector that can help to attract climate finance (Table 4).

**Table 4 | Enabling Conditions for Attracting Climate Finance**

<table>
<thead>
<tr>
<th>PUBLIC SECTOR</th>
<th>PRIVATE SECTOR</th>
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<tr>
<td>▪ Well-designed and enforced laws and regulations</td>
<td>▪ Stable financial markets and actors</td>
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<tr>
<td>▪ Plans and targets for low-carbon, climate-resilient development</td>
<td>▪ Awareness of investment opportunities</td>
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<td>▪ Capable and effective institutions</td>
<td>▪ Engineering and technical expertise</td>
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<td>▪ Complementary/supporting infrastructure</td>
<td>▪ Capacity to create bankable projects</td>
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Laws, regulations, and policies that are well designed, adequate, and enforced are foundational to low-carbon energy development, and they have been integral to the successful case studies examined. In Denmark, Portugal, Thailand, and Uruguay, legislation with time-bound targets has helped to spearhead low-carbon energy development.

Clear, consistent policies are critical. While there should be flexibility to increase the ambition of policies, to reflect advances in technology, costs, and scientific urgency, it is important to ensure that the enabling environment remains stable in order to build investor confidence. In particular, policies should not be retroactively weakened; Spain illustrates the setback that can occur to low-carbon energy development when policies are unstable over time.

There has been a marked difference in deployment of renewable energy across EU member states, even though they operate under the same 2020 renewable energy target. Some countries have successfully designed stable policies that sent strong signals to the energy sector about future direction, while others have pursued fragmented or frequently amended approaches that have sent mixed messages (Box 3). Until recently, policy uncertainty hindered the development of renewable energy in South Africa and Indonesia. When these countries introduced well-designed and stable policies, installations increased significantly.

**Box 3 | The EU Experience with Renewable Energy: Same Overarching Framework, Very Different Outcomes**

All EU members are subject to the same overall policy framework, centered around the 2007 EU climate and energy package, which includes 2020 targets for greenhouse gas emissions, energy efficiency, and renewable energy (subsequently made binding). Despite their location within the same region, their similar levels of development, and their shared overarching policy framework, EU countries’ low-carbon development has varied greatly.

Examining only western European states, which have similar levels of per capita income, some have made strong progress toward meeting their renewable energy targets (Denmark, Germany, Portugal) while others lag behind (the United Kingdom, the Netherlands, Belgium) (Figure 15). These countries have similarly favorable investment climates; the United Kingdom, the Netherlands, and Belgium are ranked 10th, 28th, and 36th respectively on the World Bank’s “Doing Business” index, compared with 5th, 21st, and 31st for Denmark, Germany, and Portugal.¹ The investment impediments appear to be specific to renewable energy, highlighting the role of national policy and leadership in creating a favorable regulatory framework for renewable energy development and grid connection. Denmark, Germany, and Portugal have sent consistently clear signals to investors, designed simple tariffs or auctioning schemes, mandated grid access for renewable energy, and invested in infrastructural upgrades. By the early 2000s, all three countries had enacted strong pro-renewable energy policies.

Denmark and Germany had experimented with feed-in tariffs throughout the 1990s. Transmission grids are publicly owned in both Denmark and Portugal, allowing the governments to align investment in expansion and upgrades with their overall energy policy to promote renewable energy integration.

While the United Kingdom, the Netherlands, and Belgium also have policies for renewable energy, they have been inconsistent and subject to uncertainty. Incentive schemes have been overly complex and frequently amended, and have not provided sufficient guidance to energy markets. The European Commission has cautioned that policies in these countries may not be sufficient to meet their 2020 targets.²
Box 3 | The EU Experience with Renewable Energy: Same Overarching Framework, Very Different Outcomes (cont.)

The United Kingdom has taken a hands-off approach to its energy market, with policy guidance exercised through market-based mechanisms, primarily the Renewable Obligation, which established a tradable certificate scheme. While this was intended to encourage development of renewable energy at least cost to the consumers and minimal intervention in the electricity market, it has introduced new pricing risks in the form of a volatile market for Renewable Obligation Credits. Market volatility does not provide long-term price certainty, leaves renewable operations exposed to grid balancing risk, and has not encouraged diversity in renewable sources, with most development focused on low-cost, large-scale wind projects. These measures have been insufficient to spur adequate decarbonization of the electricity sector. The UK has one of the lowest shares of renewable energy in Europe and electricity generation is still heavily reliant on fossil fuels. In 2010, the government introduced feed-in tariffs for small-scale renewable energy, which have helped increase investment; the country ranked fourth globally for total renewable energy investment in 2014. However, the recently announced elimination of subsidy support for onshore wind from 2016, and reductions in solar subsidies have created policy uncertainty and risk, causing a decline in clean energy development.

The Netherlands illustrates the problem of policy uncertainty and time lags in effects; in 2006 the government removed the subsidy scheme, concerned with rising costs and anticipating that its 2010 renewable energy target would be met anyway. However, by 2009, new project development had dried up. Although a new renewable energy subsidy was introduced in 2008, it took until 2011 for development to pick up again. The start-stop approach to renewable energy incentives has not created a stable environment for long-term planning and investment, and the lag time in the impacts of policy change along the project development pipeline has made it difficult to ensure continued progress toward the goal.

Lastly, Belgium highlights how policy fragmentation obstructs renewable energy development. Policies and targets differ among the regions of Flanders, Wallonia, and Brussels, with each area having different energy regulators, subsidies, and green certificate schemes, making the development process extremely complex.

The marked contrast between these six countries operating under the same overarching target framework illustrates the importance of ambitious and consistent national policies to encourage development of renewable energy.

