IRENA
International Renewable Energy Agency

Adapting Renewable Energy Policies To Dynamic Market Conditions

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. *www.irena.org*

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Supporting entity: Bloomberg New Energy Finance (BNEF) provides analysis, tools and data for decision makers driving change in the energy system.

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This report is available for download from www.irena.org/Publications.

Foreword

A combination of effective support policies, high learning rates and rapidly decreasing technology costs has enabled the accelerated deployment of renewables globally. Renewables now make up a distinct share of the energy mix in several countries with further substantial growth anticipated in the coming decades. This ongoing transition of the energy sector opens up new opportunities for governments to reap the long-standing benefits of a sustainable energy system. Ensuring an effective and rapid transition, however, is a challenge faced by policy makers today. This requires the timely adaptation of policies to the dynamic market conditions caused by changing costs, growing deployment and increasing variable generation.

IRENA's report - *Adapting renewable energy policies to dynamic market conditions* - identifies key challenges faced by policy makers due to renewable energy market dynamics and analyses policy adaptation responses to address them. The study builds upon diverse country experiences and provides a framework for understanding the conditions under which policy measures to support growing shares of renewables in the energy mix can be optimised.

The report shows that with decreasing cost of renewable energy technologies, governments are adapting policy measures to ensure that incentives are appropriately set while increasing transparency and stability within the sector. The country case studies presented here demonstrate how such measures contribute to ensuring that the growth of the sector remains sustainable and cost-efficient in the long-term.

The report highlights the importance of adopting a systemic approach to policy-making in order to reach high shares of renewables. Integration of variable renewables are known to have system-wide impacts which intensify as deployment grows. Technical measures, such as development of grid infrastructure, smart technologies and storage as well as adequate regulatory interventions facilitate integration efforts. The report also highlights that the growth in decentralised generation, driven by approaching grid parity and adoption of enabling policies, is transforming the traditional ownership structures within the energy sector. This presents new challenges for incumbent stakeholders, which need to be accounted for in the policy-making process to allow a smooth market integration of renewables and ensure the long-term reliability of the energy system.

I am confident that the findings from this study will contribute to the ongoing discussions on pathways to further increase the share of renewable energy in the global energy system. The lessons laid out in the report can serve as an important reference point for countries at different stages of renewable energy market development.

Adnan Z. Amin
Director - General of International Renewable Energy Agency

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Acronyms

AC	Alternating Current
AEEG	Italy's Regulatory Authority for Electricity and Gas
APS	Arizona Public Service
BNEF	Bloomberg New Energy Finance
BNetzA	German Federal Network Agency
BRL	Brazilian real
Capex	Capital Expenditure
c-Si	Crystalline silicon
CRS	U.S. Congressional Research Service
CSP	Concentrating solar thermal power
DKK	Danish krone
DSO	Distribution system operator
DR	Demand response
EEG	Germany's Renewable Energy Sources Act
EUR	Euro
EV	Electric vehicle
FiP	Feed-in Premium
FiT	Feed-in Tariff
GBI	Generation Based Incentive
GBP	British Pound
GSE	Gestore Servizi Energetici
GW	Gigawatt
H1, H2	First half, second half (of a given year)
HVDC	High-voltage direct current
IPP	Independent power producer
IRENA	International Renewable Energy Agency
ITC	U.S. Investment Tax Credit
KRW	South Korean won
kW	kilowatt
kWh	kilowatt-hour
LCF	U.K.'s Levy Control Framework
LCOE	Levelised cost of energy
MW	Megawatt
MWh	Megawatt-hour
NIS	Israeli sheqel
O&M	operations and maintenance
OECD	Organisation for Economic Co-operation and Development
PJM	PJM Interconnection LLC
PPA	Power purchase agreement
PROINFA	Brazil's Programme of Incentives for Alternative Electricity Sources
PTC	U.S. Production Tax Credit
PUA	Israel's Public Utilities Authority
PV	Photovoltaic
Q1, Q2	First quarter, second quarter (of a given year)

R&D	Research and development
RD&D	Research, development and deployment
RDL	Spain's Royal Decree Law
SDE+	Netherlands' Stimulering Duurzame Energieproductie
SEDA	Malaysia's Sustainable Energy Development Authority
TSO	Transmission system operator
UK	United Kingdom
USD	U.S. dollars
VOS	Value of Solar
W	Watt
Wp	Watt-peak
WTPI	BNEF's Wind Turbine Price Index

Executive Summary

The conditions affecting renewable energy policy-making have shifted dramatically within a very short time span. In some countries and jurisdictions, rapidly declining renewable generation costs have made it challenging to set "appropriate" levels of public support. In others, the proliferation of renewables is having unanticipated consequences for power grids and markets. Meanwhile, almost everywhere, tighter post-recession fiscal conditions have meant that fewer funds are available to support the industry.

These conditions have prompted policy makers to reconsider how they support renewable energy development and deployment. This has resulted in the adoption of innovative policy design features as well as in the introduction of a new generation of support policies that are crafted to be compatible with the ongoing transformation. Such policies are intended to be transparent and impactful, with emphasis on flexibility, efficiency and cost effectiveness.

This report sets out to provide an overview of selected challenges emerging from dynamic markets and policy responses being adopted to address them. In particular, it identifies four key challenges faced by policy makers today: 1) accounting for rapidly falling renewable generation costs, 2) addressing tax/rate-payer burdens, 3) accounting for renewable energy's cost competitiveness, and 4) integrating variable renewable power. For each of the challenges, innovative policies being implemented or proposed around the world are analysed with the aim to assess their recent or potential impact and to highlight their potential risks. Through the analysis, the report gathers "lessons learned". A framework is then presented that allows policy makers to assess the suitability of specific policies to different contexts.

Accounting for rapidly falling renewable generation costs

The sharp fall in renewable energy equipment costs, while a positive trend, presents challenges for policy makers to ensure that support measures are kept effective and efficient. A fine balance needs to be maintained between implementing mechanisms that allow for cost tracking and maintaining a stable environment for investments into the sector. In attaining that balance, countries have either implemented design features into existing policies, such as degression rate in feed-in tariffs, or introduced new policies altogether, such as auction schemes. Some lessons that can be learned from country experiences include the following:

- Adaptation policies that integrate technology cost-tracking features (e.g. degression schemes, auctions, etc.) provide transparency and predictability to market participants.

- The design stage of policies benefit from active engagement with stakeholders within the sector to clearly communicate the intended policy objectives and to better calibrate specific policy elements, such as tariff revision frequency, degression rates, etc.

- Market-based policy support mechanisms, such as auctions, are gaining increasing prominence as a way of reducing information asymmetry between governments and developers on generation costs. When well designed, these can be critical to identify the appropriate level of public support and also contribute to more predictability in the sector.

Addressing tax/rate-payer burdens

The substantial growth that has been experienced by the renewable energy sector during the past decade has mostly been a result of financial support offered by "early-adopters". These countries recognized the long-term benefits of renewables from an environmental, economic and social standpoint. The support for renewables is a means of internalising external costs not accounted for in traditional energy markets. Resilient support for the sector translated into the scale-up in deployment, thereby leading to a substantial decrease in technology costs and the development of the renewable energy industry. This results in relatively less support required for further deployment. It is, however, important to ensure that the cost of support is kept under control and that it is distributed fairly across the different stakeholders. As a result, several countries have adopted spending caps on support for renewables directly or indirectly (through deployment caps) which are often complementary to other deployment policies. The analysis of country responses to address this challenge yields the following lessons learned:

» Limiting the cost of renewables support gains importance as the market expands and deployment grows. While providing higher support levels may be important to kick-off new technology deployment, it is essential that the costs are closely monitored as the share of renewables rises.

» Somewhat counterintuitively, capping support may improve rather than diminish investor confidence in a market, as it provides long-term predictability to the market.

» When designing spending control measures, a critical element is the distribution of costs across different stakeholders. Controlling costs is as important for high-income countries concerned about their economic competitiveness as for middle- or low-income countries focussed on basic economic development.

Accounting for renewable energies' cost competitiveness

As renewable energy costs continue to decline and grid parity is attained in different countries, a new era of policies will be necessary to ensure the further expansion of renewables in the energy mix. Support measures in a 'post-parity' era will need to transition from being purely financial-based to those that are compatible with the overall system of renewables promotion and the general structure of the electricity system. The report analyses the role of policies, such as net metering, that can play an instrumental role in promoting the deployment of decentralised renewable energy. Net metering schemes are being widely adopted globally and while their design features might vary, innovation is afoot on ways to address specific challenges associated with distributing costs between consumers with or without renewable systems. Some of the lessons learned from country experiences include:

» Net metering policies can drive residential solar PV adoption, particularly in markets characterised by relatively high electricity prices. However, policy design needs to carefully consider the "reconciliation period" (i.e., for how long the project owners can claim back thee credit generated by the electricity fed into the grid) to avoid unintended consequences for grid stability.

» Policy makers need to estimate in a timely manner technical and economic impacts of massive deployment of decentralised systems on transmission and distribution systems in order to ensure reliability of supply and efficient management of the electricity system.

» Residential-size storage systems present important opportunities to promote self-consumption and better integrate electricity from distributed projects into the grid. Their widespread adoption will mostly depend on the decrease in the cost of storage technology.

Integrating variable renewable power

Effective and efficient integration – in terms of physical connection, network management and market integration – is necessary to allow an increase in the share of renewables in the energy mix. Integration of variable generation can become a pressing challenge for the sector, particularly in markets or regions with higher rates of renewable penetration. Grid integration needs to be supported by technical and economic measures. Those include planning for and investing in physical grid development and enhancement, promoting grid-scale storage and smart infrastructures, and defining new market designs that consider the broad market-wide impacts of integrating variable renewables. The analysis of country case studies on these issues yield the following lessons:

» Inadequate grid infrastructure development can lead to geographically uneven renewable energy capacity deployment, mismatch between transmission and generation capacity, and significant cost for system balancing. The lead time associated with developing the infrastructure to facilitate grid evacuation and transfer can be relatively long and, hence, needs to be accounted for in the planning process. "Passive" development of infrastructure can increase costs, lead to stranded generation assets and hurt investor confidence in the long term.

» Emerging technologies, such as smart grids, smart meters, storage applications, will play pivotal roles in managing the system to enable further integration of renewable power while maintaining supply reliability.

» Integrating high shares of zero- or low- marginal-cost renewable power into power markets can affect the competitiveness of conventional "mid-merit" or "peak" plants. Providing dispatchable capacity remuneration in some cases may prove necessary, but it is important to ensure that such schemes incentivise only the needed capacity and, if possible, the different forms of capacity – generation as well as demand response, potentially storage, etc.

Analytical framework

The report presents analytical frameworks or "prisms" which policy makers can use to assess which renewable energy policy adaptation mechanisms analysed in this report might be best suited for the circumstances in their countries. The prisms are based on country experience and on how policies have been implemented in different contexts. it is acknowledged that policies or policy types generally do not fit neatly into clearly defined boxes. The "prisms" adopted, however, are intended to serve as rudimentary tools for policy-making. An example of such a framework is illustrated below. It compares the type of policy adaptation mechanisms which could be best suited for jurisdictions where renewables have achieved "low", "medium" or "high" penetration rates.

Other "prisms" seek to identify relevant policy types for contexts that are: 1) at varying levels of economic development (low, middle, or high); 2) interested in supporting specific technologies (wind, solar, smart grid, storage and others); or 3) seeking to craft policies that affect various asset owners (utilities, independent power producers, community/ residential consumers or commercial customers).

Policies best suited for differing levels of renewable energy penetration

<table>
<tr><th rowspan="2"></th><th colspan="4">RENEWABLE ENERGY PENETRATION</th></tr>
<tr><th>LOW</th><th colspan="2">MEDIUM</th><th>HIGH</th></tr>
<tr><td rowspan="13">POLICIES</td><td colspan="4">Integrating 'real time capacity corridors' into the feed-in tariff reduction structure (1.2.1.)</td></tr>
<tr><td colspan="4">Holding auctions for power contracts (1.2.3.)</td></tr>
<tr><td colspan="4">Designing flexible tax policies (1.2.4.)</td></tr>
<tr><td colspan="4">"Value of Solar" tariff (3.2.2.)</td></tr>
<tr><td colspan="4">Permitting net metering (3.2.1.)</td></tr>
<tr><td colspan="2">Grid development plan - India (4.2.1.)</td><td colspan="2">Grid development plan - Germany (4.2.2.)</td></tr>
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<tr><td colspan="2" rowspan="2"></td><td colspan="2">Integrating residential storage in the system (3.2.3.)</td></tr>
<tr><td colspan="2">Demand response programmes (4.2.7.)</td></tr>
<tr><td colspan="3" rowspan="4"></td><td>Offshore wind connection liability arrangement (4.2.3.)</td></tr>
<tr><td>Smart grid implementation and smart meter rollouts (4.2.4.)</td></tr>
<tr><td>Grid scale energy storage (4.2.5.)</td></tr>
<tr><td>Capacity mechanisms (4.2.6.)</td></tr>
<tr><td rowspan="6">GOALS</td><td colspan="4">PROVIDE ADEQUATE SUPPORT FOR RENEWABLES</td></tr>
<tr><td colspan="4">MINIMISE COST</td></tr>
<tr><td colspan="4">TRIGGER TECHNOLOGY INNOVATION</td></tr>
<tr><td colspan="4">INCENTIVISE SELF -CONSUMPTION</td></tr>
<tr><td colspan="4">ENSURE SECURITY AND RELIABILITY OF POWER SUPPLY</td></tr>
<tr><td colspan="4">IMPROVE MARKET INTEGRATION OF RENEWABLES</td></tr>
</table>

Note: The degree of blue shading indicates how appropriate the goal is for each level of renewables penetration (for example, improved market integration of renewable power applies more to the most mature markets). A reference to the individual sub-sections from the report has been included for each policy.

Like with any policy-making, there is no one-size-fits-all solution for renewable energy. Each country is unique with its own set of characteristics that influence how public policies are crafted and implemented. Still, today a common set of dynamics is having global impact. And, just as importantly, a variety of innovative policy responses are being set in motion in various corners of the world. While some of these renewable energy policies are relatively recent, they hold great potential to support the industry as it advances to its next, all-important phase of development, in which it attempts to compete with more traditional forms of generation in a post-parity era.

Introduction

Policy support has played a critical role in spurring both a scale-up in renewable energy capacity deployment and a major industry expansion. At one time, designing these schemes appeared to be relatively straightforward to legislators and regulators. Some renewable energy technology costs were high and their deployment levels were low. In countries with governments that were committed to promoting renewables, market-creating measures, such as feed-in tariffs (FiTs) and tax credits, were widely adopted.

In just a few years, the situation has changed dramatically in many countries. Rapidly falling costs for renewable technologies, particularly for solar photovoltaics (PV) and onshore wind, have caused spikes in installation levels. Unexpected side effects have included inflated government financial liabilities and/or higher consumer electricity bills. In countries with the largest share of variable renewable generation in their energy mix, rapid renewables deployment has highlighted an urgent need for upgrades and extensions to grid infrastructure.

In some cases, these unintended results have left policy makers with little choice but to react post-factum and change the support schemes in place. In Europe, governments are addressing the issue through comprehensive reviews, in some cases resulting in retroactive FiT cuts. In the United States, costs associated with the Production Tax Credit partly led to the its expiration at the end of 2013. In Australia, states have cut support for solar in the wake of higher-than-anticipated installation rates. All of this has raised market uncertainty and lowered investor confidence.

Now, however, a new wave of policy innovation is under way around the world as policy makers seek to craft supports that are not just transparent and impactful, but also tailored to the new realities of the market. More than ever, the emphasis is on flexibility, efficiency and cost effectiveness. These interesting – and potentially transformative – new efforts are the subject of this report.

This report pursues three objectives. First, it aims to profile renewable energy market dynamics which policy makers should take into account when designing new policy frameworks. These include: rapidly falling renewable energy equipment costs (Section 1), impact of support schemes on national budgets and/or consumer electricity bills (Section 2), approaching grid parity for renewable energy technologies (Section 3), integration of variable renewable generation and broader power market design considerations (Section 4).

Second, this report highlights interesting and potentially innovative policies that seek to address the challenges emanating from the market dynamics discussed earlier. These include flexible tariff or tax schemes which take into account "real-world" costs, auctions to enhance price discovery and other solutions. The result can be better controls over the amount of renewable energy which is deployed in certain time frames and at certain costs. The report provides background and assessments of each of the highlighted measures as well as the potential risks associated with implementation.

Finally, the report draws preliminary conclusions about which of these types of policies might be best suited for different types of markets, situations or countries, given differing economic, political and power market structures. The conclusions are preliminary also because some of the policy ideas discussed in this report are relatively new. Some solutions may be best for countries with state-run utilities and lower levels of electrification. Others may be a better fit for countries with liberalised power markets and high connectivity rates. The report concludes with basic "prisms" which policy makers can use to assess the types of renewable energy policy solutions that might be best suited for the circumstances in their countries.

Methodology

The analysis focusses on broad challenges which policy makers may face when contemplating renewable energy policy frameworks, with a particular focus on electricity. These apply to a wide range of countries, depending on the level of economic development, degree of renewable energy penetration, power market structure and other factors. Four key challenges have been identified, which are addressed in the next four sections:

1. Rapidly falling renewable generation costs have made it difficult to calibrate public sector supports to appropriate levels in recent years.

2. Support schemes that have been successful in spurring renewables deployment have in some cases proven to be relatively expensive contributing to consumer/tax-payer burdens.

3. Approaching (and in some locations, the arrival of) "socket parity" for solar PV and growth in decentralised generation has resulted in unanticipated competition between distributed generators and incumbent generators.

4. Growing levels of variable renewable generation are placing strains on certain national grids and power markets which are generally unequipped to accommodate variable sources of power.

For each of these challenges, the report analyses examples of countries or other jurisdictions that have pursued novel policy approaches to address them. Such policies have been selected either because they have a proven track record of addressing the particular challenge, or because they sought to bring relatively new ideas to address it. These policy approaches are categorised by the challenges they seek to address. Each scheme profiled includes:

- Policy Overview – an explanation of what the measure is, who it affects and what objectives it aims to achieve.

- Impact Assessment – an assessment of the policy's impacts as it can be measured, including measures implemented in response to the challenges outlined above.

- Risk Assessment – an examination of potential factors that might undermine a new policy scheme's success.

In the case of the latter two, the report provides the best information available on impacts to date and speculates to some degree about potential risks. In a number of cases, the policies highlighted have been adopted recently, and it remains to be seen how beneficial they will prove to be.

Each policy outlined in the report is assessed based on seven selected indicators (see Table on the next page). These are presented as a box alongside the respective policy section and aim to highlight the characteristics of markets where such a policy might fit best.

Of these indicators, the "policy goal" is potentially the most ambiguous, and thus the potential options merit further explanation. Given that policies often have multiple, overlapping aims, the following goals are not mutually exclusive:

- Providing adequate support for renewables – Ensuring that financial support aligns with real costs of power generation from particular technologies. Supports should provide sufficient help to incentivise investment when necessary but not to "overpay".

- Minimising cost of support – Ensuring that costs associated with supporting renewables are minimised and distributed equitably. Often, such costs result in surcharges on electricity bills or taxes. Determining who pays is an important part of determining cost.

- Incentivising self-consumption – Where grid parity is already a reality, policy makers can empower consumers to become producers by providing appropriate regulatory frameworks.

INDICATOR	KEY QUESTION	INDICATORS
Penetration level of variable renewables	How advanced is the market where this policy has been implemented, in terms of renewables deployment in the generation mix?	» Low (<5% renewable energy vs. total annual generation) » Medium (5-20%) » High (>20%) This measure refers primarily to variable renewable sources and hence excludes large-hydro
Economic development	How economically advanced are the countries and jurisdictions where this policy has been implemented?	» Low income » Middle income » High income (World Bank, 2013)
Policy goal	What is the policy's primary objective?	» Provide adequate support for renewables » Minimise cost of support » Incentivise self-consumption » Improve market integration of renewables » Ensure security and reliability of power supply » Trigger technology innovation
Policy type	What mechanism does the policy use to accomplish its goals?	Feed-in tariff, market premium, tax-based incentive, net metering, auctions, Renewable Portfolio Standards (quota schemes), ring-fence budget, grant, soft-loan, grid regulation, market regulation, smart meter rollout, regulated investment return, strategic reserve, capacity mechanism, demand-response incentive.
Eligible technologies	Which technologies can benefit from – or are affected by – the policy discussed?	All renewable energy technologies, grid, smart meters, storage
Asset ownership	Who owns the generating assets affected by the policy?	» Utilities » Independent power producers (IPPs) » Private owners (individuals, farmers, residential, etc.) » Community (clusters of individuals, community-based organisations, etc.) » Businesses (owned by commercial entities, used at least partly for self-consumption) » Investment funds/banks
Complementary policies	What associated policies (if any) help this policy succeed?	A list of policies that can be implemented in concert with the case study.

» **Ensuring security and reliability of power supply** – Providing adequate transmission and distribution infrastructure and adequate load management mechanisms, to ensure that the grid system is able to cope with higher levels of variable power without risking power supply disruptions.

» **Improving market integration of renewables** – Adjusting power market structures to ensure that renewable power is integrated and that sufficient back-up exists as necessary. This goal captures more-effective system balancing, demand management and storage incentives.

» **Accelerating innovation** - Creating an enabling environment for fostering innovation in technology design, production processes, deployment and operation. This contributes to increasing efficiency, cost reduction and enhancement of competitiveness.

Section 5 of the report uses these indicators to present analytical frameworks under which these novel policy approaches can be assessed. This is done through the presentation of "prisms" which policy makers can use when designing – or reforming – their policy frameworks for renewables, and broader power markets. These prisms map the indicators highlighted throughout the report against the policies presented to illustrate which schemes potentially make the most sense under specific conditions.

It is important to note that this report does not contain prescriptive conclusions or recommendations. In that sense, its dual aims are: 1) to highlight novel policy responses to the challenges that have arisen as the renewable energy industry has matured and 2) to shed some light on how these new policy tools might best be applied elsewhere.

This report builds on the analytical policy work conducted by IRENA and several other institutions and non-governmental organisations to date and represents original analysis and synthesis[7].

7 *Several figures presented in the report are derived from proprietary datasets created by Bloomberg New Energy Finance (BNEF).*

1 Accounting for Rapidly Falling Renewable Generation Costs

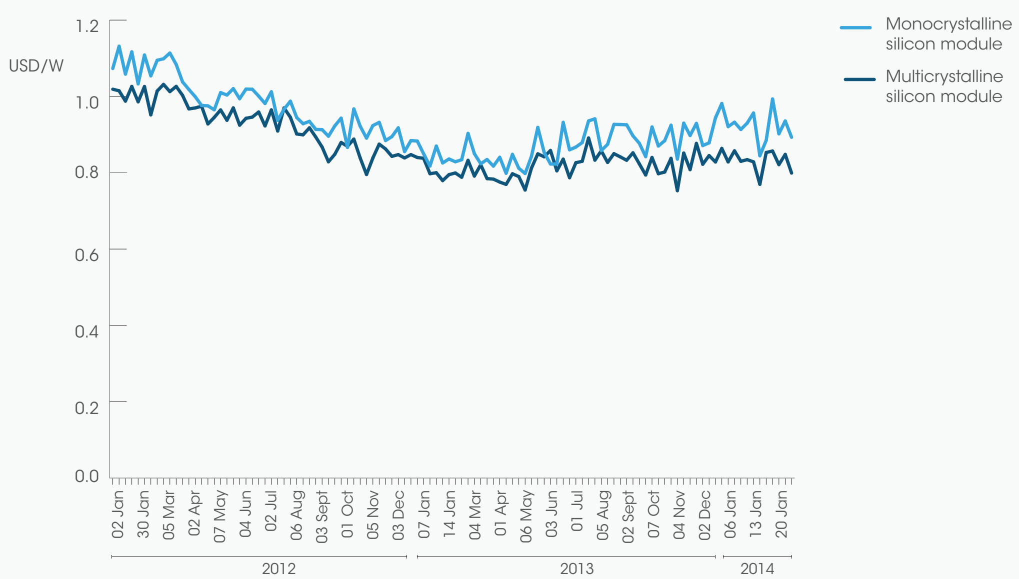
1.1 CHALLENGE: KEEPING PACE WITH COST DECLINES

Complex technological improvements and simple economies of scale have combined to drive down renewable energy equipment costs in recent years. Between December 2009 and December 2012, solar PV module prices declined by 65-70%. In 2012 alone, solar module prices dropped more than 20% (see Figure 1.1). This was also due to an expanding manufacturing overcapacity that peaked in 2010 when almost twice as much module production capacity existed globally compared to demand. Module prices stabilised in 2013 as manufacturers tried to return margins to sustainable levels. Despite an anticipated reduction in the global surplus of solar production capacity, the overall trend for solar is expected to continue to be characterised by falling technology costs due to the high learning rates for solar PV.

Wind turbine prices dropped by around one-quarter between 2009 and 2013 (see Figure 1.2). While prices are expected to level in 2014, the long-term downward trend is expected to resume due to learning-curve effects. As turbine sizes grow, more wind is harvested from a given site, meaning that even though price reductions per kilowatt (kW) may be more modest than in the past, the trend in delivered electricity costs will continue downwards at near-historical rates.