Notes:

a World Bank (2014a).
b EC (2015).
c Mitchell et al. (2006).
d IEA (2012).
e REN21 (2015).
f Reed (2015); Wintour and Vaughan (2015).
g Statistics Netherlands (2012).
h IEA (2009).
Regulatory policies—such as feed-in tariffs, renewable portfolio standards, renewable energy credits, reverse auctions, and power-purchase agreements—have been widely employed to advance renewable energy. So too have a number of fiscal policies, such as capital subsidies or rebates, tax credits, energy production payments, and public investment loans or grants. By early 2015, renewable energy support policies were in place at the national or state/provincial level in 145 countries (REN21 2015). The determination of whether or not a case is transformational does not depend on the type of procurement policy in place, but rather on how well it is designed and its suitability for the national context.

Portugal took an innovative approach to its feed-in tariff design by basing the price paid to producers on the avoided costs of conventional generation capacity, plus the environmental benefits of renewable energy. In Spain, feed-in tariffs included insufficient cost-control mechanisms, meaning the financial burden was far greater than expected; when subsidies were cut (retroactively, in some cases), development ceased. To avoid problems with unlimited public finance obligations, Bangladesh, Denmark, Portugal, Tunisia, and Uruguay have designed support mechanisms that phase down over time.

Institutional capacity building has been important to ensure that policy is well designed and effectively implemented. In Uruguay, prior to the wind energy project, the state utility company had no experience with intermittent generation; the project worked to build the expertise needed within the utility to handle wind technology. In Thailand, the government embarked on intensive staff and management training programs to strengthen the capacity of the Department of Energy Development and Promotion. Capacity building for the private sector is also important. In Uruguay, the state utility addressed the financial sector’s lack of information on renewable energy through workshops with private sector stakeholders. In Tunisia, training, certification, and accreditation programs for solar water heater suppliers and installers helped to reduce technology failure rates.

One of the most critical enabling factors for private sector investment is underlying infrastructure. Grid connectivity has often been a bottleneck for renewable energy development. Government investment in modernizing the grid, as well as reforming regulations to streamline and promote connectivity of renewable energy, has been instrumental to the successes in Portugal and Denmark.

Building enabling conditions is not an endpoint, but a long-term dynamic process. Moreover, the importance of enabling conditions highlights that the climate finance challenge is not only about mobilizing the investments needed to fill the finance gap, but also creating a pipeline of fundable projects so that countries are in a position to absorb increased finance flows.

Financial Incentives Aligned to Address Market Distortions

Getting the financial incentives right and addressing market distortions are integral to catalyzing transformational low-carbon energy development. Climate change has been called the greatest market failure the world has seen (Stern 2007), and incorporating the externalities of fossil fuels (the social cost of carbon) in prices can aid the low-carbon transformation. However, today, fossil fuels receive major subsidies, which encourage their continued use—by artificially boosting supply and demand—and impede the spread of clean technology. The International Monetary Fund (IMF) has estimated total post-tax fossil-fuel subsidies, including the externalities associated with local air pollution and the costs of climate change, to be more than $5 trillion—6.5 percent of global GDP—in 2015 (Coady et al. 2015). The International Energy Agency (IEA) estimates that global fossil-fuel consumption subsidies were $548 billion in 2013, more than four times the support renewable energy sources received in the same year ($120 billion), and over four times the total investment in energy efficiency. The majority of these subsidies are found in developing countries, with the top 10 countries providing subsidies, mostly large fossil-fuel producers, accounting for more than three quarters of the global total (IEA 2014b). Fifteen percent of global carbon dioxide emissions receive an incentive of $110 per ton in fossil-fuel subsidies, while just 8 percent of emissions are subject to a carbon price (IEA 2013). Fossil-fuel subsidies (per GDP) are a significant predictor of a country’s emissions intensity (CO₂ emissions per GDP) (Figure 16). In addition, fossil-fuel subsidies tend to be regressive, with IMF research showing that the richest 20 percent of the population receives over 40 percent of the benefits from fossil-fuel subsidies, while the poorest 20 percent receives just 7 percent (Arze del Granado et al. 2010). Cash transfers or other targeted compensation schemes have been a more effective mechanism for addressing fuel poverty. Following its 2004 phase-out of gasoline and diesel subsidies in Thailand, the government introduced free travel on some trains and buses and free tap water and electricity for households with low consumption, which have been effective measures for alleviating poverty without subsidizing wealthier households (IISD 2013).
The case studies reviewed here demonstrate different approaches to addressing the market distortion of incorrectly priced fossil fuels, in order to facilitate low-carbon energy development. The feed-in tariffs in Denmark, Portugal, and Uruguay have been important financial incentives for the growth of renewable energy. Thailand’s sales tax on petroleum products has raised funds for its Energy Conservation Promotion Fund, yielding a dual benefit: it discourages fossil-fuel use and enables energy-saving measures. Tunisia used targeted subsidies to support renewable energy by shifting demand away from fossil fuels. The reduced spending on fossil-fuel subsidies will result in net savings for the public budget over the lifetime of the solar water heaters. Conversely, Indonesia’s system of fixed electricity and fuel prices significantly burdens the public budget and disadvantages low-carbon energy. Efforts in recent years to remove these subsidies have helped to level the playing field in the electricity market, making geothermal more competitive.

Strategic Use of Public Resources to Mobilize Private Investment

Turning billions of dollars in climate finance into the trillions of dollars of investment needed for global transformation will require new sources of private sector capital. While the private sector provided 58 percent of climate finance flows in 2013 ($193 billion), these flows will have to be magnified if the climate finance gap is to be filled (Buchner et al. 2014). In the developing world, there are several challenges to scaling up private investment: investment risk, return on investment, cost of capital/access to capital, market liquidity (the greater the liquidity the higher the investor confidence), market and project size (smaller projects incur higher transaction costs), market transparency (the more data and information that are available the higher the investor confidence), tenor-risk constraints (investors are reluctant to invest in risky

Figure 16 | The Relationship between Fossil-Fuel Subsidies and Emissions Intensity in 178 Countries

Notes: Authors’ statistical regression. The post-tax fossil-fuel subsidy data are for 2011, collected by the International Monetary Fund. The emissions intensity data are for 2010, obtained from the World Bank.
projects with a long investment horizon), and a lack of business and technical capabilities (IPCC 2014; Venugopal and Srivastava 2012). The public sector has myriad tools available to reduce the cost or improve the risk-adjusted return of low-carbon energy projects and make them more attractive to private sector investment (Figure 17). These measures include supporting the development of the enabling environment described above, project-level assistance, and public financing.

The strategic use of public money—both domestic and international resources—is integral to low-carbon energy development. Denmark, Uruguay, South Africa, and Indonesia used public funds for critical initial scoping work, such as mapping and feasibility studies. In Uruguay, a limited initial grant of millions of dollars by UNEP and the GEF has translated into billions of dollars in private investment. South Africa has used both grants and concessional loans (from the GEF, the World Bank, and the CTF, among others) for capacity building, and to address policy and financing barriers to renewable energy development. The country has also backed the Independent Power Producer program with sovereign guarantees, which increased investor confidence. Supported by various external funders, Bangladesh is providing a grant subsidy to solar home systems, as well as creating a refinancing facility to address risks with consumer loans. In Thailand, the energy efficiency revolving fund is incentivizing private bank financing of energy efficiency. In addition, the Thai Government’s equity finance to energy service companies is ameliorating their inability to access capital.

It is critical that countries commit and mobilize domestic resources to sustain low-carbon energy gains. The Energy Conservation Promotion Fund in Thailand is supported by a petroleum sales tax, largely allowing the country to use international public finance for targeted purposes related to technical assistance and readiness activities. Half the program costs in Bangladesh are covered from domestic sources. In Tunisia, the energy conservation fund is supported by domestic revenue, specifically revenues from motor vehicle registrations and custom duties.

**Technology and Innovation Investments**

Technological innovation has enabled massive cost reductions that have driven global renewable energy deployment. Portugal and Uruguay embarked on wind development much later than Denmark, and have benefited from technology cost reductions driven in part by early Danish investment. Wind turbines today can generate 100 times the power of those 30 years ago (Figure 18). Wind turbine prices have fluctuated with economic cycles and the prices in commodities; however, since a peak in 2009, the Bloomberg New Energy Finance’s wind turbine price index ($/kW) declined by 28 percent in 2014 on average across turbine sizes. Solar has also seen major technological breakthroughs; the production cost of solar PV panels ($/W) in 2008 was less than 2 percent of the cost in 1974, while reliability has increased by a factor of more than 10. The levelized cost of electricity for residential solar PV in Australia, China, Germany, Italy, and the United States fell between 42 percent and 64 percent from 2008 to 2014 (IRENA 2015).

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**Figure 17 | Public Tools Available to Create Favorable Conditions for Private Sector Investment in Low-Carbon, Climate-Resilient Development**

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**PUBLIC SUPPORT MECHANISMS**

- **Policy and Overarching Support**
  - Corrects systemic market failures to create a foundation for low-carbon investment

- **Project-Level Assistance**
  - Provides critical support to transition projects from concept to demonstration

**PUBLIC FINANCING INSTRUMENTS**

- **Lending (Debt)**
  - Most common source of finance for upfront and ongoing project costs

- **Equity Investment**
  - Builds a project/company’s capital base, allowing it to grow and access other finance

- **De-Risking Instruments**
  - Help projects/companies and their investors manage specific types of risk

**MARKETS WITH ATTRACTIVE RISK-REWARD, LIQUIDITY, SCALE, AND TRANSPARENCY**

More resources can be devoted to low-carbon energy research and development (R&D) (Box 4). While absolute spending for energy R&D has increased recently, the share of energy research and development in OECD countries’ total research budgets has declined over the past 30 years (IEA 2014). In the United States, investment in energy R&D declined from $7.4 billion in 1978 to $1.8 billion in 2007 in constant 2005 dollars. Of all the major technology-dependent sectors, the energy sector spends the smallest share of its sales on R&D—0.3 percent (AEIC 2010).

However, with many renewable energy technologies already cost competitive, the challenge now lies not just in bringing hardware costs down (though this could be continued), but also enabling greater grid integration for variable renewable energy (VRE). Most power systems can handle a 5–10 percent share of VRE in annual generation with few challenges, and integration up to 25–40 percent is technically feasible with current levels of grid flexibility (IEA 2014a). As the case studies show, many of the barriers to integrating renewable energy into the grid are related to market design and planning rules. Address-
ing these policy barriers can result in the integration of significant amounts of VRE into existing grids at low cost, without the need for new technology (IEA 2014a; 21st Century Power Partnerships 2014). However, innovations in energy storage and smart grid technology can help to integrate large shares of VRE at lower cost.

Early stage research and development played a significant role in Denmark’s pioneering success in wind power, and its continued innovations in smart grids and other balancing technologies are helping to integrate higher shares of variable renewable energy cost-effectively. Research and development is not confined to more advanced economies. R&D can be helpful in developing and deploying locally appropriate technologies, often building on existing technologies while adapting them to differing national contexts. In Bangladesh, solar PV technology was adapted to meet the needs of rural households with low-cost, small-scale systems.

Experiment with Innovative Financial Instruments and Arrangements

There is no generally agreed upon definition of innovative finance for climate, or development more broadly, although the concept dates back at least 50 years (Herman 2013). The World Bank defines innovative financing as that which involves non-traditional applications of solidarity (i.e. finance that has explicit social and often environmental objectives), public-private partnerships, and catalytic mechanisms that either support fundraising by tapping new sources and engaging investors beyond the financial dimension of transactions, or deliver financial solutions to development problems on the ground (Girisankar 2009). The OECD considers innovative financing to consist of new approaches for pooling private and public revenue streams, new revenue streams (e.g., new tax or bond raising), or new incentives (e.g., guarantees, insurance) (Sandor et al. 2009). Thus, innovative financing would extend beyond traditional financial instruments, such as grants, loans, or equity.