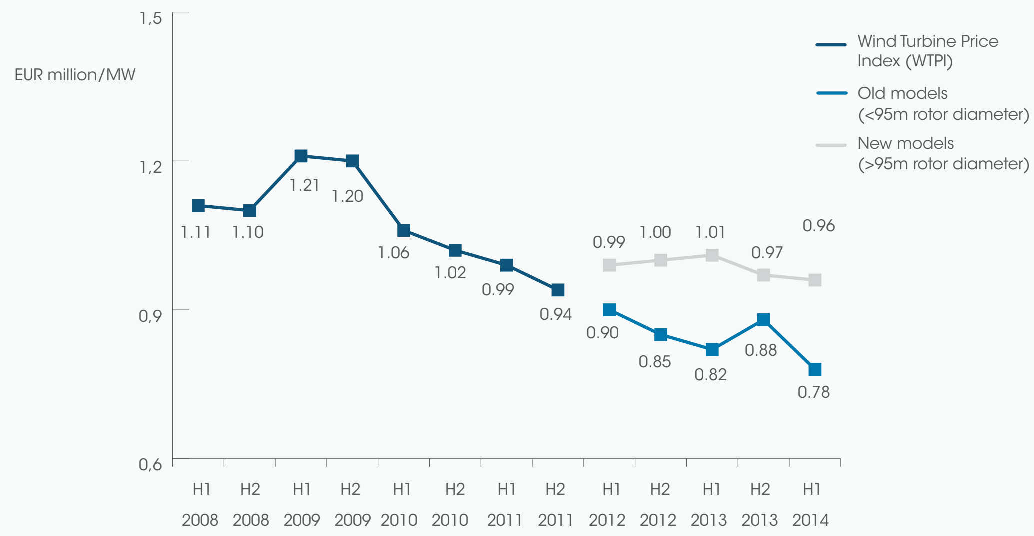
Another reason for the decline in prices is a dramatic improvement in the technologies used to manufacture equipment. Assembly lines have become more sophisticated, automated and efficient. But sheer economies of scale combined with major supply gluts are also important reasons. Until recently, roughly twice as much final capacity for wind turbine manufacturing was available around the world as demand for such equipment. The same was true for PV cells. As a result, manufacturers are faced with marginal profits on equipment sales. In some cases, manufacturers have actually sold equipment at a loss, a situation that is unsustainable over the long term. The capacity-demand gap has narrowed recently, allowing prices to stabilise and, in some cases, rise slightly.

Figure 1.1 Spot price of crystalline silicon modules, January 2012 – January 2014 (USD/W)



Source: BNEF solar price index.

Figure 1.2 Wind turbine price index, mean price by date of delivery, H1 2008 – H1 2014 (EUR million/MW)



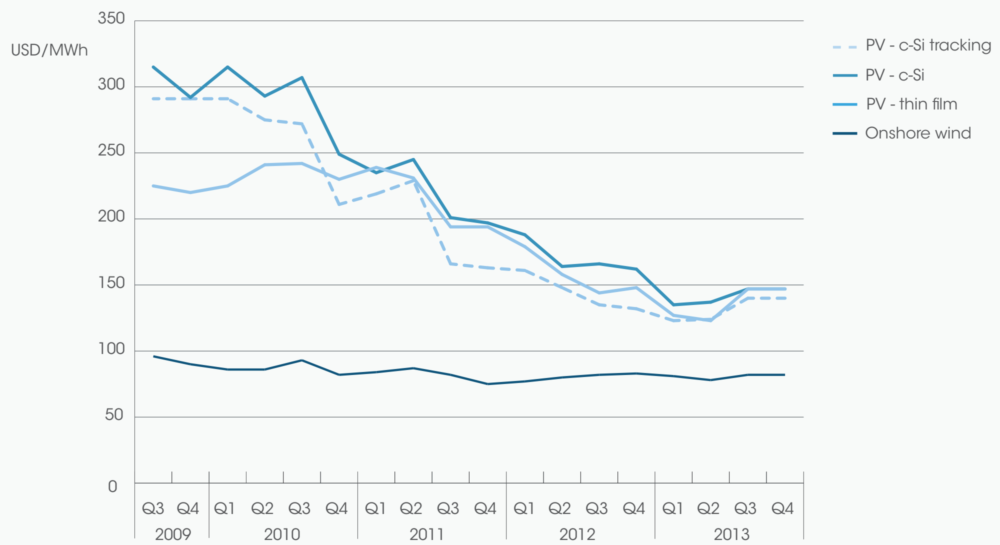
Source: BNEF Wind Turbine Price Index (WTPI).

Notes: Contract prices include turbine plus towers and transport to site, and they exclude value-added tax. Turbine contracts signed for delivery in China are excluded from this Index. "Old models" are those designed for the highest wind conditions. "New models" typically have longer blades and are designed for lower-speed conditions. Until H2 2011, BNEF tracked both varieties of turbines as one (the "WTPI" line).

Decreasing technology costs have translated into lower installed costs and cheaper electricity from renewables. As shown in Figure 1.3, the levelised cost of electricity for solar PV technologies and onshore wind has followed a downward trajectory. For solar PV, in particular, the decrease in the cost of generation is also linked to the production overcapacity that has existed in the industry over the past few years (see Figure 1.4).

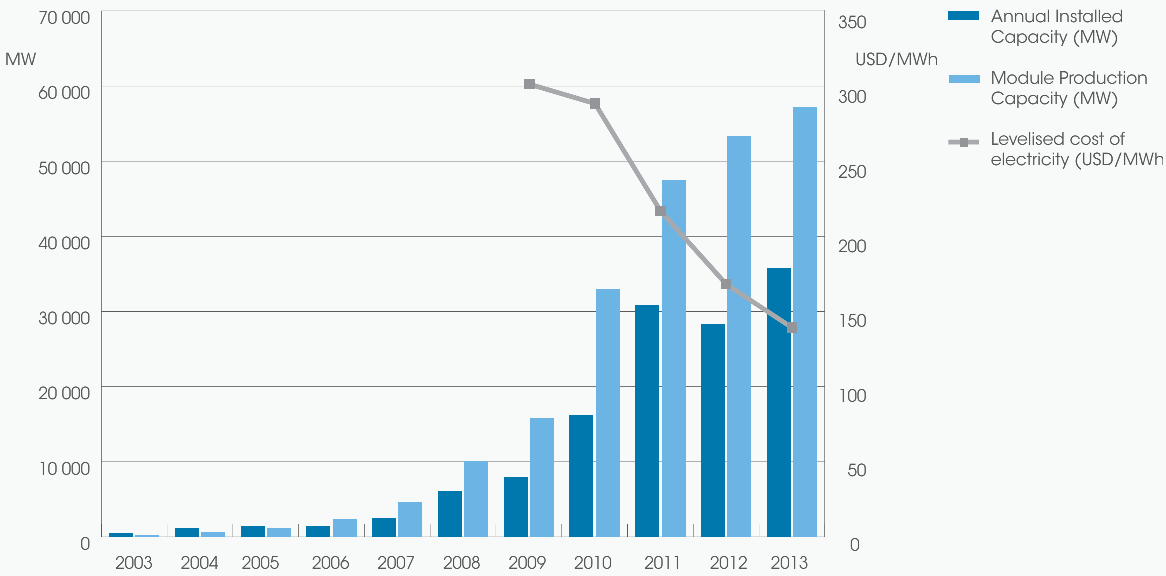
The virtuous cycle of high learning rates and increased deployment is driving down the costs of solar and wind technologies; meanwhile, hydropower, geothermal, and biomass for power

Figure 1.3 Levelised cost of electricity for select technologies, Q3 2009 – Q4 2013 (USD/MWh)



Source: BNEF.

Figure 1.4 Comparison of annual installed capacity of solar PV with module production capacity (MW) and levelised cost of electricity for c-Si solar PV (USD/MWh)

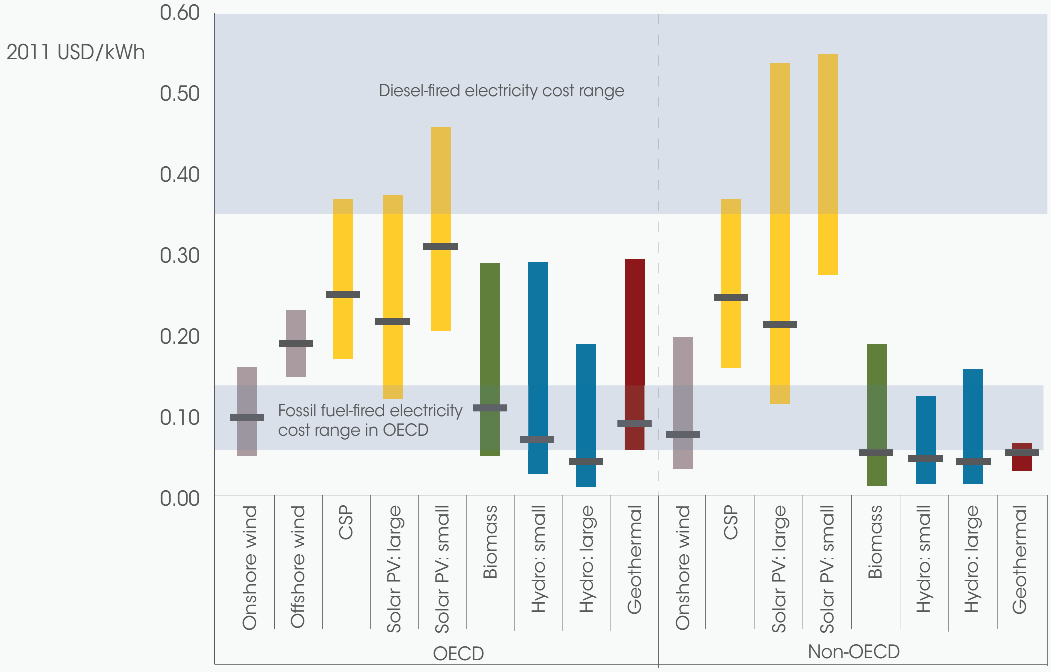


Source: GlobalData, 2014; BNEF.

generation are mature technologies. Renewables are now increasingly the most economic choice for new grid supply, and they are cheaper than alternatives in virtually any power system reliant on liquid fuels (*e.g.*, on islands) (see Figure 1.5).

The speed at which prices fell, although indisputably positive for developers and end-users, clearly caught some policy makers by surprise. The situation was further complicated by lag times between when policies were proposed, approved and implemented. In order to guard against windfall profits by developers and to protect consumers from unnecessary cost burden, policy makers are moving quickly to re-evaluate support programmes which were instituted at a time when equipment prices were much higher and were expected to decline more slowly.

Figure 1.5 Levelised cost of electricity ranges in OECD and non-OECD countries, 2012-2013 (USD/kWh)



Source: IRENA Costing Alliance.

Some governments have reacted quite radically to this challenge which was further compounded by the global economic crisis. They implemented sharp subsidy cuts, sometimes with retroactive effect. Others started thinking of creative ways of providing the necessary support for the renewables sector while ensuring that rate-payers or tax-payers see their funds used in the most efficient manner possible.

1.2 RESPONSES

This section presents a set of measures that have been adopted by various governments to address the challenge of keeping pace with decreasing costs of renewable energy technologies.

1.2.1 Integrating "real-time capacity corridors" into feed-in tariff reductions

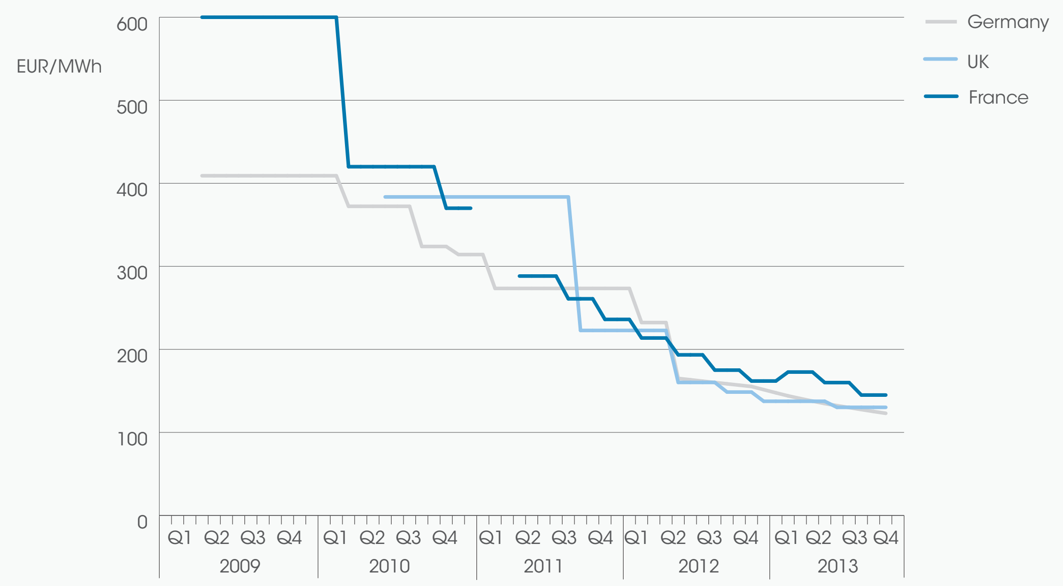
Policy overview: Degression mechanisms – or regular, administrative feed-in tariff rate reductions for new projects – are not new features in renewable energy policy-making and are typically implemented annually. However, in late 2011 and early 2012, some countries, such as Germany, France and the United Kingdom (U.K.), added important features to make their mechanisms more effective in tracking generation cost reductions while avoiding potential overcompensation. These features included maintaining real-time registries of deployment and introducing capacity corridors based on data from these registries.

Capacity corridors allow regulators to announce modifications in FiT levels on a pre-set periodic basis. The period for review varies among countries. Germany has opted for monthly reviews, while the U.K. and France review support levels every quarter. The capacity corridors determine the extent of change in the FiT level, which depends directly on the number of megawatts (MW) connected to the grid in the preceding period (see Box 1.1). To administer this, a special project registry had to be created and monitored to ensure that the changes are decided based on accurate and up-to-date information.

The U.K., French and German degression mechanisms differ in design, but they share the same aim: to limit capacity added to the grid to a manageable level and to align the support with the real costs of generating power from these projects. Figure 1.6 demonstrates the changes in the FiT levels in these three countries from adopting a degression mechanism. The smoother decrease in tariffs in the case of Germany has been achieved through the application of a degression rate on a monthly basis. This rate is set for each quarter based on PV deployment over a preceding 12-month period.

Impact assessment: Implementing a degression mechanism based on project registries and "real-time capacity corridors" has certain advantages. First, it provides governments with a clear picture on how attractive their tariffs are by highlighting how much

FIGURE 1.6 PV FIT DEGRESSION MECHANISM IN GERMANY, THE U.K. AND FRANCE, 2009-13 (EUR/MWh)



Source: BNEF based on data from Ofgem (UK), CRE (France) and BNETZA (Germany)
Note: The data gap between Q4 2010 and Q1 2011 in the case of France represents a three-month moratorium implemented to reassess FiT support.

Box 1.1

DEGRESSION MECHANISM FOR SOLAR PV FIT SUPPORT IN THE UK

As in most countries, the feed-in tariff policy in the UK is designed in a manner that once the system is installed and registered, the tariff levels remain fixed and are subject only to the inflation index. As deployment costs decrease, a mechanism for estimating the future FiT rate was established through a consultation process conducted in 2012. The mechanism adopts a three-pronged approach to estimate the level of support:

1. **Pre-planned degression:** The frequency was revised from an annual review of tariffs to a quarterly one. The degression takes place on a fixed date but the amount depends on the capacity deployed relative to pre-set capacity thresholds. The relevant deployment period considered is the quarter ending three months before the degression applies. The table below provides an overview of the deployment corridors and the degression factor which they trigger for different capacity bands.

	DEPLOYMENT CORRIDORS (MW PER QUARTER)				
Solar PV capacity band (kW)	Low	Default	High 1	High 2	High 3
<=10	0-100	100-200	200-250	250-300	>300
>10<=50	0-50	50-100	100-150	150-200	>200
>50	0-50	50-100	100-150	150-200	>200
Degression factor (% per quarter)	0%	3.5%	7%	14%	28%

2. **Contingent degression:** As evident from the table above, deployment under the 'low corridor' attracts zero degression. However, the mechanism put in place allows for the degression to be skipped only up to two consecutive periods, after which an automatic default rate (3.5%) applies.

3. **Annual reviews:** Tariff review is also conducted annually to ensure that the mechanism is operating efficiently and effectively in adequately supporting PV deployment.

A similar degression mechanism is applied to other technologies, including wind, anaerobic digestors and biogas, with different design characteristics depending on the technology maturity, volatility in deployment costs and policy objectives.

Source: (U.K. Department of Energy and Climate Change (DECC), 2012)

new capacity is actually being added to the system over a period of time. Second, they provide investors with clarity about the timing and the extent of tariff changes. The design also lowers longer-term political risk by reducing the likelihood of an uncontrollable boom which could lead a government to cut tariffs suddenly or even retroactively.

The German experience shows that the degression mechanism has been successful in accurately and timely tracking the decreasing cost of the technology, as depicted in Figure 1.7.

Furthermore, by aligning the tariffs more accurately and rapidly with falling technology costs, such a mechanism can accelerate the reduction of the amount that consumers pay per megawatt-hour (MWh) of electricity generated from PV plants. As tariff reductions are implemented more frequently, new projects receive lower support, minimising the impact on consumers' electricity bills. In Germany, this reduction was around 20% in 2013 (see Table 1.1).

Risks: The success of degression mechanisms depends on effective design and administration. The specific design features of the mechanism, such as the setting of degression rates, capacity corridors, capacity caps, and the time period between successive revisions, are critical for the success of this adaptation measure.

One of the primary design risks, as observed from the case of the U.K., is the possibility of situations where despite lower-than-expected (below capacity corridor) deployment, a degression is applied (even if in

Table 1.1 German FiT degression: impact on consumers

	2010	2011	2012	2013E
Cumulative installed PV capacity (MW)	17 103	24 588	32 192	35 292
Power output from German PV projects (GWh)	8 296	19 399	24 072	34 674
Impact on consumers – total EEG payments for PV (million EUR)	3 883	7 937	8 685	10 156
Cost to consumers per MWh of electricity generated from PV (EUR/MWh)	468	409	361	293

Source: Adapted from annual forecasts published by transmission system operators (TSOs) in Network-Transparenz, 2014. Figures are rounded up.

successive review rounds), further reducing the incentive for deployment (see Box 1.1). From an administration point of view, regulators in particular must operate timely project-by-project registries that are accurate and maintained in real time. Delays in the registries may result in lack of transparency and hence in misguided decisions. Moreover, any tariff degression mechanism needs to start from an appropriate "starting price". If the initial level is set too high, even an aggressive degression schedule would not prevent windfall profits, at least for a while.

Finally, the regulator must decide at which point in the project development the installations can apply and be awarded a feed-in tariff – often this is granted when planning permission is obtained. It is essential that after granting the tariff, a commissioning deadline is set. A significant lag between when the FiT is set and deliveries begin may create a windfall for the generator in a time of falling project costs.

POLICY INDICATOR

Renewables penetration: Low-medium-high

Economic development: Middle-high income

Policy goal: Provide adequate support for renewables; minimise cost

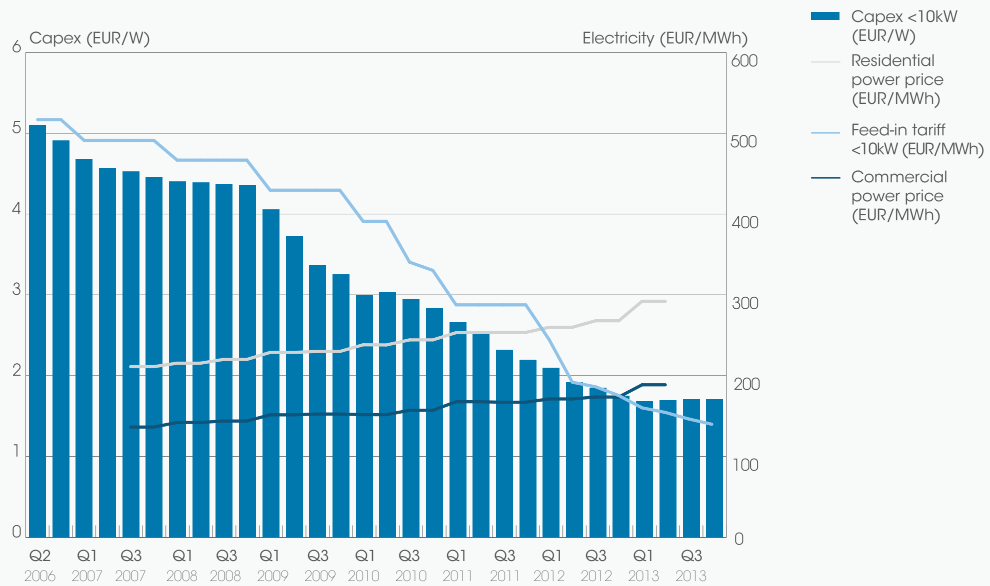
Policy type: Feed-in tariff

Eligible technologies: All renewable energy technologies

Asset ownership: Residential, community, commercial, IPP, utility

Complementary policies: Budgetary and capacity caps

Figure 1.7 Small-scale PV capital expenditures, feed-in tariff rate and power prices in Germany, 2006-2013



Source: BNEF; BSW Solar; Eurostat, n.d.

1.2.2 Building third-party metrics into feed-in tariffs

Policy overview: The most effective FiT rates over the long term are those that are set high enough to incentivise the desired level of generation but not too high to constitute windfall profits for generators or to incur outsized liabilities on the government or utilities. Building FiTs that successfully achieve this goal can be challenging, however.

In Israel, the country's grid regulator, the Public Utilities Authority (PUA), took an unique approach to degression in 2012. It decided to peg the FiT that it offered directly to a set of factors that closely reflect the state of solar markets. Specifically, these factors include interest rates, inflation, exchange rates, the cost of capital, and the BNEF module and inverter price indices (which are based on a confidential survey of buyers and sellers of such equipment).

The objective of adopting such an approach was to avoid a "solar bubble" in which the support schemes become disconnected from actual market costs. In March 2013, the PUA significantly reduced FiTs in light of lower PV equipment prices. The rate available to medium-sized PV projects was cut by 41% to NIS 0.57 per kWh (USD 0.16/kWh). The tariff was calculated separately for each project based on a specific formula (see Box 1.2). As such, the mechanism was applied mainly to utility-scale plants, since the quota for other capacity brackets had been fulfilled at the time of the scheme's introduction. This unique approach may offer a comparative advantage over capacity-based degressions wherein the elasticity between decreasing price and increasing deployment might not necessarily be as definitive as required.

For 2014, Israel has shifted its scheme to focus instead on net metering for residential systems, having concluded that solar PV technologies are now cost competitive in the sunny nation. In addition, the country's Ministerial Committee on Promotion of Renewable Energy approved the raising of the target quota for PV by nearly 290 MW, which were originally allocated for solar-thermal and wind technology (Udasin, 2014). In both cases, these decisions were informed in part by the experience with the index, which allowed regulators to track "real-world" prices closely.

Impact assessment: Israel's novel scheme was in effect for just a short time, so gauging its success is difficult. Integrating the market index into the rate did result in the tariff declining sharply. There is little to

Box 1.2

CALCULATING THE ISRAEL SOLAR FEED-IN TARIFF

$$RP_t = P * \left[\frac{D_t}{D_o} * \left(35\% * \frac{MI_t}{MI_o} + 20\%\right) + 45\% * \frac{Cp_t}{Cp_o}\right] * Z$$

$$Z = 0.15 * \frac{r_t}{r_o} + 0.85$$

Where:

P	Base tariff in NIS/kWh (*e.g.* 0.66 NIS/kWh for utility-scale PV)
RP_t	Updated tariff in NIS/kWh
Cp_t	Most updated Israeli Consumer Price Index
Cp_o	Base Israeli Consumer Price Index
MI_o	Base BNEF module and inverter index (e.g 0.87+0.11 USD/Wp)
MI_t	Updated BNEF module and inverter index known on the day of update
D_o	Base NIS/USD exchange rate
D_t	Last month average of NIS/USD exchange rate known on the day of update
Z	Interest rate factor update formula
r_o	Base interest rate
r_t	Quarterly average of A+ non-tradable inflation indexed bonds

Source: PUA, 2013

suggest that this led to a drop in market activity (or deployment), however. There were also some concerns, that the incentives that otherwise would be provided by above-market offtake rates were blunted by delays in acquiring land use and construction permits (BNEF, 2012a).

Risks: A scheme such as the one employed by Israel in 2013 is tied inherently to the longevity and accuracy of an outside market index. The discontinuation of the index or a significant change in its design or underlying determinants could undermine such a policy. In addition, there is the risk that such an index is inaccurate, particularly given how much local conditions can vary. Indeed, in Israel some developers highlighted that the index portrayed global conditions, when what really mattered was the cost of PV in Israel.

POLICY INDICATOR

Renewables penetration: Low-medium

Economic development: Middle-high income

Policy goal: Provide adequate support for renewables; minimise cost

Policy type: Feed-in tariff

Eligible technologies: All renewable energy technologies

Asset ownership: Utility, IPPs, others

Complementary policies: Procurement (national/state/local), target for installed capacity of renewables, target for share of renewable energy

1.2.3 Holding auctions for power contracts

Policy Overview: A potential way to avoid "overpaying" for renewable energy is to attempt to harness free market forces and to adopt instruments that allow price discovery. This is one of the primary features of auction schemes in which bids are made by the seller rather than the buyer. Auction schemes also provide policy makers with more control over the quantity of renewable energy that is deployed. As of early 2014, auctions were the policy option of choice in at least 55 countries/jurisdictions around the globe, primarily developing countries (IRENA, 2014).

In a renewable energy auction, a grid operator, energy regulator or energy ministry issues a call for tenders to install a certain capacity or level of generation. Project developers typically submit bids with a price per unit of electricity to be delivered. The government or other entity evaluates the offers on the basis of the price and other criteria and enters into power purchase agreements (PPAs) with the winning bidders. Auction schemes harness the rapidly decreasing costs of renewable energy technologies, the increased number of project developers, their international exposure and know-how, and the considerable policy design experience acquired over the last decade.