However, the innovative aspect of most instruments may derive not from their novelty, but from how they are applied in a given context. A number of the case studies examined for this paper involved new financial arrangements, if not innovative instruments. Denmark’s requirement that communities are offered a 20 percent share in local wind developments is an innovative approach to the traditional shareholding model, which fosters community support for renewable energy developments. In Bangla-

desh, microcredit institutions were offered debt refinancing to enable them to provide more favorable credit terms to low-income households. In Tunisia, an interest rate subsidy was used in conjunction with a capital cost subsidy to make credit for solar water heaters more affordable. Thailand’s Energy Efficiency Revolving Fund has used revenues from a fuel tax to finance energy efficiency measures, which have a fairly rapid payback, allowing finance to be largely self-sustaining.

While the use of innovative financial instruments and arrangements should be examined as part of the low-carbon transformational process, some of the most transformational case studies required little in the way of direct project financing. Financing in these cases focused instead on readiness activities and removing barriers to private investment. For example, in Uruguay, public funding was used to reform electricity market regulations, removing barriers to wind development.

Continuous Learning and Improvement

Transformational change entails reflection and evaluation. It is important for implementing entities to learn continually throughout the process of deploying finance for low-carbon energy development, making adjustments as necessary to keep on track. While a stable enabling environment is needed to build investor confidence, this should not preclude updating policies and targets to take account of advances in technology, costs, and scientific urgency. Regular monitoring and evaluation cycles that feed back into the overarching strategic vision and specific policies can help to ensure that momentum toward a low-carbon society is maintained and that advances made do not stagnate or regress.

All three of the transformational case studies had strong elements of learning and improvement. As Uruguay’s wind energy deployment targets were met ahead of schedule, the government continually increased its ambition. Denmark has also set increasingly ambitious targets for wind energy and, after seeing that premature subsidy reductions in 2004 stunted progress, learned from this mistake and restored the subsidies in 2008. Denmark’s efforts to improve the grid’s ability to handle ever-larger shares of variable wind energy and to address public opposition to turbine construction also demonstrate a flexible “learning by doing” mindset. Portugal not only set and then raised targets for renewable energy development in line with progress, but adjusted its feed-in tariff rates as technology-specific goals were met. This approach has
helped to ensure that the government is not paying more in subsidies than is necessary to meet its targets.

The case of Spain illustrates what can happen if continual evaluation and adjustment mechanisms are not incorporated. When the government finally addressed feed-in tariffs, the problem was so severe that the government felt compelled to implement retroactive changes, which seriously undermined investor confidence. More gradual policy adjustments, made earlier on, might have avoided this outcome.

Evaluation and policy adjustment have been critical to setting countries on a more transformational pathway, as demonstrated by experiences in South Africa, Indonesia, and Thailand. In South Africa, the government revised its Integrated Resource Plan in response to civil society and private sector feedback. Indonesia adjusted its geothermal feed-in tariff to vary by region, and Thailand reformed its Demand Side Management program in response to evaluations, which found that the program did not fit the national culture. Establishing evaluations as regular processes with clear mechanisms to feed into policymaking, rather than conducting them only in response to public pressure, or when new project funding is sought, can help to ensure continuous improvement while giving investors clarity and confidence about the timing of policy adjustments.

III. ROLES AND RECOMMENDATIONS FOR DIFFERENT ACTORS

Low-carbon energy transformation will require action by many actors, across many scales, including recipient governments, development finance institutions, private sector technology providers, commercial banks, utilities, technical institutions, and community organizations. Here, we provide recommendations for two sets of actors: recipient governments and development finance institutions/contributor governments. Our recommendations are based on insights gleaned from the case studies.

Recipient Governments

- **Take ownership of the process.** Transformation must be endogenously driven. The most successful cases of low-carbon energy development occurred in countries that took ownership of their programs, from establishing enabling conditions to full-scale deployment. Country ownership may be enhanced when a country contributes domestic resources.

- **Organize government to facilitate low-carbon transformation.** This would include creating incentives for government agencies to work together to implement plans and targets. Moreover, our analysis indicates that low-carbon energy transformation is most likely to occur when there is a local champion—a specific government agency or body—that is empowered to lead and provide policy coherence and coordination across government. This agency can also serve as a focal point for stakeholder engagement.

- **Formulate national plans and targets in an inclusive, multi-stakeholder process.** Plans and targets are foundational to transformational change, and they signal to the international community and private sector investors both ambition and engagement. Moreover, as transformation is a multi-actor process, it is imperative that plans address multiple sectors and multiple scales—from local communities and civil society organizations to business and government. The plans should be long-term, and articulate development pathways, but flexible enough to be adapted and updated in light of developments in climate science and impacts, and progress in implementation.

- **Adopt consistent policies and regulation.** Policies must be consistent and well designed, so they do not lead to unsustainable fiscal burdens. An uncertain policy environment will retard private sector investment. Fiscal and regulatory policies should be tailored to the local context. In some cases, regulations by themselves can lead to transformation, even without fiscal support, but require continual evaluation and possibly, reform.

- **Identify barriers to climate investment and gaps in enabling conditions.** Governments should assess capacity gaps in their own institutions and the private sector, and impediments to private sector investment, such as information barriers. They should seek and provide financial support to address these barriers; the sums required may prove to be modest over the long term.

- **Support enabling infrastructure.** Low-carbon energy transformation is not possible without appropriate infrastructure, such as transmission lines and grid extensions to handle renewable energy connectivity. Plans must be cognizant of the quality and adequacy of infrastructure, and government should provide financial support, where possible, to address deficiencies.
If resources allow, invest in research and development to adapt technology to local conditions. Research and development is not simply the purview of developed countries; developing countries should provide resources, where possible, to adapt technologies to local markets and contexts.

Use international support strategically. Recipient governments should have ownership over the process and use international public finance for targeted purposes, such as to address key capacity gaps and provide training and awareness raising. Millions of dollars of public finance dedicated to enabling conditions over the long term can galvanize larger investments from other sources.