When well designed, the price competition inherent to the auction scheme increases cost efficiency and allows for price discovery of renewable energy-based electricity, avoiding windfall profits or underpayments. The experience of several developing countries, including China, Morocco, Peru, South Africa and Brazil, in designing and implementing auction schemes were analysed in IRENA's earlier work on *Renewable Energy Auctions in Developing Countries* (IRENA, 2013a). In this sub-section, the experience of Brazil is further discussed.

THE BRAZILIAN EXPERIENCE

The Brazilian government in 2002 set up a FiT scheme – the Programme of Incentives for Alternative Electricity Sources (PROINFA) – to support investments in wind, biomass and small-scale hydropower. Against a target of 3 300 MW by 2009 (distributed equally among the three technologies), 2 888 MW was deployed (1 157 MW of small hydro, 1 182 MW of wind and 550 MW of biomass). While successful in starting the domestic RE business, PROINFA was not applied in the most efficient way because of the high tariffs that were initially set. Moreover, the selection criterion of qualified projects was based on the date of the environmental permit (the older the permit the higher the priority of the project in the merit order for contracting). This led to a "black market" for environmental licenses. Although there was an established procedure for obtaining environmental licenses at each step of the project, requirements sometimes varied and licenses were frequently difficult to obtain. Therefore, many projects were delayed, faced large cost overruns, or in some cases failed. Additional difficulties included grid connections, construction delays and limited domestic manufacturing capacity for local content requirements to be effective, leading to delays specifically for wind projects (IRENA, 2013a).

Experience with the FiT scheme led the government to explore a legal framework to use energy auctions as a mechanism to deploy renewables. Accordingly, an auction scheme to contract generation capacity was launched in 2007 (see Figure 1.8). The original motivation for auctions was

Figure 1.8 Evolution of renewable energy electricity tariff-based support mechanisms in Brazil

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
FIT		Biomass	Wind	Hydro								
AUCTION						Biomass, Hydro	Biomass	Wind	Biomass, Wind, Hydro	Biomass, Wind	Wind, Hydro	Solar, Wind, Biomass, Hydro

BIOMASS HYDRO WIND SOLAR

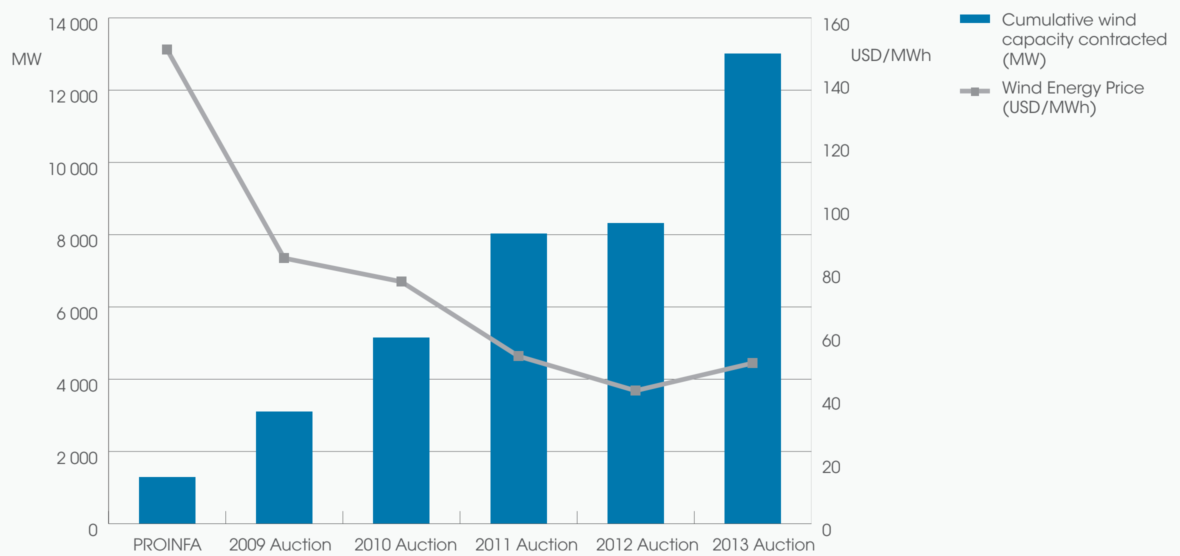
Source: Adapted from IRENA, 2013a

price disclosure and efficiency in the procurement process by reducing the asymmetry of information between the industry and the government. These auctions have been technology-specific, alternative energy auctions or technology-neutral. Renewable energy technologies, in particular wind, have seen much success during the different rounds of auction. Nearly 13 GW of wind has been contracted until the end of 2013 with the price of wind energy consistently reducing with a general trend of decreasing prices (see Figure 1.9).

The challenge that many countries face in implementing auction schemes is ensuring that winning bids translate into the timely development of projects and to sustainable generation over their envisaged lifetime. As such, projects supported through FiTs or auctions all have an incentive to maximise output.

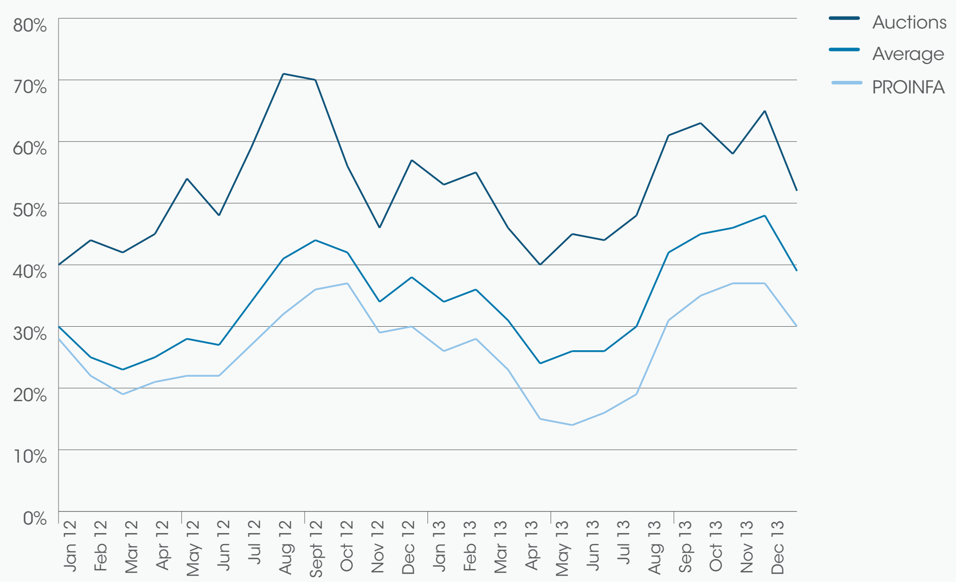
Figure 1.10 provides a comparison of capacity factors for projects deployed under the PROINFA FiT scheme and the auction scheme in Brazil. It is clear that projects that obtained PPAs via an auction operated at higher

Figure 1.9 Wind capacity contracted in Brazil (MW) and average price (USD/MWh)



Source: Adapted from IRENA, 2013b (data for PROINFA, 2009, 2010, 2011, 2012 auction) and GWEC, 2014a (data for 2013 auction using exchange rate: 1USD = 2.2 BRL)

Figure 1.10 Verified capacity factors for Brazilian wind projects commissioned under auction scheme and under PROINFA feed-in tariff, 2012 (%)



Source: BNEF; ANEEL; ABEEólica (2013).

capacity factors than those contracted under the FiT scheme. This is primarily due to technological improvements, but also to siting and operational choices.

The experience from Brazil demonstrates that several factors should be considered while designing and implementing auction schemes. For instance, in a departure from previous auctions, the government instituted a "P90" standard for qualifying projects. This meant that a project's annual generation had to equal 90% or more of the probability of generation forecast by wind measurement and annual generation data. The P90 standard differs from the P50 capacity factor required in previous auctions, which allowed for a larger margin of error in qualifying for a PPA.

To address previous nonfulfillment of commitments associated with grid connection limitations, the August 2013 auction included inter-connection qualifiers. Developers had to connect their projects to the grid at their own expense if necessary, and a project may only be bid in the auction if it is feasible to connect it. When the project developer submits a proposal, it must identify which substation it plans to connect to. All substations are mapped onto the transmission system. In the case where multiple projects compete to connect to the same substation, the project which bids lowest is offered the contract.

Impact assessment: In the August 2013 auction, 66 contracts were signed with a total capacity of 1 505 MW and an average price of BRL 110.51 (USD 50.9) per MWh. The November 2013 auction resulted in the award of 39 projects with a combined installed capacity of 867.8MW at an average price of BRL 124.43 (USD 57.3) per MWh. In December 2013, the auction resulted in the award of 97 new projects totalling 2.3 GW at an average price of BRL 109.93 (USD 50.6) per MWh (GWEC, 2014a).

These results were higher than the minimum price reached in the 2012 auction that resulted in the award of just 10 projects of 281.9 MW total capacity at BRL 87.94 (USD 42.16) per MWh. The surprisingly low prices of 2012 were attributed to the low ceiling price established for the auction (USD 54 per MWh), among other factors (Brazilian Wind Energy Conference, 2013). Factors that could have influenced the marginal increase in price in 2013 include: 1) the developers were responsible for connecting their projects to the grid at their own expense, if necessary; 2) the developers were responsible for delivering the projects in a short period of two years; and 3) BNDES had more stringent local content requirements for financing projects.

In November 2013, Brazil held its first auction in which solar projects were encouraged to compete.

Developers registered 3 gigawatts (GW) of potential capacity to bid for contracts. However, a ceiling price for contracts of just BRL 126 (USD 58) per MWh was set by regulators, and no registered solar projects won contracts. Later that year, a solar-exclusive auction was held on December 27. It registered 122.82 MW of total capacity at an average price of BRL 228.63 (USD 105.25) per MWh.

Risks: The most significant risk in auctions is that developers will offer bids low enough to win contracts but too low to ensure that they earn an adequate return on investment. Such "low-ball" bids, whether intentional or not, can result in financing delays and, in the worst case, in failure of the project to be built at all. While different countries have adopted various design features to avoid such a situation (*e.g.*, introducing floor tariffs, establishing tariff benchmarks, etc.), the risk remains as domestic markets become increasingly competitive.

Successful auctions also are contingent on the power purchaser following through on commitments to buy electricity at an agreed-upon price. Even for transactions in which the offtaker is government-owned or -backed, it is important to assess its history in fulfilling contract obligations and its track record on payments and dispute resolution. Finally, the process relies on transparent and efficient administration of bids in order to preclude accusations of "fixing the contracts".

POLICY INDICATOR

- **Renewables penetration:** Low-medium-high
- **Economic development:** Middle-high income
- **Policy goal:** Provide adequate support for renewables, trigger technology innovation
- **Policy type:** Auctions
- **Eligible technologies:** All
- **Asset ownership:** Utility, IPP
- **Complementary policies:** Power market liberalisation

1.2.4 Designing flexible tax policies

Policy overview: Policy makers have long used tax codes as an instrument to incentivise private sector participation. In the context of renewable energy development, tax policies have been used extensively to encourage investment in new generating capacity. These supports have typically come in one of two forms:

» *Tax credits*, which allow renewable energy asset owners to directly reduce the taxes they pay at the end of the year, pegged either to the volume of electricity that their project has generated or their total investment in building the project.

» *Allowable accelerated depreciation*, which allows developers to amortise the costs of a renewable energy project in an expedited manner. The result is higher booked costs in the earlier operating years of a project to reduce reported earnings and associated taxes. Later, when the costs are fully amortised, the asset can generate larger profits that do get taxed; but in the meantime, the actual economic cost to the project owner has been reduced.

Tax policies have been used most notably in the United States and India (see Box 1.3) to spur renewable energy deployment. The United States has relied on a combination of accelerated depreciation and tax credits. Wind projects commissioned before 1 January 2014 benefitted from the Production Tax Credit (PTC) which allowed them to directly reduce their annual tax bills by USD 23 for each MWh that a project generates over the first ten years in operation. Solar project owners can apply for the Investment Tax Credit (ITC), set at 30% of a new project's capital expenditure. Combined with accelerated depreciation rules, these tax credits have proven critical to the expansion of U.S. renewable energy capacity. However, the tax policies put in place in the United States require periodic extensions that are often approved either close to the expiry date or retroactively. While the ITC is available in its current form through 2016, the PTC has been allowed to expire four times since 1999 and officially expired at the end of 2013. At the height of the financial crisis in January 2009, Congress enacted a key change to make the PTC more flexible through the establishment of "cash grants" that project developers could receive in lieu of the PTC. The grants would cover 30% of a typical wind project's capital expenditure. Developers quickly put the cash grant to use, building nearly 21.3 GW of new capacity from 2009 to 2011.

The cash grant programme expired at the end of 2011. The PTC lived on for two more years until its expiry at the end of 2013, but not before a key change was

Box 1.3

ACCELERATED DEPRICIATION FOR WIND SECTOR DEVELOPMENT: THE CASE OF INDIA

In India, accelerated depreciation rules for both wind and solar PV have played a key role in supporting deployment of those technologies. During the initial stages of market development, the entire value of an Indian wind project could be depreciated in the first year of its existence. First-year depreciation was then lowered to 80% around 2003 and, in March 2012, reduced further to 15%. The incentive was withdrawn in April 2012 (PIB, 2012), along with another key incentive- Generation Based Incentive (GBI). With no economic incentives in place, the installations dipped to 1 700 MW in 2012-13, compared to 3 164 MW in 2011-12 (CSE, 2014). This led the government to re-introduce the GBI scheme with the objective of incentivising generation rather than capacity deployment as well as to allow a broader set of developers to enter the market. However, there is growing demand for reinstating the accelerated depreciation benefit (CSE, 2014).

Accelerated depreciation benefits those projects that rely on balance-sheet financing rather than a project financing. The argument against such an approach is that it hinders the scalability of the sector (as the purpose of lending is not directly power generation) and that it does not encourage the participation of a broader set of IPPs that face difficulties in accessing corporate credit for wind projects. While a GBI scheme addresses this to a certain extent, in this case investors need to take on performance risks given that the revenues become entirely dependent on the generation of wind projects.

made to increase the flexibility of the policy. Whereas projects previously needed to be commissioned by the time of the PTC expiry, at the end of 2013 they merely needed to be "under construction". Partly as a result of this change, developers were able to keep considerably more projects in motion and their "pipelines" full. The U.S. Energy Information Administration is projecting that 16.1 GW of new wind capacity will be built in 2014-15 (U.S. Energy Information Agency, 2014).

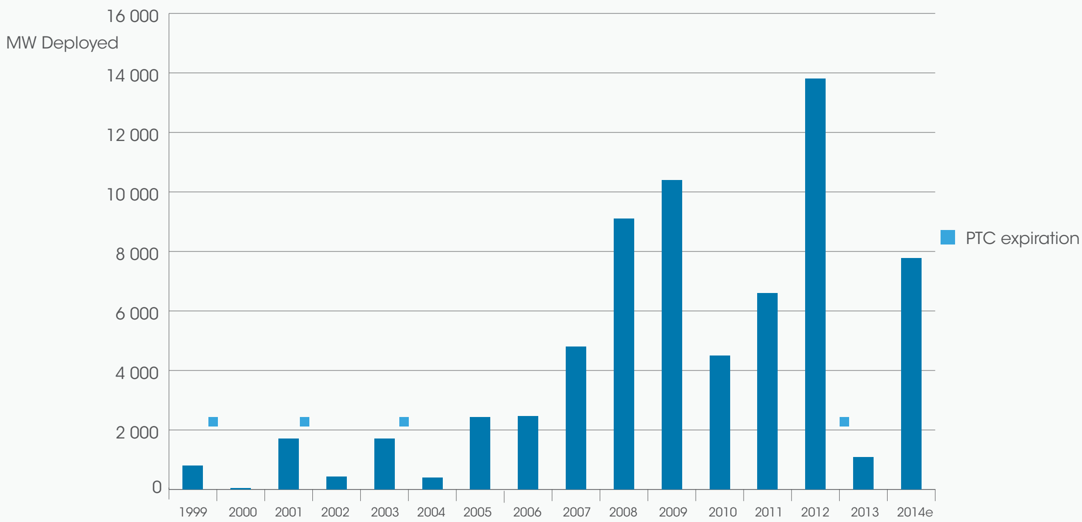
Against this backdrop, the non-partisan Congressional Research Service (CRS) published a paper that examined some policy options to address the shortcoming of the PTC. One option considered that the level of the PTC that is presently fixed at USD 23 (and rises at the rate of inflation) could be set annually at a rate just high enough to bridge the gap between the average levelised cost of electricity (LCOE) for wind power generation and a similarly set LCOE for natural gas combined-cycle power generation (CRS, 2013).

The annual adjustment was proposed with a PTC "phase out" in mind, under the assumption that the LCOE for wind will continue to decline, natural gas prices will rise, or some combination of both will occur. The result would be that the PTC could be reduced accordingly. Once that gap closes altogether, the PTC would fall to zero and effectively sunset itself. Thus, the PTC would exist on an as-needed basis. Implicit in the policy design is that if the gap between the LCOEs for wind and natural gas does not close, the PTC remains on the books.

Impact assessment: The impact of the PTC on U.S. wind installations is clear: they peaked in 2009 and 2012, as developers rushed to build projects ahead of the anticipated expiry of the credit (see Figure 1.11). As evident from the figure, each time the credit has been allowed to expire, the following year has experienced a significant drop in deployment. The PTC was last extended in January 2013 for one year, but the effect of its "false" expiry is permanent. Only an estimated 600 MW of new wind capacity was added in the United States in 2013, in part because projects which would have been completed that year were brought on line in 2012 by developers fearful of missing out on the PTC. Although the PTC expired in January 2014, the extension in 2013 included an adjustment of the eligibility criteria to include projects that began construction in 2013 and not necessarily coming online in the same year (NREL, 2014). This has led to a positive outlook being adopted for the industry in 2014 with over 12 GW of new generation capacity being under construction at the end of 2013 (GWEC, 2014b).

Risks: The potential drawbacks of the proposed revisions of the PTC include: 1) complex implementation, 2) issues with using LCOE as a way to compare the

Figure 1.11 US Wind Capacity Additions and PTC (1999- 2014e) (MW)



Source: Adapted from IRENA, 2014. Note: The capacity addition for 2014 is estimated from GlobalData, 2014.

economics of wind and natural gas combined-cycle power generation, 3) regional resource and market variations and 4) industry's ability to realise cost reductions (CRS, 2013).

Each of these has the potential to undermine the flexible PTC proposal. The first – "complex implementation" – simply refers to the difficulty overall of adding any level of nuance to what to date has been a fixed-rate subsidy. The second raises questions about whether LCOE is the proper metric for comparing wind with its nearest-priced competitor in U.S. power generation. The third refers to the fact that there are substantial regional differences in the United States in terms of natural resources (and hence LCOEs), raising the possibility that a "one-size-fits-all" approach to setting a support level may not be appropriate. Finally, the entire proposal rests on the assumption that the wind industry will continue to innovate and reduce its costs in order for the PTC to decline and eventually disappear. Should costs not drop, the gap between the LCOE for wind and natural gas will not necessarily narrow, and the PTC will have to remain at current or higher levels.

There is one additional and associated concern: if the wind industry knows that the PTC will be set annually at a level substantial enough to bridge the gap between wind and natural gas costs, will it still be sufficiently motivated to continue to reduce its costs? A system that automatically reduces the PTC year by year might provide greater incentive for the industry to make improvements over a certain period of time.

POLICY INDICATOR
Renewables penetration: Low-medium-high
Economic development: Middle-high income
Policy goal: Provide adequate support for renewables , trigger technology innovation
Policy type: Tax-based mechanism
Eligible technologies: Multiple
Asset ownership: Utility, IPP
Complementary policies: U.S. Production Tax Credit

1.3 LESSONS LEARNED

The sharp fall in renewable energy equipment costs has both a positive and a negative impact for policy-making. It is positive in that cheaper solar PV modules or wind turbines have led to an expansion in renewable energy deployment. It is negative in that it can be challenging to set support levels appropriately enough to spur market activity and low enough to avoid unintended windfall profits for developers. Sudden efforts to rein in supports have created market uncertainty. In a number of cases, this has resulted directly in decreased private investment and deployment.

Three key lessons can be learned from the experience of the countries analysed in this section:

1. Virtually all of the policies discussed here aim at providing as much transparency as possible to market participants. In Germany, for instance, regulators took steps to create a registry of projects that have secured FiT access with an eye towards informing the broader market about when step-downs in the tariff are likely to arrive and how deep they will be. In Israel, regulators publicised a specific equation for calculating the rate of the country's FiT based on regularly updated sources of information.

2. While each of these policies may have flaws, all present a key lesson learned: policy moves that have not been communicated clearly and in advance to the market can have negative consequences. The solutions being proposed by most of the policies here seek to address this problem by providing greater transparency and improve predictability.

3. Market-based policy support mechanisms, such as auctions, are gaining increasing prominence as a way of reducing information asymetry between governments and developers, and in identifying the appropriate level of public support. When well designed, these schemes in their own way also provide transparency and predictability by providing clear guidelines to the market on how much new capacity is being sought and by offering specific rules on how such power will be procured. In the best cases, the auction organisers offer quite specific guidance on what projects will or will not be deemed acceptable.

2 Addressing Tax/Rate-payer Burdens

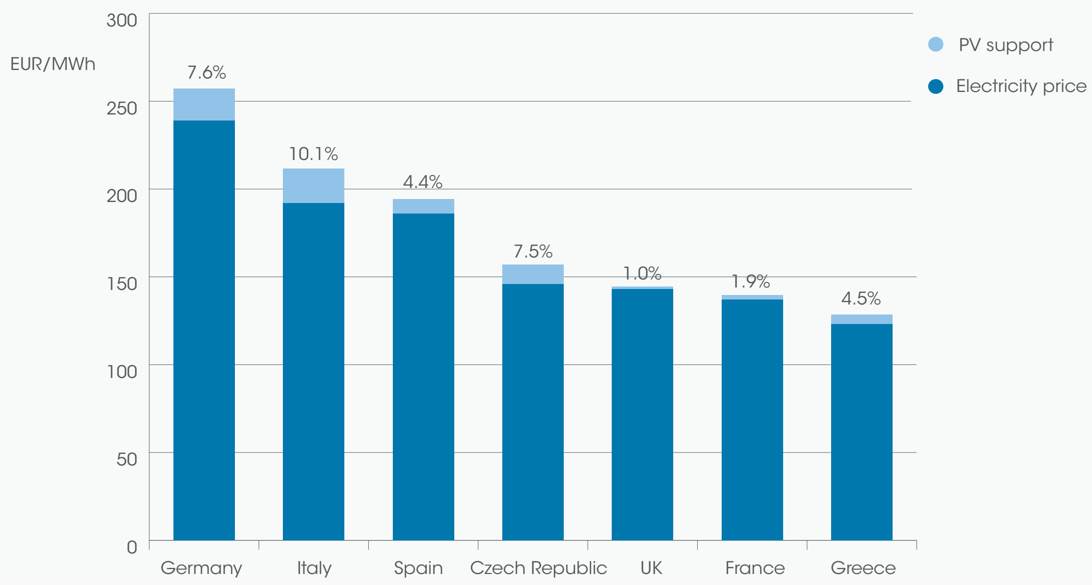
Renewable energy deployment has experienced substantial growth during the past decade-global solar PV installed capacity has risen from over 7 GW in 2006 to 137 GW in 2013, while wind capacity has grown from 74 GW to 318 GW in the same period (REN21, 2013; GWEC, 2014b). Much of this growth has been a result of financial support offered by countries that have been early-adopters of these technologies. These countries recognized the long-term benefits brought on by renewables from an environmental, economic and social standpoint. As such, support for renewables has been seen as a means of internalising external costs presently not accounted for in traditional energy markets. Resilient support for the sector translated into a scale-up in deployment, thereby leading to a substantial decrease in technology costs and the development of the renewable energy industry. As a result, further deployment will not require the level of support witnessed in the past. While the support for renewables has generally been much lower than for fossil fuels, it is important that it is kept under control and that its cost is distributed fairly across the different stakeholders.

2.1 CHALLENGE: REDUCING IMPACTS ON TAX-PAYERS OR CONSUMERS

The misalignment of the level of support and the cost of technology is one of the factors that has led to an unprecedented spike in renewable energy capacity installations in some countries. This boom, driven largely by attractive support rates, has in some cases resulted inadvertently in an increased burden on consumers and tax-payers – or, as in Spain, in a "tariff deficit" caused by policies that have at times forced utilities to sell electricity to consumers at rates below the cost of supply.

Figure 2.1 illustrates that in 2012, the Italian residential power price rose by 10% purely as a result of FiTs

Figure 2.1 Cost of PV support as a share of 2011 electricity prices in select European countries (EUR/MWh)



Source: BNEF based partly on data from Eurostat, n.d.

Note: Estimates based on FiT rates and installation levels in these countries; domestic power prices from Eurostat.

for solar PV. In the U.K., this increase was around 1% at the time, but with increasing megawatts installed, this number has been rising as well. In Germany, the impact on electricity bills has been obvious for a few years now, but the 47% spike in the renewable energy surcharge ("EEG Umlage") in 2013 shocked consumers and policy makers alike.

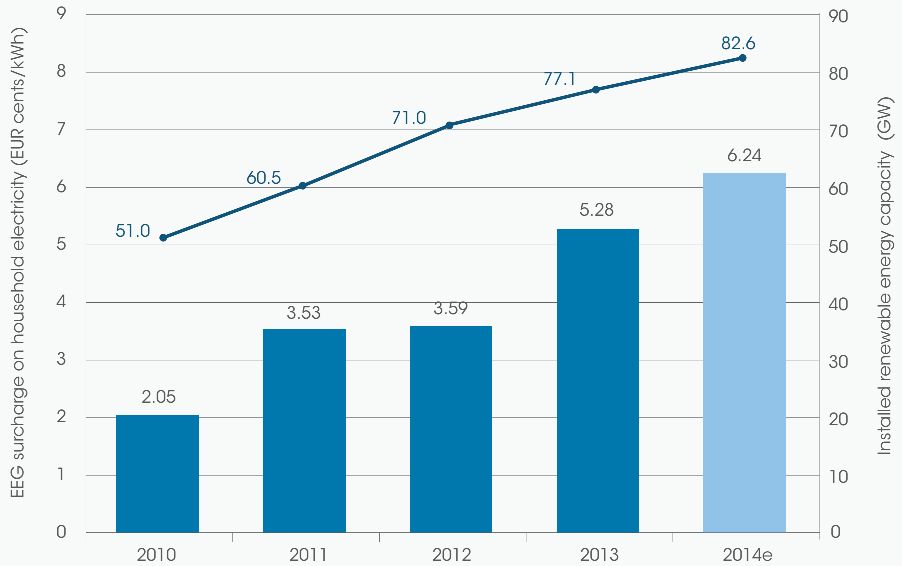
Germany is a clear example of a country whose ambitious – and successful – renewable energy policies led to the development of a local industry, albeit at a cost (see Figure 2.2). Several gigawatts of installed renewable energy capacity resulted in significant cost added to final consumers' electricity bills. As a result, speculations were abound that the 2014 level of the EEG surcharge was likely to exceed EUR 7 cents per kWh. To the surprise of many, it increased to only EUR 6.24 cents/kWh in 2014, which may suggest that these costs are beginning to be contained and that some cost-efficiency measures that have been implemented are bearing fruit.

In virtually all of these cases, policy makers were willing to support the renewable energy sector seeking to make inroads into a power sector dominated by large incumbent players such as utilities or independent power producers. To a large degree, the policies of Germany, Spain, Italy, Denmark and other nations succeeded in allowing the renewable energy sector to scale up and drive down the generation costs. The result has been the emergence of several socio-economic benefits such as economic development and job creation. along the various segments of the value chain (IRENA, 2013b; IRENA and CEM, 2014). In Germany, for instance, the renewable energy sector supported over 371 000 direct and indirect jobs in 2013 (IRENA, 2014).

Still, these policies have had a cost. There have been clear instances where they have inflated rate-payers' electricity bills or tax-payers' tax bills. Europe is chosen as a suitable example to illustrate this impact for three reasons: 1) the continent has been a front-runner in several renewable energy technology deployment, and hence the effects of support are most obvious; 2) for many years high FiTs were the dominant support policy in the continent, raising the overall costs of support, and 3) timely data are either readily available or relatively easy to calculate, because European operators are obliged to report periodically.

However, the impact of support measures on consumers is different depending on the form in which this support is granted. FiTs, feed-in premiums and green certificates usually affect consumers in a similar way – by adding a "renewables surcharge" to their electricity bills. Countries using auctions as the main support measure for renewables are likely to include their costs in the "cost of electricity" component of the final consumer bill, as

Figure 2.2 German EEG surcharge on household electricity bills (EUR cents/kWh) and installed renewable generation capacity (GW), 2010-14e



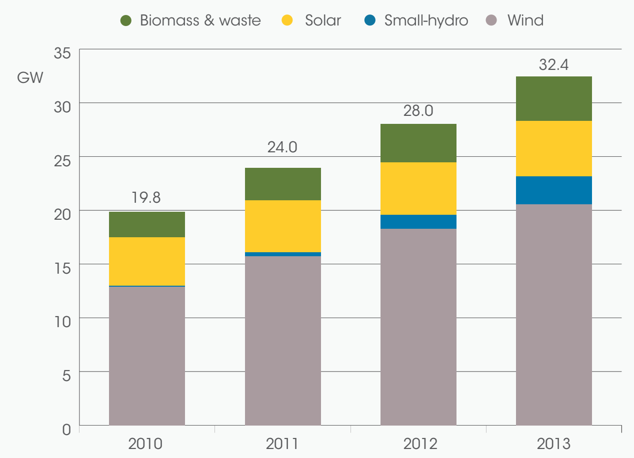
Source: Adapted from Network-Transparenz, 2014. Note: 'e' denotes that the figure is an estimation for the given year.
Note: Figures provided by the German Ministry of Environment and BNetzA. Installed capacity numbers are from BNEF and the Capacity for 2014 is estimated.

arguably this is not subsidised since projects win contracts via competitive bidding (unless the auctions are technology-specific, in which case a subsidy is sometimes included). This is the case in many Latin American markets, such as Brazil, Uruguay and South Africa.

Assessing the impact of net metering is more difficult (see sub-section 3.2.1), for example, given the often avoided fixed payments for transmission and distribution. In cases where the cost of support does not permeate through to the consumers, as with many developing countries like India, the state simply underwrites the debt (partly or entirely) that distribution companies accumulate by selling electricity at subsidised rates, as is also the case in Spain. This may affect credit ratings of both the underwriting authorities and the companies themselves.

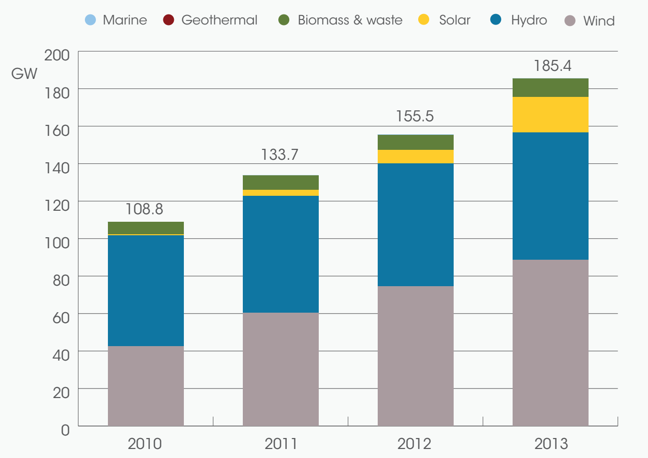
An analysis of average annual spending on renewable energy support – calculated as the difference between the wholesale power price and the price paid to renewable generators – of some of the most prominent players among the emerging markets highlights that as India and China have added more renewables to their power generation mix (see Figures 2.3 and 2.4), the burden on consumers (or tax-payers, where subsidies are funded from the budget) has risen as well (see Figures 2.5 and 2.6).

Figure 2.3 India's installed renewable energy capacity, 2010-13 (GW)



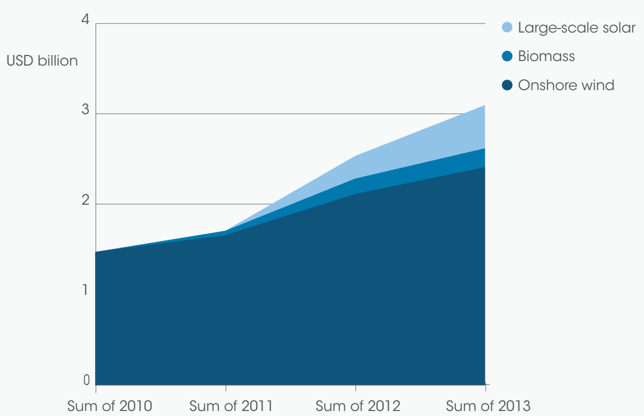
Source: BNEF. Note: Large hydro not included.

Figure 2.4 China's installed renewable energy capacity, 2010-13 (GW)



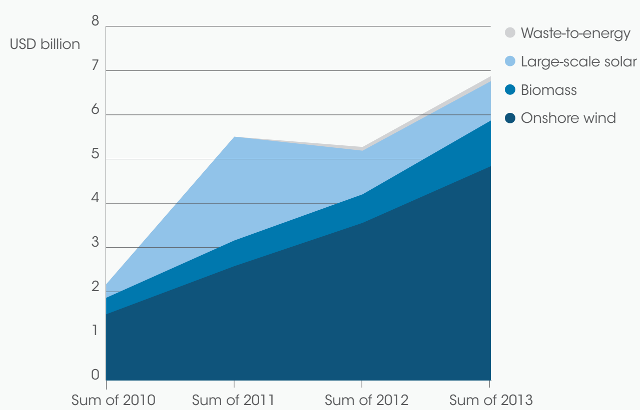
Source: BNEF. Note: Large hydro not included.

Figure 2.5 India's estimated annual national spending on subsidies, 2010-13 (USD billion)



Source: BNEF. Note: Chart represents net cost of subsidies (i.e., excluding wholesale electricity prices). Direct subsidies only, local incentives not included.

Figure 2.6 China's estimated annual national spending on subsidies, 2010-13 (USD billion)



Source: BNEF. Note: Chart represents net cost of subsidies (i.e., excluding wholesale electricity prices). Direct subsidies only. China Development Bank funding and local tax breaks not included

2.2 RESPONSES

Virtually all governments around the world are now concerned about the cost of support they offer (or are considering offering) to renewable generators. These concerns often result in reduced levels of support justified by falling costs of renewable generation from particular technologies. Some governments, however, implemented measures explicitly targeting spending caps on renewables support.

2.2.1 Implementing spending caps on support for renewables

Policy Overview: Europe has experienced a rising cost of support for renewables. The U.K., Italy, Germany and the Netherlands all have made explicit efforts to limit the potential burdens on consumers. While each does it in a slightly different manner, all are setting caps on their bill levies – the amount that can be passed on to consumers – to cover the support. Once the cap is reached, the policies need to either be altered in line with the budgetary prescriptions, or the support is suspended or terminated. Some countries implement "capacity" caps, rather than budgetary limits, to achieve the same purposes. This way, the governments try to ensure that the cost borne by society is both controlled and predictable.

As many developing nations embark on the renewable energy route, they too need to take into account the impact that any support provided to the sector may have on consumers. Malaysia has taken these aspects into account by introducing a spending cap on FiTs provided to renewables.

Impact Assessment: Below is a brief overview of five different budget cap designs, to illustrate various approaches adopted by governments. Each aims first and foremost to limit the costs passed on to consumers. These limitations can provide additional certainty and transparency for investors. Knowing in advance that the caps are imposed – and will be respected – sends a strong signal that the government will not allow for too high an increase of retail electricity prices. Thus, the risk of policy changes implemented retroactively (*i.e.*, affecting operating assets) is significantly reduced, if not eliminated.

Risks: One of the key requirements for such policies to work is that they need to be transparent. In other words, the government – or a regulator – needs to be able to track in detail how many projects are connected, how many are applying for support and how much overall support has already been provided. This, in turn, depends on being able to forecast – and track – the output from renewable energy projects, since in all of the cases discussed below, the support is provided per unit of electricity produced (in kWh). Lack of transparency of the system may, on the one hand, undermine investor confidence over the government's ability to actually support the renewable energy sector. On the other hand, with no ability to track progress towards the cap, the government may find itself in a position where the cap has been exceeded but there was no registry to flag it. That could result in more cost on consumers, defeating the primary purpose of such a measure.

ITALY: BUDGET CAP ON SUPPORT FOR SOLAR PV UNDER THE 5TH CONTO ENERGIA LAW

Following the solar boom of 2011, when 9.3 GW of solar PV was added to the Italian grid (see Table 2.1), the country decided to limit the amount of economic support available to the technology. Under the 5th Conto Energia law, enacted in August 2012, FiTs were allocated to projects included in a registry administered by the Gestore Servizi Energetici (GSE), created specially for this purpose. Through this registry, the regulator could track the number of projects applying for support and ensure that the half-yearly budget cap was not exceeded. These caps were set at EUR 140 million for the first registry, EUR 120 million for the second and EUR 80 million for the third. The caps resulted in significant slowdown of additional PV capacity built in Italy, particularly of large-scale projects.

Table 2.1 PV growth in Italy (2008-2013)

YEAR	ADDED CAPACITY (GW)
2008	0.3
2009	0.7
2010	2.3
2011	9.3
2012	3.6
2013	1.8

Source: GSE, 2014.

Note: 2013 data is preliminary

Italy has also set a cap limiting total annual spending on the support for PV to EUR 6.7 billion, with the government agreeing that once this is reached, there would be no further FiT support available. This budgetary cap was reached on 6 June 2013 and the FiTs stopped being allocated a month later. However, the residential segment still benefits from a tax incentive (income tax deduction), which has been driving steady growth in this market following the FiT termination.

U.K.: LEVY CONTROL FRAMEWORK

The U.K.'s Levy Control Framework (LCF) provides an upper budget limit on the annual surcharges added to consumer bills to fund renewable energy projects. It was introduced by the government in 2010 to keep a lid on expenditures that are off the government balance sheet but still considered public spending. Since then, the LCF has come to be viewed by investors as a source of confidence that the U.K. is less likely to overspend on renewable energy and put a high burden on consumers. That in turn reduces the risk of retroactive cuts for existing assets.

The framework also offers visibility about the government's ambitions and scale of support over time. Notably, the U.K. Department of Energy and Climate Change (DECC) has published LCF amounts out to 2020/21, with a levy cap of GBP 7.6 billion in 2020 (2011/12 prices), providing a long-term framework for prospective investors (see Figure 2.7).

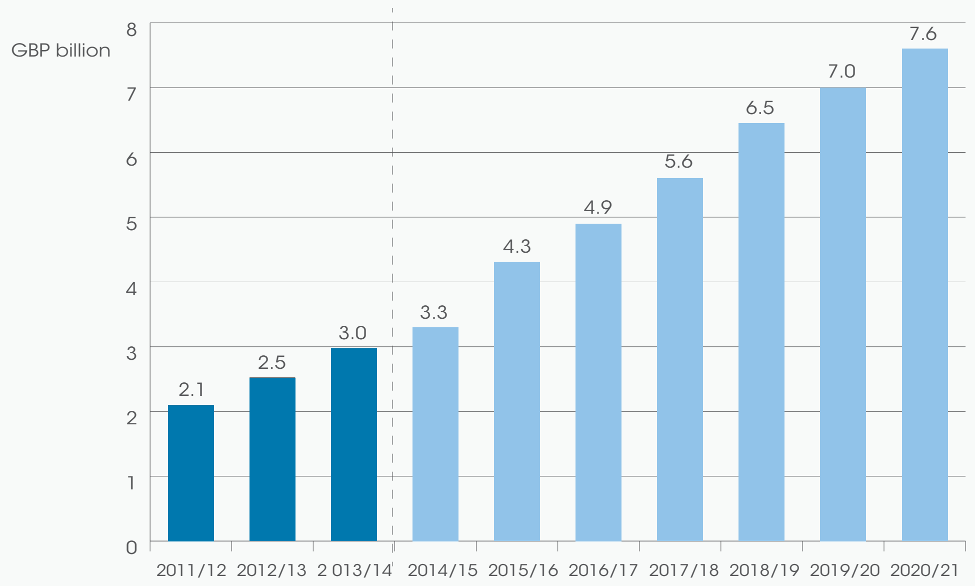
GERMANY: PROPOSED EEG SURCHARGE LIMIT

In Germany, support for renewables – both feed-in tariffs and feed-in premiums – is funded via an EEG surcharge (EEG Umlage) added to consumers' bills. While energy-intensive industries benefit from discounts on that surcharge, the cost is paid primarily by household consumers. The levy is set each year by the regulator, following the renewable generation forecast and consultations with transmission system operators (TSOs).

For calendar year 2013, the EEG surcharge was raised 47%, from EUR 3.59 cents/kWh to EUR 5.28 cents/kWh on domestic electricity bills (seen earlier in Figure 2.2). Soon after the announcement of that increase, a proposal was initiated to control electricity prices via a limit on the EEG surcharge increase. Under the proposal, in 2014 the surcharge would stay level at EUR 5.28 cents/kWh. From 2015 onwards, it can rise by no more than 2.5% annually. A set of measures lowering the support for renewables and limiting the exemptions available to energy-intensive industries was proposed to achieve this goal.

Although the proposal was not implemented due to objections from the Bundesrat (Upper House of Parliament), it was a clear attempt to set binding budget limitations for renewables support. In 2014, the EEG surcharge increased to EUR 6.24 cents/kWh, and, following the September parliamentary elections, the new government's priority was to stop further cost escalation.

FIGURE 2.7 U.K. LEVY CONTROL FRAMEWORK, 2011/12 – 2020/21 (GBP BILLION, 2011/12 PRICES)



Source: DECC, 2013

As such, the reform sets out to concentrate on the deployment of wind and solar energy, that have proven to be the most cost effective technologies in Germany. Moreover, it proposes to adopt instruments that are more responsive to the market than FiTs, such as auctions, to support investments in renewable energy.

THE NETHERLANDS: BUDGET CAP FOR THE STIMULERING DUURZAME ENERGIEPRODUCTIE (SDE+) 2013

The Dutch government caps its spending on new renewable energy projects through its SDE+ tender scheme. Feed-in premiums are awarded to the most cost-competitive projects and technologies through a series of tender rounds, with an overall annual budget. This is based on the total lifetime subsidies forecast to be allocated to projects selected in that year, amounting to EUR 3 billion in 2013. After the budget ceiling has been reached, no more funding is available for new projects that year.

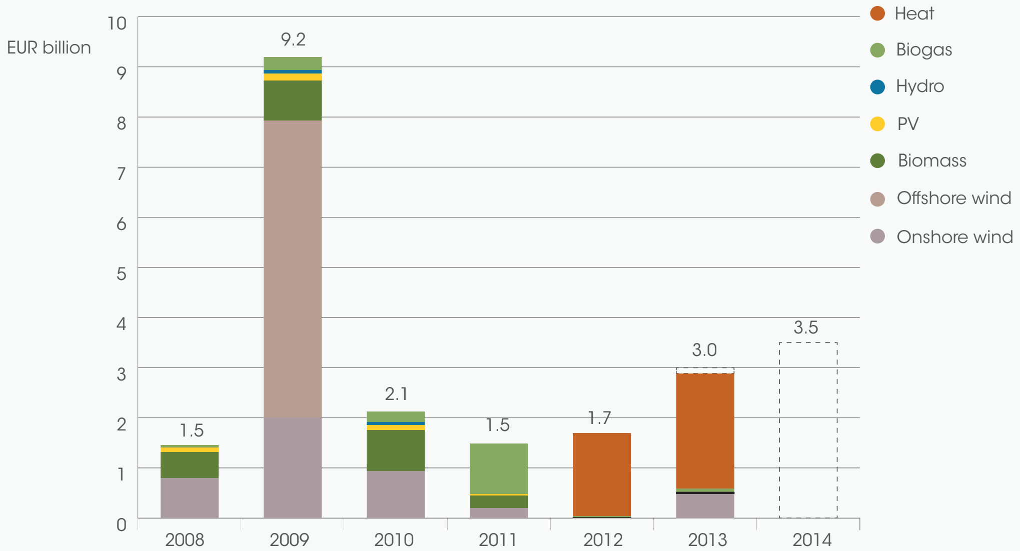
The competition among technologies has meant that low-cost sectors have dominated each year's scheme over the past three years, starting with biogas in 2011, before it was opened up to renewable heat in 2012 (see Figure 2.8). The drive to thriftiness was a response to higher subsidy allocation to offshore wind in 2009. However, in the pathway towards meeting its 2020 renewable energy targets, the Netherlands decided to expand the SDE+ budget and to return to pricier offshore wind.

MALAYSIA: FEED-IN TARIFF FUND LIMITATIONS

Malaysia approaches the spending caps in a somewhat different manner. Rather than setting an overall budget limit, it limits the surcharge passed on to non-domestic consumers to 1.6% (previously 1%) of the retail electricity price. Domestic consumers are exempt from paying this surcharge altogether unless they consume over 300 kWh a month. Based on the revenues it collects from this surcharge and transfers to the special renewable energy fund, and on forecast renewable power output, the Sustainable Energy Development Authority (SEDA) defines the capacity cap for projects. For the period 2012-15, this cap was set at the total of 485 MW (SEDA, 2013).

While this design can be effective, it can be difficult to administer, as neither the exact amount of funds available nor the output from renewables can be forecasted accurately three years in advance. In 2013, it became clear that the current fund is not sufficient to support larger-scale renewable developments. For this reason, SEDA had requested an additional 1% surcharge, subject to approval from the Ministry of Energy, Water and Green Technology. A more modest increase to 1.6% was granted, following a debate with affected consumers.

FIGURE 2.8 SDE+ BUDGET CEILING PER SUBSIDY YEAR, 2008-2013 (EUR BILLION)



Source: Dutch Ministry of Economic Affairs (n.d.).

Note: Dotted line shows the remaining budget; 2014 figure represents the new allocated budget; "biomass" includes biogas and landfill gas used for power production; "biogas" is delivered as gas; "heat" includes geothermal and biomass heat.

POLICY INDICATOR

Renewables penetration: Medium-high

Economic development: Middle-high income

Policy goal: Minimise cost of support

Policy type: Budget caps

Eligible technology: All

Asset ownership: N/A

Complementary policies: Feed-in tariffs, market premiums, green certificates, market premiums, grants, other support schemes

2.3 LESSONS LEARNED

Policy makers need to strike a balance between being supportive of renewable energy deployment and ensuring that the costs associated with that support do not fall disproportionately on one segment of the population. Offering uncapped support for renewable power generation can add a high burden on consumers or tax-payers, who ultimately cover the costs through an electricity bill surcharge or via additional taxes.

Putting a budget cap on spending for renewable energy support can limit this impact greatly, and several countries have successfully demonstrated the impact of such measures. Italy stopped providing FiT support to solar PV when the total expenditure reached EUR 6.7 billion, avoiding further escalation of the costs. The U.K. restricts its spending via a special levy control framework, limiting the spending to GBP 3.3 billion in 2014 and GBP 7.6 billion in 2020. The Netherlands managed to reduce its annual expenditure on renewables support from EUR 9.2 billion in 2009 to EUR 3 billion in 2013 through strict budget allocations.

Three key lessons can be learned from the experience of the countries analysed above:

1. Limiting the costs of renewables support gains importance with increasing market maturity. While providing higher support levels may be important to kick-off new technology deployment, it is essential that the costs are closely monitored as renewable energy share expands.

2. The Malaysian example illustrates that keeping costs under control is as important for middle-income countries, concerned about maintaining household income, as it is for high-income countries, concerned about industrial competitiveness. This in part explains why in Malaysia, the support is funded largely by non-domestic consumers, while in Europe the schemes are funded primarily by households.

3. In a somewhat counterintuitive way, a cap on support may improve rather than diminish investors' confidence in the market, as it provides long-term visibility and predictability to the market. It also minimises the risk of sudden or even retroactive changes.

It is important to note that these budget caps can – and should – be complementary to all of the policies analysed in the previous section. In other words, governments need to think about ensuring that the support they provide accurately reflects the costs of generation and provides sufficient incentive to developers; at the same time, they need to state their intentions clearly and to indicate early on how big a market they are willing to support financially.

3 Accounting for Renewable Energy's Cost Competitiveness

3.1 CHALLENGE: PREPARING FOR THE ARRIVAL OF GRID AND SOCKET PARITY

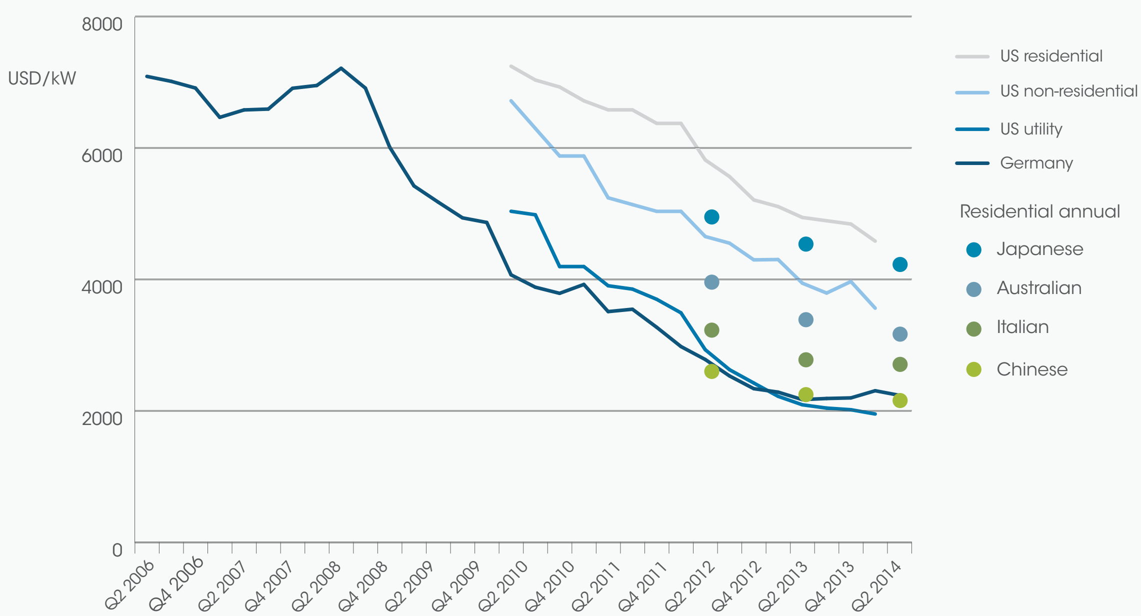
Economies of scale of renewable energy deployment have led to significant learning gains, which in turn have resulted in improved generation efficiencies, or capacity factors. As LCOE for many technologies have been steadily declining, some have already reached the so-called grid parity in many contexts. In other words, they can produce electricity at a cost roughly equal to, or less than, the price of power from the grid on a levelised basis.

Hydropower projects and some geothermal technologies, for example, have been competitive for some time now. Onshore wind has been steadily lowering its LCOE by reducing equipment costs and improving turbine efficiencies with equipment that can operate in less windy locations.