Get the prices right by removing fossil-fuel subsidies and internalizing externalities through carbon pricing or other instruments. Fossil-fuel subsidies should be removed and replaced with targeted cash transfer or compensation schemes to address energy poverty. Concomitantly, internalizing the external costs of fossil fuels through taxation or other measures can provide quadruple “wins,” namely, reductions in GHG emissions, a more competitive environment for low-carbon energy, co-benefits (such as reduced health care costs from air pollution), and increased government revenues.

Focus on developing the private sector and adopt competitive practices. The public sector should help catalyze the development of the private sector rather than supplant it. The public sector should focus on funding pilots or demonstrations of new technologies and funding models. When offering finance, government should select recipients based on competitive tendering processes. Moreover, governments should consider the role of small and medium enterprises, which are the biggest drivers of employment in the developing world (Ayyagari et al. 2011). Governments can also look to community organizations for wide-scale replication and to help ensure broad-based economic participation.

Update and iterate. Low-carbon energy transformation is a long-term process that requires a continual iteration of policies, regulation, and public financial support. Projects, programs, and policies need to be enacted with measurable goals and evaluated on a periodic basis.

Development Finance Institutions and Contributor Governments

1. Make sure international support aligns with recipient country plans and priorities, and provides long-term sustained assistance. Low-carbon energy transformation will not materialize unless international support is consistent and in accord with national development plans and priorities. A decision to provide support should be considered a long-term commitment.

2. Working in concert with recipient governments, help to identify deficits in enabling factors (e.g., institutional capacity, laws, policies, and regulations), and provide support to address them. Low-carbon energy development will not succeed unless the enabling conditions are well established. In general, support for public policy and institutions tends to precede measures to address industry capacity and financing of projects. Establishing an enabling environment is an iterative process, and there can often be a long lag time between implementation of policies and capacity development and a noticeable, on-the-ground impact.

3. Move beyond thinking of transformation at the project-level and coordinate with other contributors. Transformation is not born from one project alone. Contributors must coordinate at the country-level and decide how best to divide the needed support. The requisite support may range from public support mechanisms to financing instruments, such as debt, equity, and risk mitigation instruments to achieve transformation across a portfolio of projects. Development finance institutions with higher risk tolerances should finance early stage investments, while those with lower risk tolerances can provide low-cost debt when the industry is more established.

4. Identify the barriers and risks to private sector investment, and tailor instruments to “crowd in, not crowd out” the private sector. There are myriad potential risks in the developing world: political, macroeconomic, policy-related, and technological and operational. These must be mapped and matched with the appropriate risk instrument. While the public sector plays an invaluable role in buffering private sector risk, it is also important to have a plan to taper public support when an industry becomes more mature.
A Planning Framework for Transformational Climate Finance for Recipient Governments

Our framework for transformational climate finance (Figure 20) builds upon the critical elements for transformation identified in the case studies and the lessons learned described above. It is designed to outline the sequence of steps in the transformational process for recipient governments. While these steps might apply for low-carbon transformation more broadly, our focus here is on low-carbon energy.

1. **Formulate the problem.** This includes articulating the long-term goal and vision, identifying metrics for transformation, and examining barriers and potential drivers at the different scales. The relevant scale may range from the individual project, entrepreneur, or technology, to the dominant institutions or societal practices, to large-scale, international, or macro-economic factors. For renewable energy, targets or metrics could be the change in installed capacity or net generation or percentage of the electricity generation (Table 5). Barriers could include low or subsidized fossil-fuel prices (landscape or macro-level, using the multi-level perspective classification of transformational processes outlined in Box 1); lack of institutional capacity for low-carbon energy development (meso- or regime-level); and competing fossil-fuel technology developments (micro- or niche-level). It is often entrenched institutions, interests, or consumer practices at the regime-level that resist transformational change. Potential drivers could be lack of fossil-fuel supplies or energy security, regulatory reform or consumer pressure for low-carbon energy, or innovations and the falling cost of renewable energy technologies (Table 6).
2. Engage with a wide array of stakeholders (government, communities, and the private sector) and delineate the roles and responsibilities of the key actors. This would include establishing stakeholder engagement and coordination processes, and designating a specific government agency or body to promote coherence and integration across government.

3. Establish a stable enabling environment that addresses both the public and private sector. This includes laws, regulations, policies, and institutions. Establishing a stable environment also entails building capacity in government, business, and civil society to ensure that each has the knowledge and technical expertise needed to design, implement, and monitor low-carbon policies and projects. While there should be flexibility to increase the ambition of policies to reflect advances in technology, costs, and scientific urgency, the enabling environment should remain stable to ensure investor confidence; policies should not be retroactively weakened.

4. Align incentives. This may entail establishing clean energy policy/regulatory incentives, such as feed-in tariffs, renewable energy credits, or renewable portfolio standards. It may also involve fiscal incentives, including capital subsidies or rebates, tax credits, energy production payments, and public investment loans or grants. Incentives can also be provided through research and development, and by eliminating or lowering fossil-fuel subsidies.

5. Develop pilot projects and test new financial arrangements, partnerships, and innovative instruments. This is a good, strategic use of public money, including domestic resources. The private sector may not have the risk appetite to solely develop experimental pilots with early stage technologies, but the public sector can mitigate some of the risk by partnering with the private sector.

6. Build monitoring, evaluation, learning, and feedback into the problem formulation and strategic vision. Transformation is not a linear process, but cyclical and iterative. By adopting a cyclical process, low-carbon energy deployment can scale up over time.

| Table 5 | Potential Metrics to Assess Low-Carbon Energy Transformation |
|-------------------------------|

- Renewable energy installed capacity (MW)
- Renewable energy net generation (kWh)
- Percent electricity generated by renewable energy
- Emissions abated in the energy sector (tCO\(_2\)e) (compared to Business As Usual)
- Emissions intensity in the energy sector (gCO\(_2\)e/kWh)
- Energy intensity of the economy (kJ/GDP)
- Emissions intensity of the economy (tCO\(_2\)e/GDP)\(^a\)
- Cost of electricity ($/kWh)
- Energy access (number of households/people with access to electricity/improved access)
- Avoided energy demand “negawatt” (MW)

\(^a\)The simple energy/GDP indicator may be misleading. For example, a shift of economic activity out of the industrial and manufacturing sectors, which use large amounts of energy per unit of output, into service industries that use only very small amounts of energy, would result in lower energy/GDP ratios, but is not indicative of improvements in energy efficiency. For this reason, intensity indexes are used to gauge economy-wide energy efficiency. They are energy-weighted averages of indexes from lower levels of aggregation (sectors). See IEA (2014c).