The most radical cost reductions have occurred in the solar sector in the last few years, with the global average cost of a typical residential solar PV system dropping more than 40% since 2010. However, the price of residential PV differs dramatically among markets. A residential system can be installed for around USD 2 250/kW or even less in Germany today, but it still costs as much as USD 4 600/kW in the U.S. or USD 4 200/kW in Japan (see Figure 3.1). One reason is that while hardware costs have declined, non-hardware or "soft costs" associated with installation, customer acquisition and interconnection remain higher in some countries than others (CEM, n.d.). The overall downward trend in deployment costs, however, is expected to continue (albeit in a somewhat less dramatic fashion) through the rest of the decade (see Figures 3.2).

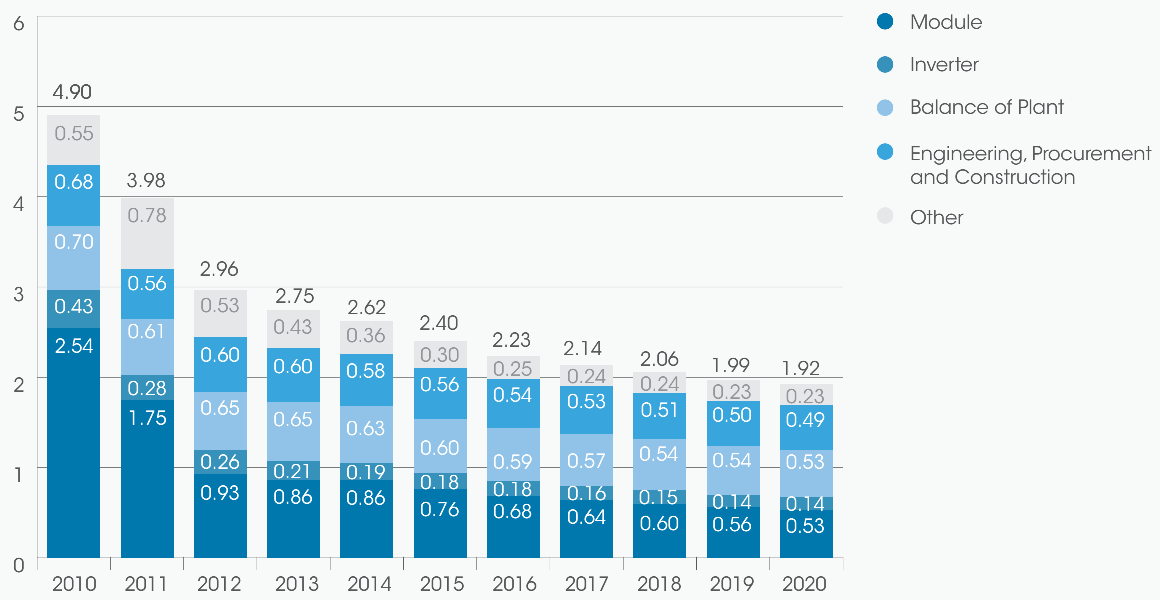
PV grid parity has already been reached in some European markets, with those in the Asia-Pacific region and the Americas to follow. However, discerning the

FIGURE 3.1 SMALL SOLAR PV SYSTEM COSTS IN SELECT COUNTRIES (USD/kW)



Source: IRENA Costing Alliance.

Figure 3.2 Estimated cost reductions in residential solar PV by component, global benchmark, 2010-20 (USD/W)



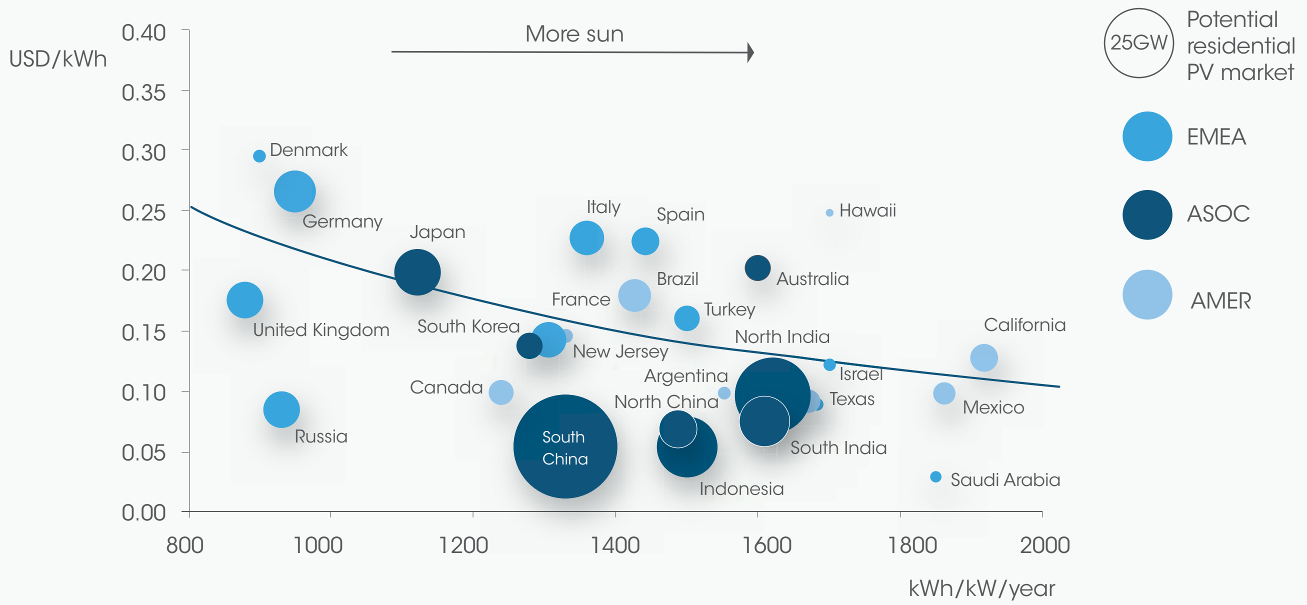
Source: BNEF.

exact moment when competitiveness arrives will be difficult in countries where consumer power prices are subsidised. Competition from solar PV versus incumbent sources comes most strongly at the small-scale commercial and residential level, where retail (not wholesale) electricity prices from the grid are being offset. Thus, the term "socket parity" is used to distinguish from the competitiveness of large, utility-scale PV projects. For large projects, "grid parity" tends to refer to the LCOE of PV compared to alternative means of wholesale electricity provision. Residential installations are, therefore, not competing against wholesale generation but, instead, with the delivered price of electricity through the grid.

While solar PV system costs clearly play a crucial role in determining socket parity, insolation levels and local residential electricity prices are also crucial. For this reason, several developing countries in particular offer a huge potential market for PV deployment. While historically the primary market for PV systems in developing countries has been off-grid applications, grid-connected solar systems play a growing role in countries where transmission and distribution networks are relatively well developed, and adequate policies are in place. Estimates suggest that countries such as Turkey, Brazil and Israel have already achieved "socket parity", while India and Argentina are likely to do so in the near future (see Figure 3.3).

As costs continue to decline towards parity in different countries, the need to adapt support policies arises. Achievement of PV competitiveness does not mean that the sector requires no further support. Instead, a policy transition is necessary from measures that are purely financial-based to measures that are compatible with the overall system of renewables promotion and the general structure of the electricity system. Alternative support incentives, such as self-consumption or net-metering, which may become increasingly relevant as decentralised PV deployment increases and as grid parity is attained (PV Parity, 2013). This brings new challenges to policy makers, grid operators and utilities, as the ongoing transformation of the traditional energy system involves consumers now not only purchasing electricity from the grid but also feeding their own excess production back into it. While this has the potential to be a benefit for consumers, it represents possible system balancing challenges (see Section 4). Spain has reacted to these challenges by proposing to impose additional charges on residential projects, and similar proposals are under discussion in Germany. In the United States, some utilities have sought to impose monthly fees on residential PV system owners. In the state of Oklahoma, for example, a new bill intends to impose an additional fixed charge on consumers with distributed generation systems installed compared to those who do not, in order

Figure 3.3 Residential electricity price in 2012, insolation, and LCOE of residential PV, Q2 2013



Source: BNEF.

Note: The blue line illustrates the LCOE levels (Q2 2013) for different insolation rates. Countries above the LCOE line have already reached "socket parity". EMEA = Europe, the Middle East and Africa; ASOC = Asia/Oceania; AMER = the Americas.

to avoid cross-subsidisation (Oklahoma Legislature, 2014).

These challenges will have the biggest impacts on markets with high PV adoption rates. Markets where solar power is just taking off will be less affected but should not disregard these impacts, as PV grid parity (or even costs falling below that level) will lead to even more rapid adoption of this technology. Rapid adoption of grid-connected small distributed PV projects will require system integration efforts, as discussed in Section 4.

3.2 RESPONSES

3.2.1 Permitting net metering to allow consumers to become generators

Policy overview: Net metering supports small- to medium-scale renewable energy development by allowing generators to "bank" (on the electricity grid) any production which they do not consume at the time of generation. They are credited for their net electricity generation on their electricity bills. As such, the policy can be introduced relatively simply.

In its most basic form, net metering requires a bi-directional electricity meter, *i.e.*, one that runs backwards when power is fed to the grid rather than consumed from it. In a basic net metering scheme, the generator receives a flat rate for grid-delivered electricity (a retail price). More-complex versions, such as the one in use in Italy, takes into consideration the varying market price of power delivered or consumed during different periods. The design features vary across different net metering schemes, thus also affecting the financial return for investors and the attractiveness of the scheme. Table 3.1 provides an overview of schemes in four selected regions across identified comparators, including total programme capacity, maximum system size, grid charges, etc.

There has been a marked rise in the adoption of net metering policies, with the number of such schemes (at the national or state/provincial level) increasing from 37 in 2012 to 42 as of early 2014 (REN21, 2014). Net metering, as a support instrument, has been widely adopted in the United States, where it originated in the 1980s to encourage distributed generation. As of early 2014, 45 U.S. states and the District of

Table 3.1 Comparison of net metering schemes in Arizona, California, Denmark and Italy

	ARIZONA	CALIFORNIA	DENMARK	ITALY
Total programme capacity	Unlimited	Capped	20 MW for systems > 6 kW; unlimited for systems < 6 kW	Unlimited
Maximum system size	125% of customer's on-site energy use	1 MW	None	200 kW
Rate awarded	Retail (kWh credit against retail price)	Retail (kWh credit against retail price)	Retail (kWh credit against retail price)	Retail price reduced of tax and levies for plants smaller than 20 kW; Wholesale price for plants incentivized also by FiT with a capacity larger than 20 kW
Period for reconciliation of net excess generation	Annual	Annual	Hourly	Annual
Treatment of net excess generation	Reconciled at avoided cost rate / adjusted average annual market price (varies by utility)	Indefinite carry over; customer option to reconcile net excess at annual average rate	Reconciled at DKK 1.3/kWh (~USD 0.24)	Indefinite carry over; customer option to redeem at value at end of year
Grid charges	USD 0.70/kW monthly charge	None currently. The California Public Utilities Commission is mandated to determine an appropriate fixed fee not to exceed USD 10/month.	None	Included in calculation to reflect net usage
Other/ notes	Grid charge passed in November 2013	Virtual net metering and meter aggregation possible. New law calls for new rules by 2017	Annual reconciliation replaced by hourly in late 2012, after a boom. This is leading to a fixed tariff	Italy's 'scambio sul posto' is differentiated from simple net metering due to its basis in market pricing

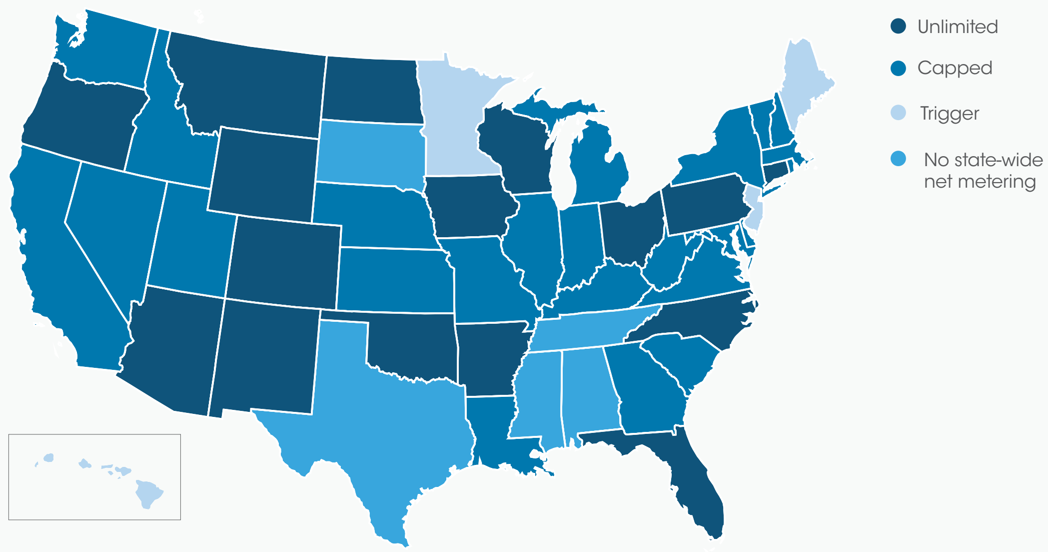
Columbia had voluntary or mandatory net metering programmes in place.

The practice is also expanding to South Asia and Latin America and the Caribbean, where several countries have introduced net metering policies in recent years, often in support of rooftop PV deployment. Several countries in Europe, such as Belgium, Denmark, the Netherlands and Italy, have adopted forms of net metering, often in addition to other support measures.

The classic form of net metering employed in the majority of U.S. states credits generators with the retail price that they would otherwise pay to consume from the grid – thus reimbursing them for non-power network charges as well. This has sparked off a continuing debate on the sharing of costs between different sets of consumers and other stakeholders within the energy sector. Some U.S. states use the utilities' "avoided cost" to calculate the rate owed, which is generally the cost of generation (see sub-section 3.2.2).

In the United States, 29 of the net metering states have in place some kind of limit on total net metered capacity – either through a defined cap (usually based on a percentage of each utility's peak demand) or through a trigger point at which utilities can request a binding limit (see Figure 3.4). These vary from 0.1% (Idaho) to 20% (Utah) of peak demand, while Maryland and New Hampshire have in place capacity limits (1 500 MW and 50 MW, respectively). Caps on individual system size run from 20 kW in Wisconsin to 8 MW in New Mexico. States are generally divided in their treatment of annual net excess generation between allowing indefinite

Figure 3.4 State net metering limits in the United States



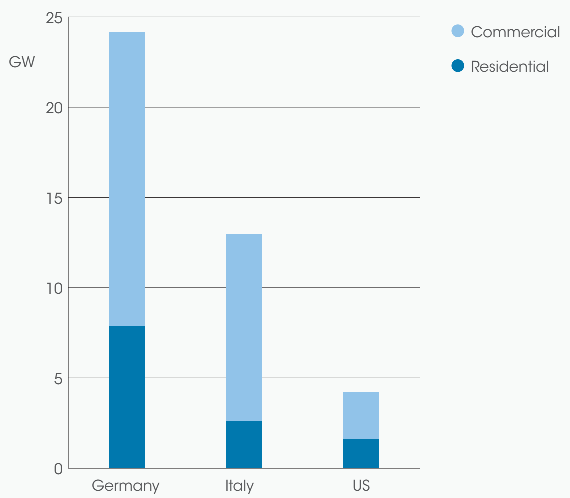
Source: BNEF.

Note: Map does not include Alaska, which is capped.

carry-over, granting the benefit to the utility or settling at an avoided cost rate.

Impact Assessment: Net metering has proven to be an effective stimulant of distributed renewable generation. In fact, over 1.5 GW of solar PV capacity deployed in the United States in 2012 was net metered, representing 99% of the total solar installations that year (Solar Electric Power Association, 2013). However, the total capacity installed in that market segment (including through net metering) is modest compared to capacities driven by FiTs in Germany and Italy (see Figure 3.5).

Figure 3.5 Commercial and residential small-scale PV capacity in Germany, Italy and the United States, 2012 (GW)



Source: BNEF.

Note: Residential installation is defined as <20kW; commercial is defined as 20kW-1MW.

There is disagreement over the balance of costs and benefits associated with higher levels of net metered distributed capacity. Increasingly in the United States, utilities argue that net metering still requires grid usage while exempting payment for it, which puts a disproportionate cost burden on other consumers. Meanwhile, solar advocates argue that net metering actually saves the utility transmission and distribution costs, because energy is generated close to consumption, and it reduces the need for expensive "peaking" generating capacity. Measures such as "value of solar" take into consideration these concerns (see sub-section 3.2.2).

Recently, U.S. utility Arizona Public Service (APS) obtained regulatory approval to charge its net metering customers a fixed charge. This charge is supposed to address the fact that by consuming self-generated electricity and receiving a full retail price for the power share fed into the grid, the net metering customers avoid paying transmission and distribution charges, which have to be spread among other consumers via their electricity bills. APS's net metering customers now pay a monthly charge of USD 0.70/kW of installed generating capacity while continuing to be paid for their power at the full retail value. Italy addresses the grid charges problem by paying the wholesale price for the electricity fed, rather than the full retail price.

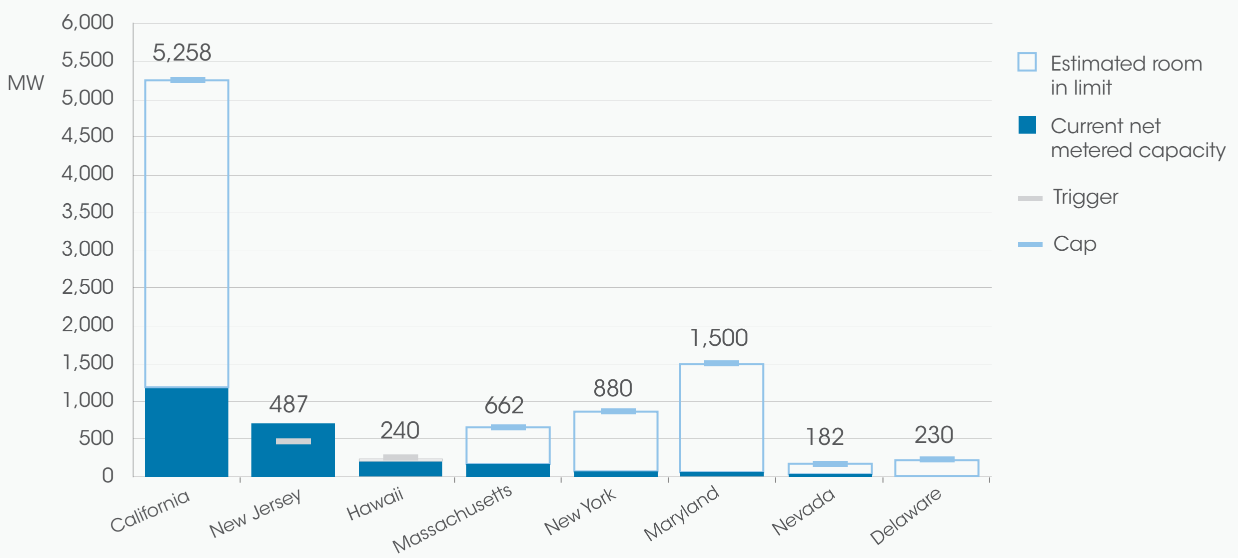
Interestingly, Spain has implemented similar charges on self-consumption projects. Consumer-generators are charged between EUR 0.07 and EUR 0.09 per kWh consumed, and no remuneration is granted for the excess electricity fed into the grid. As such, the proposed net metering scheme that would allow for exports to the grid was never implemented.

The assertion that net metering presents a significant challenge to utility business models given present PV penetration rates is somewhat premature in the United States, where only six states have PV penetration rates representing more than 1% of peak demand. This is not to suggest that the traditional utility business models do not face challenges from increasing penetration of PV. The state of Hawaii, with the highest penetration rate at 15%, is the only instance where concerns have been relatively significant. It is also the only state that sets limits on specific local circuits where a high penetration of self-generation creates operational risks for the utility (such as providing backup service on short notice). New Jersey has exceeded the statutory "trigger" after which it could block new net metering, but so far the state has not exercised that prerogative. California leads in total capacity installed but retains about 4 GW of headroom for further development (see Figure 3.6).

Risks: Net metering relies on the grid operating as a back-up for self-generators, contrary to the traditional structures of a centralised energy system. The risk is that, if not designed appropriately, such schemes can place a disproportionate burden on other rate-payers without PV systems. As with FiTs, there is a social equity dimension to this: those that make use of the incentive must be able to afford the upfront cost of a solar system, or own a rooftop to lease, and those that do not may have to settle for higher grid charges.

Denmark may have experienced the most dramatic installation boom – and consequent policy shift – from net metering. After seeing the installation of over 350 MW of residential PV in 2012 alone, taking the country well above its 2020 solar capacity target, it switched from annual to hourly net metering for the smallest systems, preventing users from using the electricity "credits" generated on a sunny summer day on a dark winter evening. The risk of similar events in the United States is limited by programme caps. Interestingly, systems benefiting from net metering schemes that compensate exported generation based on real-time power market prices may need further attention when implementing incentives for integrating residential storage (discussed in 3.2.3). In this case, individuals could

Figure 3.6 Net metered capacity versus estimated limit in selected U.S. states, H2 2013 (MW)



Source: BNEF.

use storage systems as a means to export electricity when it is more profitable.

POLICY INDICATOR
Renewables penetration: Low-medium-high
Economic development: Low-middle-high income
Policy goal: Incentivise distributed renewables generation, triggering technology innovation
Policy type: Net metering
Eligible technology: PV, other small-scale installations
Asset ownership: Residential, commercial, industrial
Complementary policies: Smart meter rollouts, "Value of Solar" tariffs

3.2.2 "Value of Solar" tariffs

As discussed in the previous section, net metering has come into wider use as a means of promoting renewable energy. However, concerns about rate-payer equity are being raised. In a typical net metering programme, the bill credit received by self-generators is equal to the full retail rate of the utility-delivered power that is displaced. The retail rate of practically all regulated distribution utilities includes a "system", "delivery" or "capacity" component, which pays for the utility's investment in power plants, wires, transformers and other non-power assets necessary to provide service. Therefore, the portion of those charges that is avoided by net metering customers is shifted to the utility's customers who do not net meter. This disparity is currently not significant due to the limited penetration of net metering-driven renewable energy deployment, but it will grow and represents a potential challenge.

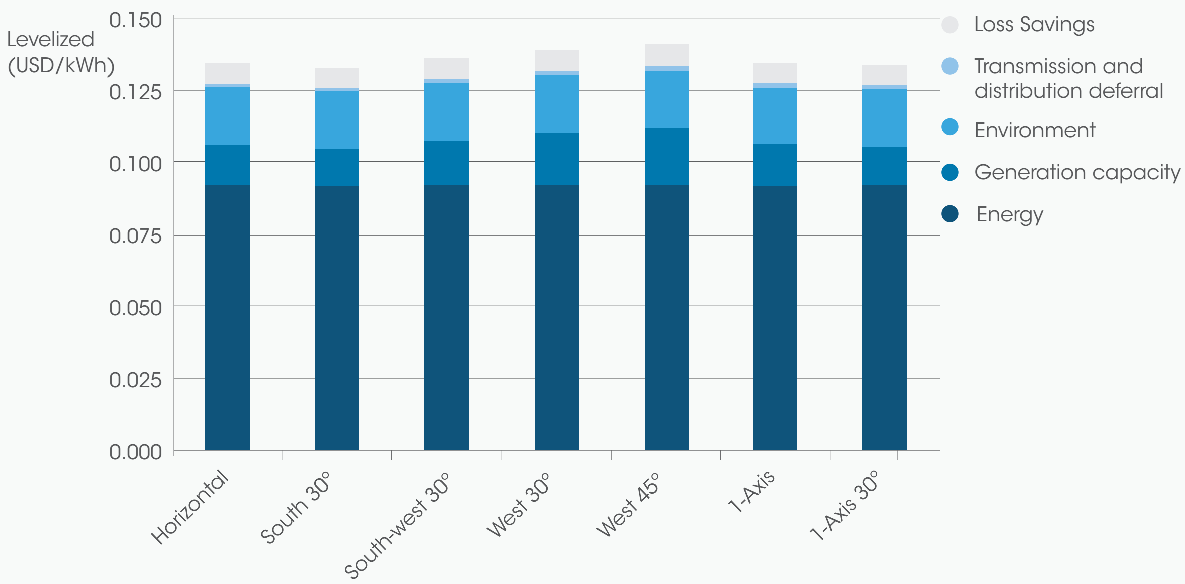
Policy overview: In part to address this, the municipally owned utility serving Austin, Texas, has adopted a Value of Solar (VOS) alternative to eliminate cost shifting. It does so by setting a credit rate for solar system owners based not on existing retail rates, but on a formula that quantifies the benefits enjoyed by both system owners and the distribution utility which provides their backup service. Austin Energy is employing the VOS to reach a distributed solar goal from all customer classes of 25 MW by 2020, of which 7 MW is to be from residential customers.

In October 2012, Austin migrated its residential solar net metering customers to the VOS-based credit programme, for which a customer-owned system is eligible for 25 years. The VOS is calculated using the following five cost inputs (see Figure 3.7):

1. *Energy*, defined as the wholesale cost of electricity displaced by the customer's generation;

2. *Capacity*, defined as the cost of a new natural gas-fuelled generating turbine that is avoided by the customer's generation;

FIGURE 3.7 PV SYSTEM VALUE BY COMPONENT AND CONFIGURATION IN AUSTIN, TEXAS



Source: Rabago, et al., 2012.

Note: Degree angles are module's tilt relative to horizontal; "1-Axis" is variable tilt and "1-Axis 30°" is fixed 30° tilt with rotation on the vertical axis.

3. *Transmission and distribution deferral*, defined as the savings from future investment in non-generation infrastructure (such as power lines and substations) based on an estimate of how much solar power customers can be relied upon to deliver to the grid;

4. *Loss savings*, defined as a self-generator's avoided need for supplemental energy to cover transmission and distribution losses; and

5. *Environment*, defined as the dollar savings from environmental damage that is avoided as a result of reducing the use of fossil fuels for power generation.

Initially, the VOS-based residential tariff was set at USD 0.128 per kWh. Effective January 2014, it was cut to USD 0.107 per kWh. It will be subject to annual adjustment based on changes in the underlying metrics. The VOS-based residential programme is applicable only as a credit against a customer's utility bill; the utility makes no payments to participating customers. The customer is billed each month for the total power consumed, plus the usual additional charges paid by every residential rate-payer. The VOS is then multiplied by the number of kWh generated by the residential system, and that figure is then subtracted from the consumer's final bill. Any surplus credits roll forward month-to-month until the end of the year but cannot be carried forward into the next year. This annual "zero out" protects the utility from longer-term payment obligations and protects the customer from a tax liability.

Impact assessment: The migration of its net metering customers to a VOS-based credit programme took place after a stakeholder consultation process in which stakeholders were made aware of the VOS formula and the differences between the VOS and net metering (Austin Energy, n.d.). At the time of the migration, the city of Austin had more than 1 750 rooftop installations totalling 6.6 MW, about 26% of its 2020 goal. In the first year of VOS, rooftop solar capacity installation rose 60%, leading utility officials to be optimistic that the 25 MW goal is achievable.

Interest in VOS is not limited to Austin. In March 2014, Minnesota became the first U.S. state to adopt VOS as an option for investor-owned utilities to use in compensating solar system owners for surplus electricity. State regulators are in the process of developing a formula to determine the VOS rate. The VOS concept has also drawn the attention of legislators in other U.S. states, including California, Michigan and Georgia.

Risks: The effectiveness of VOS-based tariffs relies on the underlying metrics and their weighting. Errors raise the prospect that VOS credits are too high, allowing participants to receive outsized benefits rather than simply getting compensated for actual costs; or too low, which could result in under-participation. A sudden or unexpected change in interest rates also could render the VOS metrics inaccurate.

In Austin's case, the first metric – the estimated cost of displaced energy – accounts for the biggest share (about USD 0.09) of the overall rate. The transmission and distribution deferral has the smallest share (a fraction of a cent). The USD 0.021/kWh reduction in the VOS tariff for 2014 was attributed by Austin to lower prices for natural gas, the marginal generation fuel in Texas. The utility also cut the assumed lifespan of a customer solar system from 30 to 25 years. It found that actual savings in avoided transmission-system costs were higher than anticipated, which somewhat moderated the tariff reduction.

The fact that the VOS tariff generates only a billing credit, not a monthly cash payment to solar system owners, may depress its uptake if it makes lenders unwilling to finance decentralised systems. But it is unlikely that regulators would allow cash payments for generation because that could expose small-system owners to the same regulations and taxation rules that apply to conventional power plant operators.

POLICY INDICATOR

Renewables penetration: Low-medium-high

Economic development: High-income

Policy goal: Provide adequate support for renewables, triggering technology innovation

Policy type: Feed-in tariff

Eligible technologies: Solar

Asset ownership: Residential, community, businesses

Complementary policies: Net metering

3.2.3 Integrating residential storage in the system

Net metering policies are designed to allow the export of excess generation to the grid. As the penetration of renewables increases, however, integrating high shares of variable generation becomes increasingly challenging. A broad range of measures are being adopted to address this, including those incentivising self-consumption; however, storage options, such as batteries, have been identified as the silver bullet in addressing this challenge. Household-size storage can also support self-consumption by saving PV-generated energy for when it is needed. This applies in particular to markets that have relatively high retail prices, such as Germany, where residential storage can help offset electricity bills and allow the owners to use the stored electricity when generation from rooftop panels is low.

Policy overview: In May 2013, Germany launched a EUR 25 million subsidy programme for PV-connected energy storage. The programme provides low-interest loans and a grant, or "repayment bonus", of up to 30% of the cost of the battery system. A new PV-connected energy storage system is eligible for a grant of up to EUR 600/kW of storage, while an existing PV system that is retrofitted with a battery could receive up to EUR 660/kW. Thus, in principle, the funding set aside for the programme could pay for up to 42 MW of storage (or 38 MW of storage retrofitted to existing PV systems).

There are two ways for a grant recipient to operate a storage-connected PV system: storing the electricity generated by the PV system and dispatching it to the grid later in the day, hence receiving the feed-in tariff; or increasing the share of self-consumption, by storing PV energy during times of low usage and consuming it later, thereby providing further independence from steadily increasing electricity prices (Bundesverband Solarwirtschaft (BSW), 2013).

Impact assessment: The economic case for PV-connected energy storage depends on a specific household's consumption, usage patterns, the size of both the PV system and the battery, how the battery is cycled throughout the day, and seasonal variations. Rough calculations indicate that the payback period for PV-connected energy storage systems in Germany ranges from 11 to 18 years, which is far too long for most customers (see Table 3.2). Despite this long pay-back time, the programme was fully subscribed within months of its launch, indicating that reasons other than payback time were motivating the uptake.

Another requirement of this particular programme is that no more than 60% of the output from the PV system can be exported to the grid at any single moment. This is beneficial from a grid management standpoint since it reduces the early-afternoon supply peak, but it makes little sense for a consumer. By accepting the subsidy and restricting the amount of electricity that can be exported to the grid, the recipient is limiting the revenue that he or she can receive from the FiT.

Table 3.2 illustrates the payback periods – calculated in terms of savings on electricity bills – for various storage system costs. For instance, a 4 kW system from RWE in

Table 3.2 Economics of PV-connected storage in Germany at various battery costs

SYSTEM SIZE	PV SYSTEM COST (EUR/kW)	PRE-SUBSIDY BATTERY SYSTEM COST (EUR/kW)	NEW-BUILD SUBSIDY (EUR/kW)	EXPECTED PAYBACK WITH SUBSIDY (YEARS)
4.5 kW PV and 4 kW battery	1 460	3 750	600	18
		3 250		16
		2 750		14
		2 250		12
		2 100		11
		1 250		8
		1 000		7

Source: BNEF.

Note: This assumes O&M costs for PV of 1.5% of capital expenditures, operations and maintenance costs for batteries of 2% and PV degradation of 0.7%. The two highlighted rows represent the products of RWE AG and BYD Auto Co., Ltd. Products costing <EUR 2 100/kW are not currently available in the market.

2013 cost about EUR 13 500, or EUR 3 750/kW, meaning a payback time of roughly 18 years.

Risks: The high costs of storage – even with the subsidy – mean that only early adopters will actually be able to invest in PV-connected storage. Even in a high-income country, such as Germany, this technology remains unaffordable for many households. Should the costs of residential-size batteries decline in the near future, this would allow for better household energy management and decrease household reliance on power sourced from the grid. It should be kept in mind the effect that the high adoption of residential storage could have on the management of the electricity system (in some markets consumers could use small storage systems to feed electricity into the grid according to the spot electricity price); therefore, preventive measures, such as limiting the amount or restricting the time when electricity can be fed into the grid, should be explored.

POLICY INDICATOR

POLICY INDICATOR

- Renewables penetration: Medium-high
- Economic development: High-income
- Policy goal: Incentivise self-consumption; Improve market integration of renewables, triggering technology innovation
- Policy type: Grants
- Eligible technology: PV-integrated storage
- Asset ownership: Residential, commercial, community
- Complementary policies: Feed-in tariffs, net metering

3.3 LESSONS LEARNED

As some renewable energy technology costs continue their downward trend, their uptake will be facilitated by self-consumption centric schemes, especially in an environment of high residential electricity prices, rather than by other policies such as feed-in tariffs. Ensuring policy efficiency in support of deployment in this context may face several challenges, as discussed above. These challenges become increasingly prominent as higher levels of distributed renewable energy are deployed.

Although self-consumption is encouraged to reduce the dependency of households or businesses on centrally provided electricity, most of these projects remain connected to the central grid network. The variable patterns of generation from such installations pose significant grid management challenges and bring up the question of how fixed transmission and distribution costs should be covered. The U.S. states of Arizona and Texas, as well as Spain and Germany, all either already have implemented or have proposed to implement certain transmission and distribution charges on distributed projects.

Three key lessons can be learned from the experience of the regulators analysed above:

1. Net metering can incentivise an uptake of residential solar PV, particularly in markets where grid parity is approaching due to decreasing technology costs and/or high retail electricity prices. However, the "reconciliation period" (*i.e.*, for how long the project owners can claim back the electricity fed into the grid) must be carefully considered.

2. Diffusion of net metering is raising concerns in terms of network cost sharing since usually project owners pay a smaller share of the grid's transmission and distribution costs. Some countries have tried to address this through special charges incorporated in the design, while the "value of solar" tariff pioneered by the U.S. city of Austin, Texas, tries to address this by estimating the real "value of solar" to the system.

3. Residential storage systems have the potential to better integrate the electricity from distributed projects with the central electricity grid; however, at the moment these technologies remain prohibitively expensive for the majority of the owners of decentralised renewable generators.

Although at the moment, the opportunities presented by approaching grid – and socket – parity have been fully embraced mostly by developed nations, the distributed nature of self-generation bring a tremendous opportunity to developing countries. While residential storage applications remain expensive and will continue to be so for a while, PV equipment is not, and the emerging markets will soon be the main source of demand for PV equipment and installations.

4 Integration of Variable Renewable Power

4.1 CHALLENGE: INTEGRATING INCREASING GENERATION FROM VARIABLE SOURCES

Effective and efficient integration – in terms of physical connection, network management and market integration – has become a pressing challenge for the renewable energy sector, particularly in markets with higher rates of renewable penetration. A recent study concluded that technical integration is not a relevant constraint for integrating variable generation when the share of such renewables is between 5 and 10% of electricity generation, so long as specific best practices, such as improved forecasting, are implemented in system operation (International Energy Agency (IEA), 2014). However, as penetration rates further increase, system integration and adaptation issues become more prominent.

This section reviews some of the different dimensions of grid and system integration of variable renewable energy generation, including expansion and reinforcement of physical grid infrastructure, the role of technological advancements in making networks smarter and better able to cope with variability of supply, and the broader impacts of integrating higher levels of renewables on power markets.

4.1.1 Grid infrastructure

Adequate grid infrastructure to evacuate renewable generation and transmit it from generation sites to load centres is critical for increasing the share of renewables in the national energy mix. At the generation level, large-scale renewable energy plants are often located in remote areas, and hence the development phase is often accompanied by an assessment of the infrastructure needed to facilitate connection of the plant to nearest connection point. Experience with grid integration has shown the need for extending such an assessment until the end-user in order to identify early on any grid enhancement needed and to avoid a situation of plant idling due to the lack of evacuation or transmission infrastructure.

At a sub-national, national and regional level, as renewable generation increases, challenges associated with grid availability, transmission capacity and balancing costs become more prevalent. Such challenges are further compounded for grids which do not benefit from adequate interconnection capacity to balance out excess or deficit generation. This subsection examines two case studies to illustrate these challenges from a developing-country (India) and developed-country (Germany) perspective.

INDIA

Renewables accounted for over 12% of India's total installed capacity of 243 GW as of March 2014 (excluding large hydropower) (Central Electricity Authority (CEA), 2014). Wind is the largest contributor with over 21 GW installed, up 2 GW from the same period in 2013. Large-scale solar deployment has picked up pace, with more than 2.6 GW deployed, following the launch of the National Solar Mission and the introduction of dedicated solar policies in several states (MNRE, 2014). However, much of this renewable generation is concentrated in certain pockets of the country that have the best resources as well as effective support policies (see Table 4.1).

In the Southern grid, for example, renewables account for almost a quarter of total generating capacity. The southern state of Tamil Nadu had the highest installed capacity of renewable energy at 7.8 GW, 7 GW of which was wind. Other states with high renewable penetration rates include Maharashtra, Gujarat, Rajasthan and Karnataka.

The challenges associated with grid integration are already apparent. Lack of adequate power evacuation capacity in the state grids has been a major concern in transmission planning (GWEC, 2012). In the state of Tamil Nadu, for example, about 40% of the energy during peak wind season was lost due to power

Table 4.1 Installed generating capacity in India as of March 2014 (by region)

REGION	LARGE HYDRO (>25MW) CAPACITY (MW)	NON-HYDRO RENEWABLE CAPACITY (MW)	TOTAL CAPACITY (MW)	NON-HYDRO RENEWABLES SHARE (%)
Northern	16 331	5 730	64 258	8.9%
Western	7 448	9 925	87 389	11.4%
Southern	11 398	13 127	58 330	22.5%
Eastern	4 113	417	30 066	1.4%
North Eastern	1 242	252	2 901	8.7%
Islands	0	10	80	12.5%
Total	40 531	29 461	243 024	12.1%

Source: CEA (2014).

evacuation issues. Capacity deployment increased rapidly, however the evacuation infrastructure could not keep pace. This is evident from the fact that overall capacity utilisation factor for the state dipped by more than 50% for the same month in 2012 and 2013 (Nampoothiri, 2014). This reduction has also been in part due to grid congestion and limited flexibility of base-load capacity operational in the region. Similar grid evacuation challenges have been faced by solar developers who are often left with stranded generating assets awaiting enhancement of evacuation and distribution infrastructure.

GERMANY

With roughly a quarter of its power demand sourced from renewable generation, the need for upgrading and expanding Germany's transmission and distribution network is emerging. The main grid-related challenges faced are distances between generation and consumption hubs, demand for offshore wind connections, and intensification of "power loop-flows".

Traditionally, fossil fuel and nuclear generation projects have been constructed relatively close to demand centres. By contrast, renewables projects – wind farms, in particular – have been developed mostly in the northern parts of the country. A large share of Germany's 32 GW of onshore wind capacity operates in the north. The hubs of German industry with the highest power demand, on the other hand, are centred in the southern parts of the country.

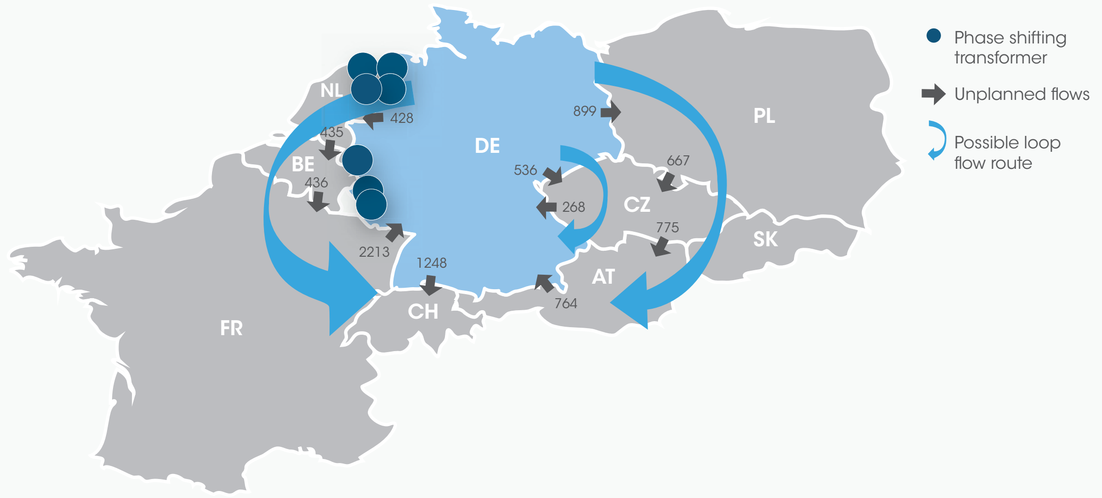
This expanded average distance between power generation and consumption has created an urgent need for a radical overhaul and expansion of Germany's network. North-south grid connections are currently unable to cope with the heavy flow of renewable power from the north to the south. Limited national grid capacity to allow power flows from the northern wind generation hub to the centre of consumption in the south often leads to electricity "detouring" to other countries via the cross-border interconnections. It is not uncommon for renewable power generated in Germany's north to move through the Netherlands and France in the west, or Poland and the Czech Republic in the east via cross-border interconnections (see Figure 4.1) before arriving at its final destination back in southern Germany. The magnitude of recent cross-border flows has highlighted an urgent need for grid network development, both nationally and internationally.

Under its proposed 2014 EEG reform, Germany aims to construct 6.5 GW of offshore wind by 2020, up from 720 MW on line today (see Figure 4.2). The new projects will need to be connected to the onshore grid and the power then transported through to demand centres (see Figure 4.3).

4.1.2 Maintaining system stability

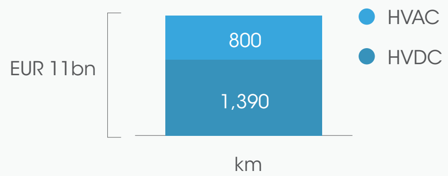
Wind and solar-generated power can displace mid-merit power in liberalised markets (see sub-section 4.1.3), but it cannot fully substitute other generation technologies in most markets due to variable generation patterns. A certain margin of dispatchable generation (*i.e.*, plants that can be switched on and off as required, with fast ramp up/ramp down capability) must stay on the system to supply power in the event of lower provision from renewables. With increasing penetration of variable renewables, the integration costs related to balancing, maintaining

Figure 4.1 Average unscheduled cross-border power flows from Germany, 2011-12 (MW)



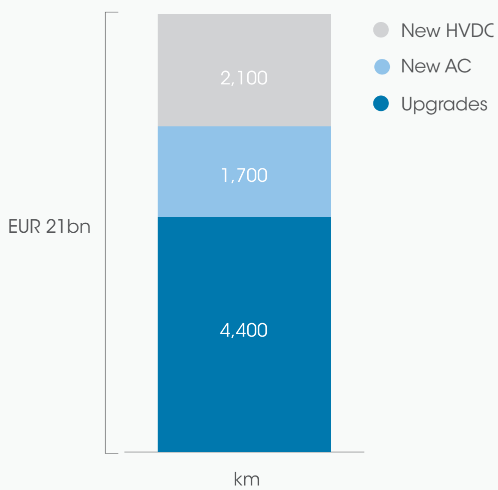
Source: Adapted from CEPS, MAVIR, PSE SA and SEPS, 2013.

Figure 4.2 Germany's offshore grid development plan to connect 6.5 GW of offshore wind projects by 2020 and estimated costs



Source: German Offshore Grid Development Plan, 2014.

Figure 4.3 Germany's onshore grid development plan and estimated cost, 2013-23



Source: German Onshore Grid Development Plan, 2013.

Note: "HV" relates to high-voltage cables' "AC" - alternating current; "DC"- direct current.

adequacy and grids may vary depending on system-specific characteristics (*e.g.* profile of balancing units) (IEA, 2014). These costs can, however, be minimised, for instance by adapting existing regulatory frameworks to effectively manage the scheduling and dispatch of renewable power. This is particularly relevant for markets where renewables are entitled to priority dispatch, thereby necessitating the need for improved forecasting to minimise cost of system management.

Governments, grid operators and regulators often find themselves in a challenging position of balancing the dual objectives of supporting the deployment of reneawble energy while maintaining grid stability and reliability of supply. Although wholly new market designs have yet to emerge, some countries are already rolling out various ways to reward those on both the supply and demand side of the electricity equation for being willing to provide flexibility. Smart grid technologies can also help address this issue and energy storage technologies are poised to play a significant role once their costs are reduced.

4.1.3 Merit-order effect and price suppression

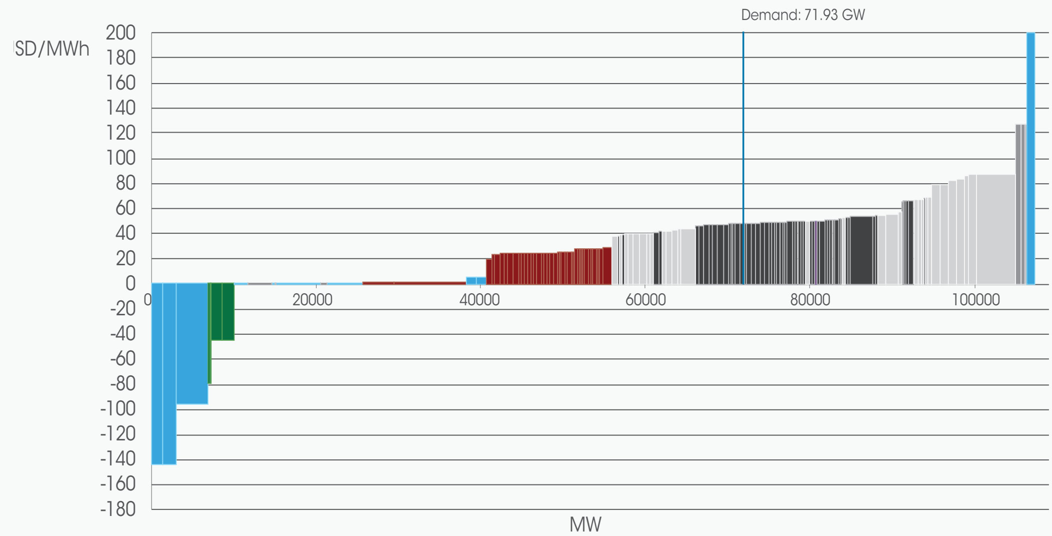
Power market structures vary widely among countries. In many countries, electricity systems are centrally managed, with a monopoly supplier (often a vertically integrated, state-owned power company) maintaining control over power supply and, consequently, over deployment of renewable capacity. In such cases, retail tariffs often do not reflect the actual cost of supplying electricity, with the responsibility of distribution and retailing resting with a state-owned entity.

In liberalised markets, however, "pool" designs are common – for instance in Europe and the United States – wherein dispatch is based on marginal costs of generation for each power producer. In such a market structure, renewables, which in most cases benefit from priority dispatch and that enter the market at zero or minimal marginal costs (by virtue of their minimal operating costs), are creating a situation where the commercial viability of flexible power providers, primarily natural gas generators, is being challenged as a result of what is often referred to as the merit-order effect.

This can be well demonstrated by the case of Germany, where some flexible power providers, primarily natural gas generators, are facing significant challenges. Figures 4.4 and 4.5 illustrate the impact of integrating higher shares of renewables in the country, using generation data from 1 June 2010 and 1 June 2012 to show how higher shares of renewables pushed coal and gas plants out of the market.

A high influx of renewable electricity can suppress wholesale power prices (see Figure 4.6) and push

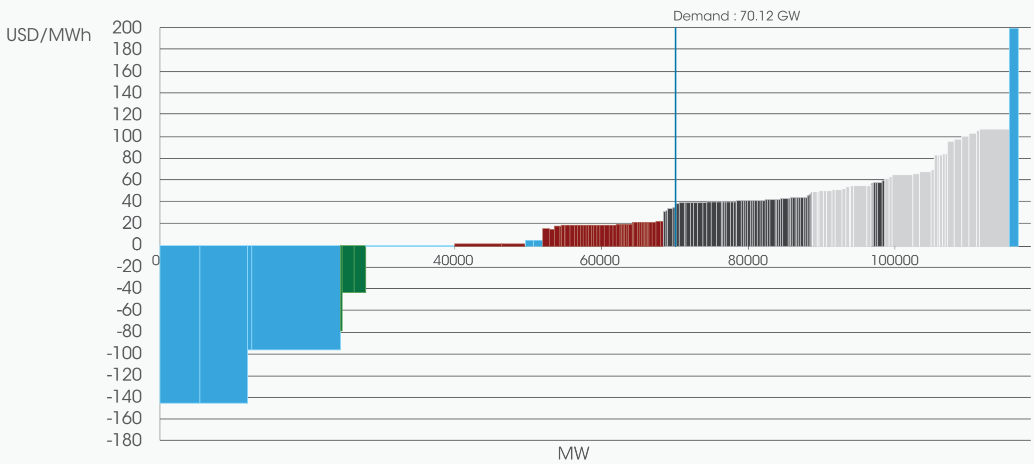
Figure 4.4 Merit order on a summer day (1 June 2010) in Germany



Source: BNEF.

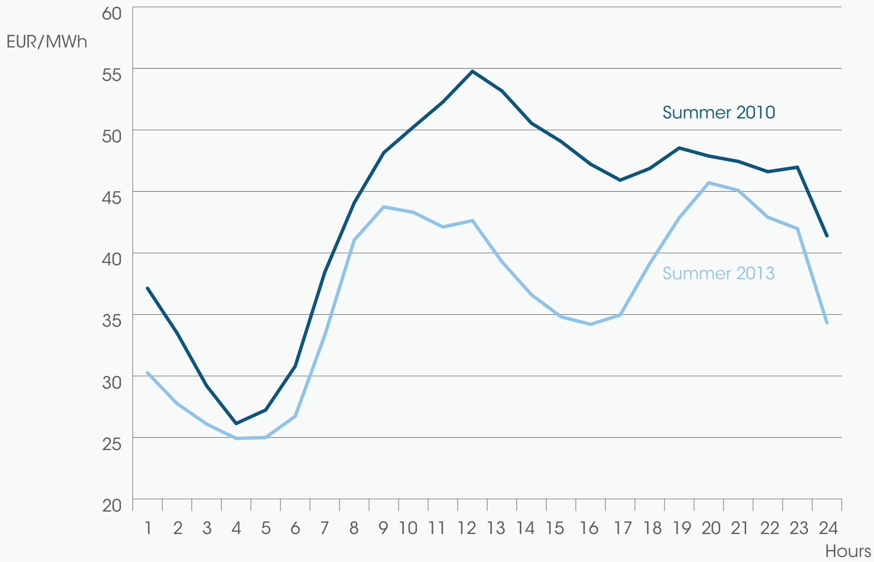
Note: The adopted colour scheme is as follows- blue (solar and onshore wind), green (biomass), red (nuclear), brown (lignite), grey (natural gas), black (coal) and dark grey (oil). Light blue (extreme right) signifies demand response.