Note: The change in the value of these metrics would generally be more informative than the absolute numbers.
### Table 6  | Drivers of Transformation in the Case Studies

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>LANDSCAPE-LEVEL</th>
<th>REGIME-LEVEL</th>
<th>NICHE-LEVEL</th>
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<tbody>
<tr>
<td>Uruguay</td>
<td>▪ Drought decreased hydroelectric generation ∙ Concerns over energy security and high fossil-fuel imports</td>
<td>▪ Ambitious targets for wind capacity ∙ Regulatory reform (e.g. reverse auctioning, feed-in tariff) ∙ Capacity-building of the state utility (UTE)</td>
<td>▪ Awareness-raising of private sector stakeholders</td>
</tr>
<tr>
<td>Denmark</td>
<td>▪ Oil crisis of the 1970s</td>
<td>▪ Ambitious RE targets ∙ Market reform and financial incentives for wind (e.g. feed-in tariff) ∙ Pro-wind regulations for zoning and technical mapping ∙ Streamlined planning processes and designation of the Danish Energy Agency as a “one-stop shop” for coordination</td>
<td>▪ R&amp;D investment in wind ∙ Community ownership of wind projects (“prosumers”)</td>
</tr>
<tr>
<td>Portugal</td>
<td>▪ Concerns over energy security and fossil-fuel imports</td>
<td>▪ Strong RE targets ∙ Financial incentives for RE (feed-in tariff) ∙ Government modernization of the grid ∙ Planning laws allow grid expansion</td>
<td>▪ Revenue-sharing with local municipalities</td>
</tr>
</tbody>
</table>
### APPENDIX | OTHER CASE STUDIES

<table>
<thead>
<tr>
<th>CASE STUDY</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td><strong>Transformational</strong></td>
<td></td>
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<tr>
<td>Chile – renewable energy</td>
<td>The introduction of a renewable energy mandate for utilities in 2007, along with a tradable renewable energy credit system and streamlining of the permitting process, have led to a rapid growth in renewable energy capacity in recent years. Chile had 2 GW of installed renewable electricity capacity at the start of 2015, over 10 percent of the power mix. Small hydro, biomass, biogas, onshore wind and geothermal are already cost-competitive with fossil fuels, and large fossil-fuel projects are struggling to get completed. More than 15 GW of renewable energy projects are in the pipeline, with more than half being solar PV. The combined capacity of all operating or planned renewable energy projects is more than the installed capacity of all existing grids.³</td>
</tr>
<tr>
<td>China - renewable energy</td>
<td>As a result of R&amp;D spending, ambitious targets, and subsidy support, China has seen an exponential growth in renewable energy capacity over the past decade. In 2009, deployment of solar PV had barely started, yet in 2013 alone over 12 GW of PV capacity came online, 50 percent more than any country had ever installed previously in a single year. The country now has the lowest installed system price for solar PV of any country in the world. China is also the fastest growing installer of wind turbines, with a hundredfold increase over the past decade, and leads the world in hydroelectric, wind, and solar heat capacity. China’s installed renewable power reached 433 GW in 2014, a quarter of the world’s total renewable electricity capacity. Of this, 290 GW was hydropower, 115 GW was wind and 28 GW was solar PV. Renewable energy sources account for 20 percent of China’s electricity generation—more than 1,000 TWh and, in 2013, China’s installation of new renewable electricity capacity surpassed that of new fossil-fuel and nuclear generation.³</td>
</tr>
<tr>
<td><strong>Potentially transformational</strong></td>
<td></td>
</tr>
<tr>
<td>Germany - renewable energy</td>
<td>The Energiewende (Energy Transition) is a comprehensive German government strategy to reform the energy system to become low carbon. Through a coherent policy framework including feed-in tariffs, environmental taxes, investment in grid upgrades, and technology mandates, the country has successfully achieved large-scale deployment of solar PV and wind. In 2014, renewable energy provided 28 percent of Germany’s electricity generation, compared to just 7 percent in 2000, and the country is the world leader in solar PV deployment, with 38 GW installed capacity at the end of 2014. Investment in clean energy has grown by 122 percent since 2004, and primarily comes from small investors—households and farmers. Wind and solar energy installation has driven down wholesale electricity prices, with a 32 percent reduction between 2010 and 2012. The installed system cost of solar PV fell by 66 percent between 2006 and 2012 and has reached grid parity. The energy transition has resulted in a reduction in greenhouse gas emissions of 22 percent compared to 1990 levels, while fostering a 28 percent growth in GDP. German demand for renewable energy, particularly solar PV, has helped drive global technology costs down.³</td>
</tr>
<tr>
<td>Mexico - wind</td>
<td>Through R&amp;D programs, regulatory reform, and pilot projects to demonstrate feasibility, Mexico has seen a rapid increase in installed wind energy over the past decade, from just 2.3 MW in 2000 to 5.9 GW by the end of 2014, with 2.5 GW installed in that year alone. 95 percent of this growth has come from private sector projects using the Independent Power Producer or self-supply modalities, and onshore wind is now cost-competitive with new coal- and gas-fired electricity plants. A further 3,400 MW of wind generation is due to come online by 2016 and, by 2020, wind generation capacity is projected to reach 12 GW.³</td>
</tr>
<tr>
<td>India – energy efficiency</td>
<td>The establishment of the Bureau of Energy Efficiency in 2001, with a mandate to coordinate energy efficiency policies, helped galvanize energy efficiency planning and promotion. This has included establishing performance standards and labeling as well as national targets. A tradable energy savings certificate scheme has proven an innovative way of ensuring ambitious but flexible efficiency improvements in industry. India is on track to achieve its target of a 20 percent improvement in efficiency by 2016–2017 compared to 2007 levels. Delivering on this target and further entrenching efficiency gains could make this an example of transformational energy efficiency policy.²</td>
</tr>
</tbody>
</table>
### CASE STUDY | DESCRIPTION

<table>
<thead>
<tr>
<th><strong>Potentially transformational (cont.)</strong></th>
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</table>
| Morocco – Concentrated Solar Power | Well designed regulatory policy to encourage competition among private developments, along with a specialized government institution to support, fund, and act as power buyer from Concentrated Solar Power installations led to the development of a 160 MW CSP plant, the first of what could eventually be a 500 MW facility. The government successfully encouraged private competition and the winning developer’s tariff bid was 25 percent below initial cost projections. With the plant still under construction, it is too soon to declare success. If it is completed on time and within budget, and helps spur other CSP development, it would be transformative.  

Falconer and Frisari (2012); Frisani and Falconer (2013); de Nevers (2013). |

| Sweden – wind | Jädraås Windfarm was the largest onshore wind development in Scandinavia when commissioned in 2013. State policies and Danish export credit guarantees helped mobilize significant private investment despite many banks being unwilling to lend in the economic crisis. The model has been replicated in one other project in Sweden, and in a development in Belgium. The financing arrangements would need to be simplified to make the approach more attractive to institutional investors in order for the model to be considered fully transformational.  

Boyd and Morgan (2013). |

| United Kingdom - wind | The UK is the world leader in offshore wind, with 4.5 GW installed by the end of 2014, more capacity than the rest of the world combined. In 2014, offshore wind generated 11.5 TWh, 3.3 percent of the country’s electricity demand, providing enough power for 10 percent of British households. Offshore wind development brings a number of additional investment risks, and the UK has been a pioneer in addressing barriers. The UK’s long-term GHG emissions reduction target, codified in law through the 2008 Climate Change Act, provides investment certainty, while tradable renewable energy certificates provide financial incentives for investors. In the case of the 367.2 MW Walney Offshore Wind Farm, the largest offshore project in the world at the time of commissioning (since superseded by another UK project, the 630 MW London Array), the developer used complex financial engineering to allocate project risk and attract nontraditional investors, including private equity and pension funds. However, continued policy uncertainty and a number of high-profile project cancellations, in the context of the UK’s overall mixed record in renewable energy (see Box 3), mean this case cannot yet be deemed transformational.  

Belgium. The financing arrangements would need to be simplified to make the approach more attractive to institutional investors in order for the model to be considered fully transformational.  

Falconer and Frisari (2012); Frisani and Falconer (2013); de Nevers (2013). |

| Kenya – geothermal | Kenya had 600 MW of geothermal capacity installed at the end of 2014, more than half of which was installed in 2014. A further 1 GW of projects are in development. Kenya’s geothermal potential is assessed at 10 GW, and the government has targets to add 2.5 GW by 2020-2021 and 5.3 GW by 2030, sufficient to meet more than a quarter of peak demand. A fixed 20-year feed-in tariff for renewable energy was introduced in 2008, but only in 2010 was it revised to include geothermal. Further reforms to the policy in 2012 introduced a standardized PPA with the aim of streamlining the permitting processes. These reforms appear to have successfully stimulated investment in the sector, with $1.7 billion in geothermal project investment in both 2010 and 2012; however there was zero clean energy investment in 2011 and less than $200 million in geothermal in 2013. A more coherent and consistent policy framework could ensure continued investment in geothermal energy.  

Well designed regulatory policy to encourage competition among private developments, along with a specialized government institution to support, fund, and act as power buyer from Concentrated Solar Power installations led to the development of a 160 MW CSP plant, the first of what could eventually be a 500 MW facility. The government successfully encouraged private competition and the winning developer’s tariff bid was 25 percent below initial cost projections. With the plant still under construction, it is too soon to declare success. If it is completed on time and within budget, and helps spur other CSP development, it would be transformative.  

Falconer and Frisari (2012); Frisani and Falconer (2013); de Nevers (2013). |

| Philippines – renewable energy | The Philippines already has a large proportion of renewable energy—28 percent of electricity generation in 2014—driven in part by a lack of domestic fossil-fuel resources. Existing renewable energy is primarily geothermal, hydropower, and biomass. The National Renewable Energy Program aims to triple its 2010 renewable electricity capacity to 15.3 GW by 2030, with specific technology targets for hydro, geothermal, and wind to ensure diversification. The 2008 Renewable Energy Act includes a comprehensive range of incentive mechanisms including a feed-in tariff, net metering, renewable portfolio standards, tax relief, and reduced transmission charges. However, political opposition has delayed implementation, with the feed-in tariff rates approved only in 2012, four years after the Act was passed. Notwithstanding the delay, the tariff is designed with built-in review mechanisms to ensure that it is responsive to market development, which should help control the fiscal burden. Problems with planning coordination, lack of technical expertise, and infrastructural barriers continue to delay renewable energy deployment. However, the number of successful projects, particularly in solar and wind, is increasing where local communities, NGOs, and the private sector have been able to participate fully in their development.  


### Missed opportunities or early stage development

| Kenya – geothermal | Kenya had 600 MW of geothermal capacity installed at the end of 2014, more than half of which was installed in 2014. A further 1 GW of projects are in development. Kenya’s geothermal potential is assessed at 10 GW, and the government has targets to add 2.5 GW by 2020-2021 and 5.3 GW by 2030, sufficient to meet more than a quarter of peak demand. A fixed 20-year feed-in tariff for renewable energy was introduced in 2008, but only in 2010 was it revised to include geothermal. Further reforms to the policy in 2012 introduced a standardized PPA with the aim of streamlining the permitting processes. These reforms appear to have successfully stimulated investment in the sector, with $1.7 billion in geothermal project investment in both 2010 and 2012; however there was zero clean energy investment in 2011 and less than $200 million in geothermal in 2013. A more coherent and consistent policy framework could ensure continued investment in geothermal energy.  