Figure 4.5 Merit order on a summer day (1 June 2012) in Germany



Source: BNEF.

Figure 4.6 Average daily summer spot price profile in Germany, 2010 and 2013 (EUR/MWh)



Source: BNEF based on data from European Energy Exchange.

some incumbent generators out of the merit order, especially when the wind/sun conditions are favourable, as has been the case frequently in Germany. Solar PV projects in particular, typically maximise output at times of peak demand and thus reduce the market clearing price at what would otherwise be lucrative moments for incumbent generators.

In Germany, the country's four major utilities traditionally looked to peak demand times as opportunities to recover costs associated with long-term investments in infrastructure. Now, with prices substantially reduced and the merit order shifted by renewables, these incumbent generators are more likely to operate fewer hours in the year and at lower prices. The high renewables influx (and their impact on power market prices) combined with low carbon prices under the EU Emissions Trading Scheme have led to a situation where natural gas plants in particular have suffered operational losses. In response, German utilities have announced plans to scale down their gas generation capacity. In April 2014, the German Federal Network Agency (BNetzA) confirmed that it received 47 requests pending from utilities to shut down power plants, up 68% from October. This case is symbolic of broader challenges currently faced by utilities and of the need for them to diversify business strategies and look at new opportunities (see Box 4.1).

4.2 RESPONSES

Governments and regulators around the world, particularly in countries with medium-to-high levels of renewable penetration, have been innovating to ensure renewables integration while maintaining system stability and reliability. As a result, diverse regulatory and technological options are now either already operating or in design to address both grid and associated market issues. This sub-section first examines available options for grid infrastructure upgrades, then shifts to system management options and finally focusses on the relevant market adjustments.

4.2.1 Grid development plan: India

Policy Overview: The grid development roadmap is outlined in India's five-year plan (2012-2017) and is elaborated on in the Power Grid Corporation of India's Green Energy Corridor Report, released in 2012 (POWERGRID, 2012). The plans are developed by the Planning Commission of India in consultation with various ministries, and the national Power Grid Corporation is responsible for implementing them.

The issue of disproportionate geographical distribution of renewable power generation, as discussed in sub-section 4.1.1, could be partially addressed by a larger inter-connected transmission system. However, as of

Box 4.1

EMERGING CHALLENGES AND OPPORTUNITIES FOR TRADITIONAL UTILITIES

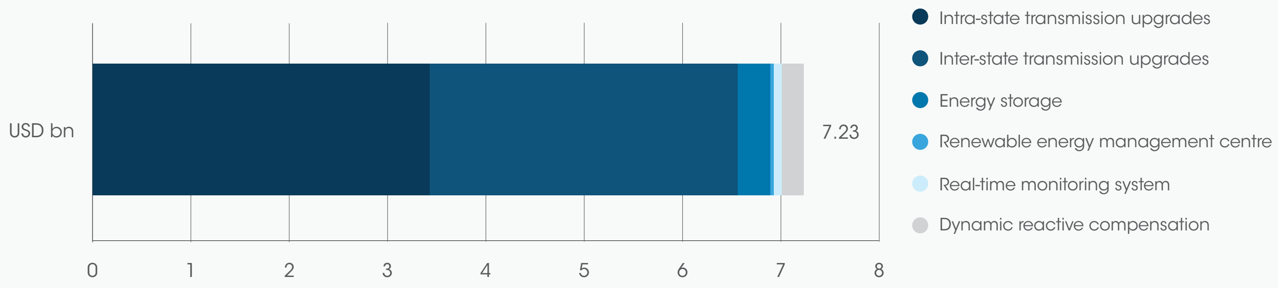
The dynamics of a transitioning electricity market are presenting particular challenges for traditional utilities. Rising deployment of renewable energy and its impact on wholesale power prices is affecting the profitability of generation assets across the utility portfolios. Additionally, rapidly growing deployment of decentralised solutions, such as rooftop PV, is altering the traditional ownership structures that have prevailed within the energy sector for decades. Many utilities are now compelled to adapt their business models to be better placed to tap into the opportunities that the transition presents. Emerging technological fields, such as distributed storage, smart grids, transport sector electrification and demand response, while adding to the complexity of conventional operations, also provide opportunities for diversification of activities.

As a result, utilities – particularly in Europe and the United States – are considering or already implementing alternative business strategies. Some utilities have started expanding their geographical focus and continuing their existing business models (providing power generation from fossil and renewable sources) abroad. They are targeting primarily markets with high (or growing) electricity demand to invest in thermal or large-scale renewable generation. In their domestic markets, utilities are increasingly considering various downstream activities. These may include, but are not limited to: demand-side management (on both the industrial and residential levels), smart-home management, offering distributed generation packages (including generation equipment and installation, operations and maintenance services), sale or loan of energy efficiency products. New utility strategies also require thorough organisational changes within the utilities, which have been operating under their traditional business models for decades without the need for significant business innovation.

the end of 2012, inter-regional transmission capacity in India was just 32 GW. The five-year plan envisages capacity to double to 65 GW by 2017, thanks to a substantial share of the overall investment directed to this expansion (see Figure 4.7). The plan also envisages improved grid management practices, centred on managing variable renewable electricity generation through storage capacity deployment and real-time monitoring of power flows, to allow early detection of stress situations.

In addition to renewables-specific grid development plans, other important milestones have been reached recently to improve the management of India's stressed transmission network. In January 2014, the southern grid was synchronously connected to the rest of the national grid as part of the country's "One Nation – One Grid – One Frequency" initiative. While this benefits the overall management of an electricity sector faced with acute power deficits, it also has positive implications for integrating variable renewable generation such as solar and wind (PIB, 2014). The plan also proposes to establish renewable energy management centres to be collocated with respective load dispatch centers at the state and regional-level. Such an arrangement aims at facilitating real-time data monitoring, coordinated forecasting efforts and more cost-effective management of the grid (POWERGRID, 2012). As such,

Figure 4.7 India's Green Energy Corridor plan, July 2012-2017



Source: POWERGRID, 2012.

Note: The INR 434 billion amounts to roughly USD 7 billion.

to allow proper scheduling and dispatching of generation from wind power plants, the grid code mandated wind energy forecasting on a day-ahead basis with 70% accuracy. Forecasting can be done either on an individual developer basis or on a joint basis for an aggregated generation capacity of 10 MW or above. Variations in actual generation beyond ± 30% of the schedule leads to the generator bearing pre-set penalties (CEA, 2013).

Impact Assessment: A clearly defined grid investment timeline established by policy makers can create important visibility for private sector players seeking to make investment decisions, particularly regarding the development of new renewable energy projects. Understanding grid constraints can reduce project development costs, prevent connection delays and lower risks of future curtailments. For these advantages to be realised, however, strong implementation is needed.

There have been several important developments in regard to smart grid technologies in India The Ministry of Power approved 14 smart grid pilot projects across the country with the aim of using these as test beds for subsequent large-scale roll out. The functionalities covered in the pilot projects include advanced metering infrastructure, demand side management and response, outage management system, power quality management, renewables integration, street light automation and smart home, electric vehicles and energy storage. The Puducherry Smart Grid Pilot, one among the 14 selected projects, has been operational with over 1400 smart meters deployed, renewables integrated through net metering, demand response measures in place and smart street lighting system introduced (POWERGRID, 2014).

Developers met the introduction of wind forecasting regulations with scepticism, stating that compliance was challenging for individual projects and rallying for more accurate, region-wide predictions which can be conducted by a centralised dispatcher. With projects unable to produce forecasts within the set margins, the regulation has been suspended temporarily (Pearson, 2014). Regulators are now tasked with identifying the most suitable mechanisms through which grid stability can be ensured, especially while integrating growing shares of variable renewable generation.

Risks: Major grid upgrade plans are useful to renewable energy markets only if they are implemented effectively in a timely and co-ordinated manner. A complex system of checks and balances can ensure that bottlenecks are identified early on and addressed through established alternative procedures. This however, requires transparent co-operation between the grid actors responsible for plan implementation, regulators and the government. A critical success factor in designing regulatory regimes that improve grid discipline and minimise costs from integrating renewable energy is ensuring compliance. India's experience with mandating forecasting on project developers demonstrates the need for more closely analysing the distribution of specific responsibilities and costs across a range of stakeholders that can collectively contribute to smoother integration of renewables.

4.2.2 Grid development plan: Germany

Policy overview: In Germany, the government has acknowledged that grid upgrades must be prioritised for its Energiewende[2] to succeed. By obliging its TSOs to submit binding grid development plans, Germany is ensuring national network development visibility. In return, the government has established a funding mechanism that allows TSOs to pass some of the associated costs on to the final consumers and that guarantees fixed returns on investments. To ensure the successful rollout of the network development plans, in July 2013 the German government passed a policy package that intends to:

» Streamline planning procedures, making BNetzA a "one-stop shop" for obtaining all necessary planning permissions, thereby, minimising the state-level approval requirements;

» End the full network charge exemption for energy intensive industries, with an aim to gradually move towards a system rewarding energy efficiency and creating a positive relationship between payments and consumption; and

» Extend the investment framework from sole transmission upgrades and developments, to cover investments in high-voltage distribution networks and related research and development (R&D).

Impact Assessment: Through this set of measures, the German government expects to secure the EUR 21 billion that the TSOs estimate will be needed to build 3 600 kilometres of new lines and to upgrade 4 900 kilometres of existing lines by 2023. A separate offshore

2 Energy transiton or turnaround, a term which refers to the decision to phase out nuclear power and replace it largely with renewable generation.

network development plan has also been developed, to ensure that offshore wind connections are well planned and co-ordinated (see sub-section 4.2.3). As a relatively new policy, the German government grid plan cannot be fully assessed yet. However, the streamlined planning process aims to cut planning times from the current approximately ten years to five years (see Figure 4.8).

Risks: A risk regarding the grid development policy frameworks is the accuracy of the TSO forecasts, which might understate or overstate actual transmission capacity needs and thus could risk the development of needed infrastructure or create unnecessary costs. This makes it essential that these plans are cross-checked by an independent organisation – as in the German case, where BNetzA can approve or reject parts of TSOs' plans.

The second big risk is the social acceptance of the new projects. Transmission lines in close proximity to households can be controversial, especially if homeowners receive no associated direct benefits. Thus it is critical that development plans adequately consider engagement of the public to overcome social acceptance barriers. This is particularly true in cases where additional costs associated with development are perceived to be or actually are borne by consumers.

POLICY INDICATOR

Renewable penetration: Medium-high

Economic development: High income

Policy goal: Improve integration of renewables; ensure security and reliability of power supply

Policy type: grid development

Eligible technology: N/A

Asset ownership: Utility, IPPs, investment funds/banks

Complementary policies: Renewables support

4.2.3 Offshore wind connection liability arrangement: Germany

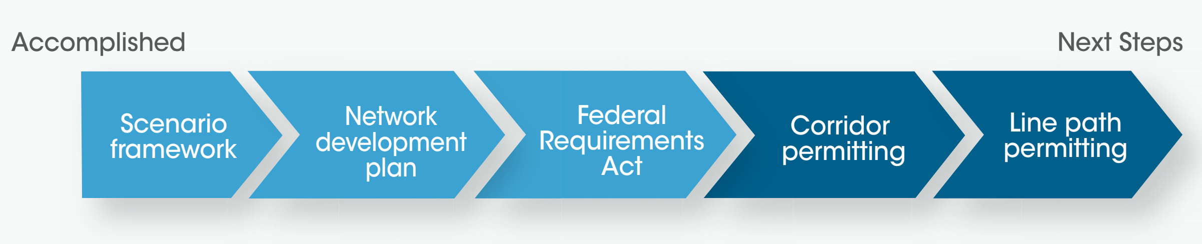
As part of its Energiewende, Germany aims to develop 6.5 GW of offshore wind by 2020, a target recently reduced from the previously expected 10 GW by that date. In recent years, many projects from the offshore wind pipeline faced delays cause by grid connection issues. In November 2011, one of Germany's four TSOs, TenneT, announced that it would be unable to connect North Sea projects on time, resulting in severe delays and losses to developers.

Policy Overview: In response, German lawmakers passed an amendment to the Energy Act aiming to protect generators from revenue loss caused by delayed grid connections or interrupted transmission. Affected power producers are entitled to fixed compensation payments amounting to 90% of the FiT they would claim otherwise. The risk exposure to TSOs in cases of delay has been limited by placing a cap on the total annual compensation at EUR 110 million. The overall cost of the support is passed on to consumers as transmission charges, which have also been capped at EUR 0.0025 per kWh.

Impact Assessment: In this case, various stakeholder interests are being taken into account to ensure greater investment certainty for those willing to deploy capital. Assuming a FiT of EUR 190/MWh, a 200 MW offshore wind project can lose up to EUR 400 000 per day of delayed connection, resulting in a 12-month cost of around EUR 150 million. Table 4.2 shows that without this regime, offshore wind project operating losses could amount to more than EUR 1.1 billion.

Risk: While aimed at improving investor certainty, the policy introduces an additional levy on consumer bills. Germany already experiences among the highest electricity prices in Europe, and the relatively high costs of offshore wind generation might influence

Figure 4.8 Key steps in Germany's network development process



Source: BNetzA, n.d.

Note: Each year, the TSOs develop a scenario-based network development plan and present it to the BNetzA. The Federal Requirements Act needs to be adopted every three years. TSOs must consider several alternative routes for each corridor, put their plans out to the public, then conduct an environmental impact assessment before receiving permission.

Table 4.2 Estimated cost of delay in offshore wind projects in Germany

WIND FARM	SUBSTATION	MW	DELAY (MONTHS)	COST OF DELAY (EUR MILLION)
Amrumbank West	HelWin II	288	15	274
Nordsee Ost	HelWin I	295	12	224
Meerwind	HelWin I	288	12	219
Dan Tysk	SylWin I	288	5	91
Butendiek	SylWin I	288	5	91
Global Tech I	BorWin II	400	3	76
Veja Mate	BorWin II	400	3	76
Borkum West II	DolWin I	200	6	76

Source: BNEF.

future policy-making towards a more-planned grid infrastructure development strategy.

POLICY INDICATOR

Renewables penetration: Medium-high

Economic development: Medium-high income

Policy goal: Improve renewables integration, ensure security of power supply

Eligible technology: Offshore wind

Asset ownership: Utility, IPPs, others

Complementary policies: Feed-in tariffs for offshore wind, grid development plans

4.2.4 Smart grid implementation and smart meter rollouts

The transition towards an energy system dominated by renewable energy is feasible, but it will require upgrading the existing infrastructure and implementing new innovative solutions to accommodate a high share of variable generation. Smart-grid technology is one such solution that can help overcome variability challenges, support distributed generation and improve system-level efficiency (IRENA, 2013c). Traditional grids were designed for a one-way interaction between the generator and consumer. The grid of the future can be envisaged to incorporate a diverse set of power plants of varying scales feeding into an interactive network at different stages in order to cater to the demands of an increasingly electrified consumer base. Such a smart grid is inherently based on a two-way flow of electricity, but also incorporates information and communication technology into every aspect of electricity generation, delivery and consumption to improve reliability of the system and enable it to react more effectively to variability in generation (IRENA, 2013c). This is increasingly emerging as a significant opportunity for transmission system operators as well as distribution system operators (DSOs) that are seeking to adapt their operations towards integrating higher shares of variable power into the grid.

Table 4.3 presents elements of the Irish DSO ESB Networks' 2013 electrification programme, identifying future alternatives to physical network reinforcements, in reaction to rapidly increasing shares of wind power entering the network system. Combined with smart meters, discussed later, and improved communication channels between TSOs and DSOs, these solutions provide a good illustration of the shift towards stronger and smarter networks.

These are technical options at the disposal of grid operators on both the transmission and distribution levels. However, the regulatory structure in many countries still incentivises grid operators to invest in traditional solutions when installing new grids or upgrading old ones rather than in cost-effective "smart" technologies, including smart meters and smart transformers (IRENA, 2013c). It is in the hands of policy makers to provide adequate incentives and regulatory frameworks to facilitate the deployment of newer technologies. Policy makers in countries such as Italy, Portugal and Finland have adapted their regulatory frameworks to provide grid operators with premium rates of return on certain types of

Table 4.3 ESB Networks' challenges in integrating variable renewables

CHALLENGE	CURRENT SOLUTION	IDENTIFIED FUTURE ALTERNATIVES
Voltage rise	Network reinforcement	Voltage and VAR optimisation, demand-side management, storage
Network capacity	Network reinforcement	Demand-side management, state estimation, network reconfiguration. storage
Sources of reactive power	Transmission network	Wind turbines connected to the distribution grid, storage assets
Aging network assets	Network reinforcement/replacement	Asset monitoring, voltage control

Source: BNEF, 2013.
Note: VVO to refers to Volt/VAR optimisation.

grid investments, such as digital grid management. Another related area is mandated smart meter installations, which has perhaps seen the most rapid regulatory progress in Europe.

SMART METER ROLLOUTS

Policy overview: Smart meters can act as grid sensors and provide valuable information to improve distribution grid management. Data from smart meters can be used to optimise voltage levels, extend the life of grid assets and help pinpoint network outages, all of which become increasingly important as shares of variable renewable power rise. They are also complementary to other measures, such as net metering, time-of-use rates and demand response, all of which help manage the system with high level of renewables penetration. While there is variation among the specific functionalities, in general they require the substitution of existing analogue and mechanical meters with digital devices capable of transmitting and receiving data from a customer's premises to a utility communications network.

The EU has mandated that member states roll out smart meters to 80% of customers by 2020, with member nations having implemented the mandates to varying degrees. Annual installations in the region are expected to reach 27 million meters by 2020 (see Figure 4.9).

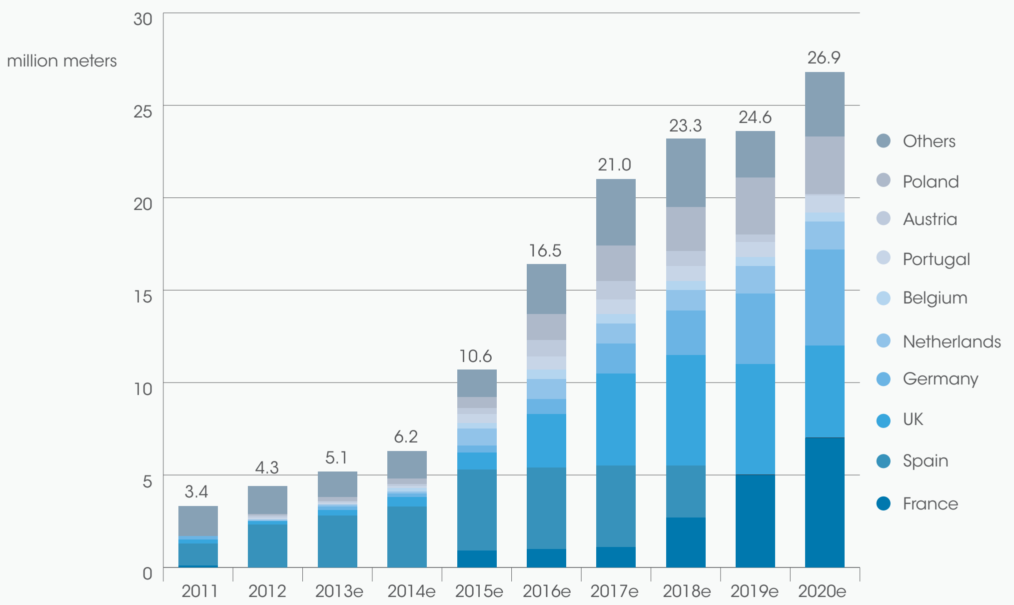
The digital nature of smart meters and their ability to actively monitor consumption patterns have raised privacy concerns among different stakeholders, primarily communities. These concerns are affecting policy-making in terms of standardising design features and introducing regulatory frameworks for smart meter rollout. The experience of Netherlands in particular illustrates how these concerns can be addressed.

Netherlands rollout: The Netherlands undertook a national smart meter deployment beginning in 2012. The objective of the scheme is to install 7.5 million electric and 6.5 million natural gas devices by 2020. Under the initiative, smart meters are being installed in newly constructed buildings as well as those under renovation. The initiative offers consumers an opt-out clause under which they may refuse to have a smart meter installed or may block it from being read remotely.

Impact assessment: By providing detailed consumption data, smart meters have a potential to facilitate demand-response activities, particularly through aggregation of data from several smaller consumers and hence enhancing grid management. Such data availability, however, raises privacy concerns, and the Dutch smart meter rollout signifies an important shift in terms of data protection. The act transferred authority for installing and maintaining the meters from private suppliers to the country's power network operators. As a result, smart metering became a regulated activity in the Netherlands, with its installation and operating costs reimbursed via retail electricity rates paid by the consumer.

To address privacy concerns, the act limits how often network operators may read smart meters and prohibits continuous data flows. Customers won options at both ends of the continuum: adopters may approve higher frequency data flows, while sceptics may opt out of smart grid-enabled services.

Figure 4.9 Annual smart meter installations in the EU, 2011-2020e (million meters)



Source: BNEF, 2012b.

Risks: Smart meter rollout policies to date have been hampered by several factors, including concerns from customers about the privacy of their data, reluctance from regulators to pass associated costs on to rate-payers, caps on utility rates of return (see Box 4.2) and higher capital spending priorities among utilities.

Data protection concerns have been a major challenge for policy makers designing smart meter rollout schemes. Creating a central data provider to be in charge of managing this data flow (as in the Netherlands) is one way of ensuring a certain level of protection. However, it may be hard for such a body to provide this data to DSOs in a timely manner which allows them to apply other mechanisms of their smart networks to react to unexpected developments such as rapid demand swings. The data and privacy concerns can also be addressed by allowing consumers to opt out of participating – an option which dilutes smart meters' value proposition.

POLICY INDICATOR — POLICY INDICATOR

Renewables penetration: High

Economic development: High income

Policy goal: Improve market integration of renewables; ensure security and reliability of power supply; triggering technology innovation

Policy type: Utility regulation

Eligible technology: Smart meters

Asset ownership: N/A

Complementary policies: Net metering, time-of-use rates, demand response

4.2.5 Grid-scale energy storage

Affordable and reliable grid-scale power storage technologies can play an important role in overcoming the variability of renewable generation. Section 3.2.3

Box 4.2

THE RISK OF CAPPING UTILITY RETURNS ON SMART METER INVESTMENTS

Spain provides an example of the challenges posed by capping the rate of return that a utility can generate by investing in smart meter infrastructure. The country's Royal Decree Law (RDL), passed on 1 February 2013, set rates for 2013 and 2014. The rate of return under the RDL is based on ten-year government bonds plus 200 basis points for 2014. This puts the regulated rate of return at around 6.5% for 2014. Such a return is below the current weighted average cost of capital for Spanish utilities of 7.3-8.9%. With returns for distributors lower than the cost of capital, grid investment could be stymied in the coming years, and smart metering and smart grid projects could be impacted.

presented the case for promoting residential storage systems as a means to encourage self-consumption and reduce the need for financial and non-financial support, especially in an environment of approaching grid parity.

At an electricity system level, the role of grid-scale storage options in improving grid management, alongside other measures discussed elsewhere – such as policies supporting smart grids, demand-side response and adequate infrastructure capacity – can be substantial for three primary reasons. Grid-scale storage options can: 1) reduce the need for fossil-fuel based balancing capacity by enabling a time-shift for generated energy, 2) relieve grid-related technical constraints by allowing for peak shaving of demand and 3) facilitate participation of variable renewables in grid balancing, thus contributing to grid stabilisation (USAID and MNRE, 2014; IRENA, 2012). Table 4.4 provides an overview of the main storage applications.

In certain contexts, storage applications have the potential to reduce the cost of renewables integration by up to 20% and thus ease the decarbonisation of the power sector (Pudjianto, et al., 2013). From a technical and economic point of view, however, the number of grid-scale storage options available remains relatively limited. Energy storage methods – including electrochemical (*e.g.*, batteries), chemical (*e.g.*, conversion to hydrogen), electric (*e.g.*, capacitors), thermal energy (*e.g.*, molten salts), mechanical (*e.g.*, flywheel) and compressed gas systems – continue to suffer from high capital and operating costs, except for pumped hydro used by transmission grids. Pumped hydro storage constitutes almost 99% of energy storage capacity globally (USAID and MNRE, 2014).

To address this issue, governments are seeking to lend a hand in expediting cost reductions. In California, for instance, regulators in October 2013 approved a plan that would require the state's utilities to add 1.3 GW of new power storage capacity by 2020. Italy's approach (outlined below) has been somewhat similar.

Another power storage source, lithium-ion batteries in electric vehicles (EVs), could play a significant role in the future. Rapid EV adoption would add millions of new flexible sources of power storage to the grid. While such a scenario would inevitably come with its own set of challenges for policy makers, it would offer a very different route for addressing the power storage issue. Approximately 200 000 EVs were sold worldwide in 2013 (International Council on Clean Transportation, 2014). Sales are poised to rise in coming years as lithium-ion battery prices decline.