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Falconer and Frisari (2012); Frisani and Falconer (2013); de Nevers (2013). |

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### Notes

1. NRDC, BNEF, and Valgesta Energía (2011).
3. Morris and Pehnt (2015); Singer et al. (2013); Barua et al. (2014).
4. Polycarp et al. (2013d); Davis et al. (2012); BNEF et al. (2014); REN21 (2015).
5. REN21 (2015); Forense (2013); Spatuzza (2014); BNEF et al. (2014).
6. Polycarp et al. (2013e); UNEP (2006); Balachandra et al. (2010).
10. Srivastava and Venugopal (2014); BNEF et al. (2014); REN21 (2015).
REFERENCES


ABBREVIATIONS

ADB  Asian Development Bank
CIFs  Climate Investment Funds
CO₂e  carbon dioxide equivalent
CPI  Climate Policy Initiative
CSP  concentrated solar power
CTF  Clean Technology Fund
DFID  Department for International Development (UK)
DKK  Danish Krone
DSM  demand-side management
ECF  Energy Conservation Promotion Fund (Thailand)
EERF  Energy Efficiency Revolving Fund (Thailand)
EU  European Union
FY  financial year
GCF  Green Climate Fund
GDP  gross domestic product
GEF  Global Environment Facility
GHG  greenhouse gas
GIZ  Gesellschaft für Internationale Zusammenarbeit (Germany)
Gt  gigaton
GW  gigawatt
GWh  gigawatt-hour
IDCOL  Infrastructure Development Company Ltd. (Bangladesh)
IEA  International Energy Agency
IMF  International Monetary Fund
IPCC  Intergovernmental Panel on Climate Change
IRP  Integrated Resource Plan (South Africa)
JICA  Japan International Cooperation Agency
KW  KfW Development Bank (Germany)
kJ  kilojoule
Ktoe  kiloton of oil equivalent
kW  kilowatt
kWh  kilowatt-hour
LCOE  levelized cost of energy
m²  square meters
MW  megawatt
MWh  megawatt-hour
NCE  New Climate Economy (Global Commission on the Economy and Climate)
OECD  Organisation for Economic Co-operation and Development
Prosol  Programme Solaire (Tunisia)
PV  photovoltaic
R&D  Research and Development
SHS  solar household system
UK  United Kingdom of Great Britain and Northern Ireland
UNDP  United Nations Development Programme
UNEP  United Nations Environment Programme
U.S.  United States of America
USAID  U.S. Agency for International Development
UTE  Usinas y Trasmisiones (Uruguay)
VRE  variable renewable energy
Wp  Watts peak (power rating for solar PV)
WRI  World Resources Institute

ENDNOTES

1. Levelized cost of energy (LCOE), the price of energy output (usually per kWh for electricity) that includes the net costs and revenues over the lifetime of a project. LCOE does not account for costs or benefits to the electricity grid once connected. See REN21 (2015).

2. A procurement process, also known as “competitive bidding” or “tendering,” by which public authorities solicit bids for renewable energy generation or capacity, with sellers competing to offer the lowest price they would be willing to accept. Typically, prices are still above market rates though in some countries, such as Brazil, reverse auctions have delivered lower prices. See REN21 (2015).

3. Feed-in tariffs provide a guaranteed minimum price per unit of energy (normally kWh or MWh) over a stated period so renewable electricity can be sold and fed into the electricity network, normally with guaranteed grid access. See REN21 (2015).

4. Feed-in premiums are in historic prices. Conversions to US$ use the UN Operational Rate of Exchange as at June 1, 2014 of US$1 = DKK5.489. Available at: http://treasury.un.org/operationalrates/OperationalRates.aspx.

5. Annual net consumption was 139.05 billion kWh in 2011. See EIA (2014).

6. PV capacity and output in AC power. Solar PV produces power in DC and a small percentage is lost in the conversion to AC, which electricity grids run on. Most countries report PV figures as DC power, so this should be taken into account when making comparisons with other countries.

7. Feed-in premium is an amount paid in addition to the market price for renewable electricity fed into the grid. Fixed feed-in premiums are subject to greater risk since they fluctuate according to the market price, whereas feed-in tariffs pay a fixed amount per unit of generation, offering greater stability. See REN21 (2015).

8. A procurement process, also known as “competitive bidding” or “tendering,” by which public authorities solicit bids for renewable energy generation or capacity, with sellers competing to offer the lowest price they would be willing to accept. Typically, prices are still above market rates though in some countries, such as Brazil, reverse auctions have delivered lower prices. See REN21 (2015).

9. A Renewable Portfolio Standard is a measure requiring that a minimum percentage of total electricity or heat sold, or generation capacity installed, be provided using renewable energy sources. A feed-in tariff is a policy that sets a fixed, guaranteed price (often structured as a US$/kWh payment) over a stated fixed-term period when renewable power can be sold and fed into the electricity network. A Renewable Energy Credit is a certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). Where they are employed, RECs can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. See REN21 (2015).

10. Based on ordinary least squares regression in R (Version 3.0.2). The R² value is 0.53, which indicates that more than 50% in the variance of emissions intensity across countries is explained solely by fossil-fuel subsidies (p value is < 10-16). The result is the same if robust regression is used, which removes the influence of outliers.

11. Tenor refers to loan duration.
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ABOUT WRI

WRI is a global research organization that works closely with leaders to turn big ideas into action to sustain a healthy environment—the foundation of economic opportunity and human well-being.

Our Challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth’s resources at rates that are not sustainable, endangering economies and people’s lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach
COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT
We don’t think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people’s lives and sustain a healthy environment.