ITALIAN INVESTMENTS IN GRID-SCALE STORAGE

Policy Overview: Terna, the Italian TSO, estimated that 1 600 gigawatt-hours of wind power, valued at roughly EUR 130 million, was lost in the country due to grid constraints between 2010 and 2012. In this context, Italy's recent Grid Development Plan called for the development of 35 MW of grid-scale storage units at three critical sites by 2014. In 2012, the Grid Defence Plan added a requirement that a further 40 MW of storage should be built by 2015. These policies allow for the consideration of several technologies, all of which must be able to store and deliver power almost

Table 4.4 Main power storage applications

AREA	APPLICATION	SYSTEM COST LIMITATION
Energy system management	Load levelling and peak shaving	Deferred grid upgrade – avoided cost of upgrading substations, grid interconnections and capacity
	Time shifting	Wind turbines connected to the distribution grid, storage assets
	Price arbitrage – difference between electricity price during day and night	Asset monitoring, voltage control
Power quality management	Frequency and voltage regulation	Prevention of fluctuations in power supply
	Reserve power	Prevention of power outages
	Fluctuation suppression	Increasing value and utility of renewables in constrained grids

instantly. The Regulatory Authority for Electricity and Gas (AEEG) is responsible for defining the return guarantee for each project, which can be proposed by distribution and transmission system operators (DSOs and TSOs).

Impact assessment: Terna has committed the largest investments to date to meet the government's plans. Its entity, Terna Plus, has begun work on the following projects:

» Six projects accounting for 35 MW of energy intensive storage corresponding to 240 MWh under the Grid Development Plan for which a 10.4% return on assets is guaranteed by AEEG;

» Two projects accounting for 16 MW of power-intensive storage under the Grid Defence Plan equally securing a 10.4% return on assets guaranteed by AEEG;

» An unspecific number of projects to a total of 24 MW of power-intensive storage, under the Grid Defence Plan, for which the sites still must be defined, securing a 9.9% return on assets guarantee by AEEG. Such projects will mainly contribute in ultra-fast frequency regulation and primary and secondary regulation for renewables integration.

Terna has signed a first contract with NGK Insulators for upto 70 MW of storage units, under which NGK will deliver the first 35 MW for an estimated EUR 100 million (NGK Insulators, 2013). The company also plans to build 130 MW of storage in the short-to-medium term, which represents 55 MW above what was set in the Grid Development and Defence Plans. These storage units should contribute greatly to grid stabilisation and load management, making integration of renewables easier and limiting curtailment.

Risks: The rationale behind Italy's policy is to enhance flexibility on a grid where renewables play a vastly expanded role compared to just five years ago. The policy could have a long-term effect of helping to reduce the cost of power storage technologies by assisting the industry in scaling up. In the short run, however, the Italian policy is being implemented while such costs are still high. Although the necessity for grid-scale storage is clear, the rapidity with which costs will decline depends on several factors, including R&D to improve efficiencies (see Box 4.3) and achieving economies of scale.

POLICY INDICATOR

Renewable penetration: High

Economic development: High income

Policy goal: Improve market integration of renewables; ensure security and reliability of power supply; triggering technology innovation

Policy type: Regulated return on investment

Eligible technology: All grid-scale storage

Asset ownership: Utility, others

Complementary policies: Demand response, strategic reserve, smart meter rollout

4.2.6 Capacity mechanisms

Historically, capacity mechanisms – or payments – have been introduced to ensure system stability and to secure electricity supply at times of demand spikes. In Europe, the policy option has been revived, as high shares of variable renewable electricity in certain markets have increased the need for dispatchable back-up capacity. This is in addition to the impact of integrating increasing renewables into the market (see Section 4.1.3) on wholesale electricity prices. The reduction in spot prices harms the profitability

Box 4.3

LOOKING FORWARD: RD&D FOR STORAGE DEVELOPMENT – THE CASE OF SOUTH KOREA

Given the potential of large-scale storage as a strategic technology for grid stability, South Korea has launched extensive research, development, and deployment (RD&D) programmes. With its national investment plan to develop the energy storage industry, the country aims to become a market leader by securing KRW 6.4 trillion (USD 38 billion) from the public and private sector by 2020. By December 2012, the government had committed KRW 304 billion (USD 1.8 billion) for the 2013-2017 period. The government also hopes that the sector will be a key source of employment.

of conventional generation capacity (mostly flexible plants) on the one hand and disincentivises long-term investments in new capacity. This has led to significant concerns, especially in the EU, about the long-term reliability and resilience of the electricity system.

Policy Overview: Capacity mechanisms can take several forms and target different types of generators based on the needs and consumption patterns identified by TSOs or regulators. In essence, capacity mechanisms reward the availability of dispatchable capacity or demand reductions in response to expected system stress resulting either from variability of renewables, power plant failure or demand spikes. Plants are usually paid per MW available to the system.

Some countries have had forms of capacity payments in place for decades, including Chile, Argentina, Greece, Ireland, Spain and Russia. These have often been limited to enhancing a "strategic reserve" of capacity. Germany's "ResKV", for example, prohibits decommissioning plants which BNetzA considers strategically important in providing stability of supply when the system is under stress. These plants (mostly combined-cycle natural gas projects) are rewarded for being available when called upon but no longer participate in the power market. As such, allocation of such capacity is done through a regulatory process rather than a market-based approach. There are ongoing discussions in Germany that propose an auction-based mechanism to procure additional generation capacity to build a strategic reserve (BDEW, 2013). Table 4.5 provides an overview of the key features of the two different segments of capacity mechanisms: price based and quantity based.

Capacity mechanisms can be far more elaborate. A regional transmission organisation in the United States, PJM Interconnection LLC (PJM), has a very advanced operating capacity market, and rapid renewable deployment in Europe may prompt policy makers to consider this option. The U.K. and France have made considerable progress with their capacity market designs, with the U.K. opening the first auctions in 2014, for delivery scheduled in 2018, while France aims to have a fully operational certificate-based scheme in 2016.

Under the PJM's Reliability Pricing Model, reliability requirements can be met through bilateral transactions, but in reality they take place mainly through centrally cleared auctions. France is pursuing a "capacity certificate" design, while the U.K.'s proposed scheme incorporates capacity auctions. Germany, which currently operates only a strategic reserve scheme, is considering capacity market options for the future and has expressed interest in the French model, although it could follow the two-segment design preserving its reserve practice. Table 4.6 outlines key differences in the approaches being adopted.

Impact Assessment: PJM represents a capacity market which has helped to ensure that marginally profitable generators stay on line and provide power when needed. For their part, the French and UK capacity markets have yet to prove themselves, as they are not fully operational. Their impact on system reliability and cost remains to be proven.

Table 4.5 Key features of capacity mechanisms

FEATURE	PRICE-BASED	QUANTITY-BASED
Price	» Established by regulator/ system operator » Often linked to fixed costs of a peaking plant or value of lost load	» Variable, determined by the market (usually through capacity auctions) » Often determined by auctions (either pay-as-bid or auctions with a uniform clearing price)
Capacity requirement	» Fixed by regulator/system operator/ government	» Fixed by regulator/system operator/ government
Who earns?	» Generators » Occasionally tiered based on baseload and peaking plants (*e.g.*, South Korea)`	» Generators » Incentives for different forms of capacity (generation, demand response, interconnectors)
Who pays?	» Typically suppliers (and hence consumers via bill surcharges) based on consumption	» Typically suppliers based on peak consumption (plus a target margin)

Table 4.6 Select capacity market approaches

AUCTIONED CAPACITY MARKET	FOCUSSED CAPACITY MARKET	CAPACITY CERTIFICATES
Auctioning of capacity and demand-side response alongside the power market, with capacity prices fluctuating according to demand. Demand for capacity is typically set in the auction by the regulator, following consultations with the TSOs.	Two-segment capacity market – strategic reserve combined with some capacity mechanism options: » Strategic reserve – covering old, currently uneconomic generation plants set to go off line, but needed in the short run for grid stability. » Capacity mechanism options – creating long-run incentives for new more-efficient generation, incentivise load shifting and demand response.	» Requiring electricity suppliers to buy sufficient capacity certificates to cover their customers' peak demand from generators to operate at times of stress. The capacity certificate allocation process is regulated by the grid operator. Electricity suppliers recover costs from customers who can opt out of guaranteed supply at peak times if they judge the cost too high.

Source: Agora, 2013.

An advantage of a well-functioning, technology-neutral capacity market is that it establishes an equivalent value between the cost of generation and demand-side management: both options can equally bid into an auction, or receive certificates. This could potentially reduce the need for additional dispatchable generation capacity. All three capacity markets discussed here – the U.K., France and PJM – establish that. However, as a relatively unexplored policy option in the context of integrating renewables, capacity markets carry several uncertainties.

Risks: The attributes described above can be realised with careful capacity market design. Yet there is also a potential for failure, which could mean either that adequate capacity is not provided in time or that its costs escalate and are reflected in increasing retail electricity prices. Table 4.7 discusses the key elements that must be considered in order to mitigate that risk. In its recent draft state-aid guidelines, the European Commission (2014) stated that any such scheme must be a last resort to solving capacity adequacy problems and should be open to generators from the neighbouring countries.

Table 4.7 Potential risks of auction-based capacity markets

RISK	GUIDING QUESTION	THE UK AND PJM EXPERIENCE
Incorrect assessment for capacity needs	What is adequate margin for secure supply?	The "reliability standard" is a measure which the U.K. grid operator develops each year to establish the amount of capacity it wishes to procure through auctions. This is approved by the regulator and reviewed each year, to allow for correction.
Inadequate number and timing of auctions	How many auctions and when?	Under the PJM's Reliability Pricing Model, a centrally cleared auction is held three years ahead of delivery. Incremental auctions are also organised in advance of the delivery year to balance changes in load forecast and allow suppliers to adjust their positions.
Adequate remuneration	What is the acceptable price?	In the U.K. design, a proposed auction price cap helps to prevent cost escalation while ensuring that the price offered covers the so-called "cost of new entry" with a sufficient margin.
Contracted generation is not delivered	What penalties should be in place?	Financial penalties are put on generators in both the PJM and the future U.K. capacity markets, if they fail to meet their contractual obligations.

POLICY INDICATOR

Renewable penetration: High	
Economic development: High income	
Policy goal: Ensure security and reliability of power supply	
Policy type: Capacity market	
Eligible technologies: Flexible generation capacity	
Asset ownership: Utility	
Complementary policies: Demand response, strategic reserve, grid development plans	

4.2.7 Demand-response programmes

Policy Overview: Demand response is a mechanism that requires or encourages consumers to reduce their load during periods of peak demand or in response to an emergency. Due to technological, financial and regulatory issues, demand-response mechanisms have tended to focus on large-scale industrial consumers. The arrival of smart grid technologies, however, has the potential to expand demand-response participants to smaller consumers.

In the context of increasing renewable generation, demand-response incentives can contribute to system stability and lower consumption peaks. Furthermore, widespread adoption of smart grid technologies – smart meters, in particular – allow for demand response to play an even more active role in contributing to system balancing.

Depending on the mechanism, incentives consist of an up-front capacity or availability payment (USD/kW) and/or a payment for unconsumed units of electricity (USD/kWh). Customers may face penalties for failure to curtail when called upon to do so. While demand-response programmes can take different forms, they are typically established and administered by grid operators (TSOs) and include the following five elements:

» Reward schemes for participants, such as electricity rate discounts, monthly payments, or one-off remunerations;

» Notification periods prior to demand-response action requirement sent by a TSO to the participant required to take action (these can vary from just a few hours to many days);

» Duration of curtailment (ranging from a few minutes to hours);

» Amount of demand curtailed; and

» Voluntary versus mandatory curtailment, once a customer opts into a scheme.

Impact Assessment: Demand-response measures require no direct subsidies and can be operated via markets. Technical costs of implementation can be quite low – installation of simple load-control devices can be enough to operate the schemes – and the demand response is called upon when it is cheaper than other forms of electricity provision.

The PJM market (see Section 4.2.6) is already cutting 7% off its seasonal peaks through various demand response actions. Although further analysis is required, a rough estimate from the Smart Energy Demand Coalition (2011) suggests that reductions of 6-11% in seasonal peaks are possible in Europe through demand-response programmes, depending on the profiles of commercial, industrial and residential resources available in each market.

Most countries experiencing serious stress on their power systems as a result of rapid renewables growth adopt several different types of demand-response schemes, as they consider it a cost-efficient option for smoothing demand peaks and preparing for emergency events (which can be caused by a power station trip, renewables output drop or other system malfunctions).

To address these challenges, demand-response measures are used by regulators in four general designs: as part of capacity markets, as "emergency mechanisms" to ensure security of supply in a system stress situation, as a part of a wholesale power market design and as ancillary services provision. These categories are not mutually exclusive – emergency services and ancillary services provision in particular can overlap, as is the case in Ireland (Eirgrid, 2012) – but they can vary in their operations. Table 4.8 illustrates how these designs differ and how advanced these schemes are in four European countries.

Risks: Demand response is a proven and relatively simple approach to contribute to increasing system reliability during periods of stress and can also provide a revenue stream to large demand-side units. A big risk comes from the signed-up consumers failing to

Table 4.8 Select European demand-response programmes

	CAPACITY MARKET	EMERGENCY MECHANISM	WHOLESALE POWER MARKET	ANCILLARY SERVICES
Design feature	Demand response (DR) effectively treated as generation capacity and eligible for "capacity payments" usually awarded via auctions (more on capacity market designs in sub-section 4.2.6).	Short-notice and short-duration curtailment in system stress situations; often TSO can cut off supply to participating consumers without prior notice.	"Consumption blocks" can be traded on the energy market.	DR eligible to participate in various ancillary markets.
UK	To be launched in 2018; transitional DR planned for 2016 (auctioned in 2015).	No, although recently proposed demand-side balancing reserve can be used in stress situations.	No (wholesale customers can avoid peak prices by load shifting).	Short-term operating reserve.
France	DR procured for capacity since 2011; full capacity market planned to launch in 2016.	Interruptible load programme operational.	A proposal under Brottes Law will allow demand curtailment "blocks" to be traded in the energy markets.	The balancing mechanism is open to DR; however, penetration is extremely low.
Germany	No specific plans yet but under consideration.	Interruptible load programme operational.	No (wholesale customers can avoid peak prices by load shifting).	DR participating in tertiary reserve.
Ireland	DR eligible for "capacity payments".	Winter Peak Demand Reduction scheme discontinued but Short Term Active Response programme partly replaces it.	No (wholesale customers can avoid peak prices by load shifting).	Short-term balancing open to DR.

Source: BNEF.
Note: Cells with blue background indicates operating programmes, while white indicates proposed or partly operating programmes and orange indicates no DR programme in place at the moment.

supply the contracted capacity. A strong regulatory and enforcement structure is thus needed to verify the availability of loads and to ensure the correct functioning of the scheme. In order to reduce this risk, several demand-response programmes provide the TSO with automatic control of the loads for short response times, rather than leaving it at the discretion of end-customers, particularly those dealing with emergency situations. However, this may not always be possible or the most economically-efficient approach.

In the wider context of integrating renewables and smoothing load curves, the potential from large consumer demand-response schemes is fairly limited, with many of the very biggest players, such as aluminium smelters, already participating. As a result, policy makers are looking increasingly at small commercial and even household-level demand response as a key source of capacity, as is the case in France. Such an approach can leverage upon the emergence of smart infrastructure revolving around smart meters and interactive grids.

Allowing for "aggregated demand response units" is also gaining currency, as purposefully created companies providing aggregation platforms execute fast, targeted curtailment on short notice. Such operations, however, again require load-control devices and digital communication technology to be installed at customers' premises and linked to an aggregation platform. While this is not inherently a barrier, it can be cost prohibitive for smaller loads. Smart metering and the related communications infrastructure can be leveraged to help further the penetration of demand response.

Finally, market design needs to enable demand-response participation and requires appropriate adaptation. Demand-response uptake has been most successful in countries with some form of capacity markets, which allow for it to be effectively treated on par with generation. Capacity markets can allow demand response to prevent overpayments to inefficient thermal generation capacity, which would otherwise be incentivised to remain on line. In extreme cases, high uptake of demand-response measures can even prevent governments from providing subsidies for additional new peaker plants.

POLICY INDICATOR

Renewable penetration:	Medium-high
Economic development:	High-income level
Policy goal:	Ensure security and reliability of supply, trigger technology innovation
Policy type:	Demand-response incentive
Eligible technologies:	N/A
Asset ownership:	Utility, private owners, businesses
Complementary policies:	Smart grid development and smart meter rollout, strategic reserve, capacity mechanisms

4.3 LESSONS LEARNED

As the level of renewable power in the generation mix increases, policy makers need to ensure that the policies they implement not only provide investment incentives but are incorporated into broader energy strategies. Ignoring the impacts which high shares of variable renewable power have on the reliability of supply can lead to higher costs later. Large grid investments may be needed to connect and integrate renewable sources, and additional subsidies may be required to maintain sufficient back-up generation.

The examples of Germany and India show that providing a long-term, transparent grid development plan is necessary to accompany rapid renewables development. Both of these countries implemented their plans taking into consideration geographically uneven renewables deployment.

A "system management approach" developed early could help high renewables concentration in the first place. Identifying priority areas for renewable energy deployment in conjunction with grid availability assessments, and needs for grid improvements, has a potential to improve co-ordination between these activities and prove more cost efficient across the system (*i.e.*, across generation, transmission and distribution costs). Such a systemic approach should take into account smart technologies capable of improving system reliability without unnecessary additional fossil fuel generation capacity. In all of these cases, the role of TSOs is fundamental and radically different from the "pre-renewables" times, as providing security of supply is becoming more complex and challenging.

Three key lessons can be learned from the experience of the countries analysed above:

1. Not adequately accounting for grid infrastructure development in renewable energy policy design can lead to geographically uneven capacity deployment and in general to a mismatch between transmission and generation capacity. The lead time associated with developing adequate grid infrastructure to facilitate grid evacuation and transfer generation to end-users can be long and, hence, needs to be accounted for in national planning process. "Passive" development of infrastructure can increase costs, lead to stranded generation assets and hurt investor confidence in the long term.

2. New technologies, such as smart grids, smart meters and storage, have the potential to play pivotal roles in effectively and efficiently managing the system so that more renewable power can be integrated without a risk of supply disruptions. Smart meter rollouts, however, have raised privacy concerns, and adequate measures need to be taken to address them.

3. It is important to realise that high shares of zero-or low- marginal-cost renewable power entering the system at variable times have an impact on the operations of power markets, by both pushing traditional fossil fuel (typically gas-based) plants out of the merit order and depressing prices overall. Providing some form of dispatchable capacity remuneration in some cases may prove necessary, but care should be taken to ensure that such schemes incentivise only the necessary capacity and, if possible, different forms of capacity – generation as well as demand response.

All of the measures discussed in this section are a consequence – rather than a cause – of rapid renewable energy deployment. As such, they should be viewed as complementary to all of the policy options discussed in this report. Implementing some of them early improves the chances of substantially lowering the overall costs of transition to a low-carbon power system.

5 The Prisms: Using Analytical Frameworks to Hone In on Smart Policy

When it comes to renewable energy policy-making, there is no one-size-fits-all solution. Each jurisdiction is unique with its own set of characteristics that influences how policies are crafted and implemented. With that in mind, this section sets out to provide an indication of the suitability of the policy adaptation measures analysed in this report to different contexts. To capture the varying conditions, this report highlights four frameworks or "prisms" policy makers can look through as they consider which policy adaptation approach fits best.

The prisms have been constructed using the indicators discussed in the Methodology section of this report. Countries or jurisdictions are categorised based on:

- » varying levels of renewable penetration (low, medium or high);
- » varying levels of economic development (low, middle or high);
- » support directed at specific technologies (wind, solar, smart grid, storage and others); and
- » seeking to craft policies that affect various asset owners (utilities, IPPs, community/residential consumers or commercial customers).

Sections 5.1 through 5.4 examine each of these categories in greater detail. Section 5.5 offers an example of how policy makers may apply these prisms in conjunction with one another to construct a policy structure that is most appropriate for their jurisdiction. As such, it is acknowledged that policies or policy types generally do not fit neatly into clearly defined boxes. The "prisms" adopted in this section, however, are intended to serve as rudimentary tools for policy-making.

5.1 RENEWABLE ENERGY PENETRATION

The stage of development of a renewable energy market to some degree influences what policy goals are more relevant and what types of measures are most suitable. Markets with low renewable capacity on line require policy makers to focus on providing sufficient "market-creating" support to stimulate investments in the sector, while at the same time ensuring that developers are not overcompensated. As the deployment of renewables increases, the focus tends to shift towards ensuring that the support cost is minimised and is fairly distributed across different stakeholders. Moreover, markets with medium or high penetration rates for renewables inevitably prompt policy-making to address the challenge of smooth market integration, to ensure the long-run security and reliability of supply. In this context, Figure 5.1 presents the different policy adaptation measures discussed in this report and illustrates their potential relevance to markets with varying penetration of renewables.

Certain types of policies analysed in this report are applicable in multiple market conditions. For instance, holding auctions for power contracts can be a useful means of price discovery in many markets, regardless of the level of renewable energy penetration. The same could be said for establishing effective net metering programmes. Other policy types have more limited applicability or relevance. For instance, the need for capacity markets tends to become acute after renewables begin to account for enough power generation to affect the grid and power markets.

5.2 ECONOMIC DEVELOPMENT

A related but somewhat different question arises around the level of market development. In most cases, developing countries have seen lower levels

Figure 5.1 Policies best suited for differing levels of renewable energy penetration

	Renewable energy penetration: LOW	MEDIUM	HIGH
POLICIES	Integrating 'real time capacity corridors' into the feed-in tariff reduction structure (1.2.1.)		
	Holding auctions for power contracts (1.2.3.)		
	Designing flexible tax policies (1.2.4.)		
	"Value of Solar" tariff (3.2.2.)		
	Permitting net metering (3.2.1.)		
	Grid development plan - India (4.2.1.)	Grid development plan - Germany (4.2.2.)	
	Building third-party metrics into feed-in tariffs (1.2.2.)	Implementing spending caps on support for renewables (2.2.1.)	
		Integrating residential storage in the system (3.2.3.)	
		Demand response programmes (4.2.7.)	
			Offshore wind connection liability arrangement (4.2.3.)
			Smart grid implementation and smart meter rollouts (4.2.4.)
			Grid scale energy storage (4.2.5.)
			Capacity mechanisms (4.2.6.)
GOALS	PROVIDE ADEQUATE SUPPORT FOR RENEWABLES		
	MINIMISE COST		
	TRIGGER TECHNOLOGY INNOVATION		
		INCENTIVISE SELF -CONSUMPTION	
		ENSURE SECURITY AND RELIABILITY OF POWER SUPPLY	
			IMPROVE MARKET INTEGRATION OF RENEWABLES

Note: The degree of blue shading indicates how appropriate the goal is for each level of renewables penetration (for example, improved market integration of renewable power applies more to the most mature markets).

of renewable energy penetration. However, that is not always the case and, in particular, some of the larger so-called middle-income nations have seen very substantial volumes of renewable capacity deployed.

The policy types examined for this report have varying levels of applicability for countries at different levels of economic development, but they are somewhat slanted towards middle- and higher-income countries. This is in part because these countries have had the capacity to provide the financial support necessary to create markets for renewables domestically. As a consequence, they often are also the ones faced by the challenge of integrating substantial portions of variable renewables into an established power grid or market.

The linkages between the stage of economic development and renewables integration enablers, such as grids and R&D infrastructure, are strong. For instance, grid infrastructure in low-income countries is often marked by high losses in transmission and distribution, whereas grids in high-income countries are more advanced in terms of control, monitoring and operation. This may affects the introduction of policies, such as net metering, which have direct relevance for distributed generation, since their success depends on the physical availability of a distribution network that can handle reverse flows as well as regulatory structures that can manage them at a system-level. Figure 5.2 maps out those interlinkages by presenting an overview of the relevance of the policy adaptation measures studied in this report for countries at different stages of economic development.

Some of the other policies illustrated here, for example spending caps on renewables support, might have applicability in countries with low, middle and high economic development, although until now these types of measures have been implemented particularly in middle- or higher-income countries.

In addition to taking into account the level of renewable energy penetration and their country's overall level of economic development, a question for policy makers revolves around the availability of resource endowment -- and which renewable energy technologies should be deployed to exploit these.

Figure 5.2 Policies best suited for differing levels of economic development

	ECONOMIC DEVELOPMENT		
	LOW	**MEDIUM**	**HIGH**
POLICIES	Permitting net metering (3.2.1.)		
	Holding auctions for power contracts (1.2.3.)		
	Implementing spending caps on support for renewables (2.2.1.)		
	Integrating "real time capacity corridors" into the feed-in tariff reducion structure (1.2.1.)		
	Designing flexible tax policies (1.2.4.)		
	Building third-party metrics into feed-in tariffs (1.2.2.)		
	Grid development plan - India (4.2.1.) and Germany (4.2.2.)		
		"Value of Solar" tariffs (3.2.2.)	
			Offshore wind connection liability arrangement (4.2.3)
			Integreting residencial storage in the system (3.2.3.)
			Demand response programmes (4.2.7.)
			Smart grid implementation and smart meter rollouts (4.2.4.)
			Grid scale energy storage (4.2.5.)
			Capacity mechanisms (4.2.6)
GOALS	**PROVIDE ADEQUATE SUPPORT FOR RENEWABLES**		
	MINIMISE COST		
	TRIGGER TECHNOLOGY INNOVATION		
	INCENTIVISE SELF -CONSUMPTION		
	ENSURE SECURITY AND RELIABILITY OF POWER SUPPLY		
			IMPROVE MARKET INTEGRATION OF RENEWABLES

5.3 TECHNOLOGY FOCUS

Renewable energy technologies require a specific mix of policies along the stages of development. Supporting their development requires a constant adaptation of policies that are best suited to the stage of development. While some policies can be designed to be technology-specific, others can be technology-neutral. A typical example is renewable energy auctions, which can either be held for contracting capacity of a specific technology to promote its deployment, or be competitive across technologies in identifying least-cost options. It is equally important for policies to focus in a timely manner on other complementary non-generating technologies, for example R&D of storage infrastructure, smart grids, etc., that support the growth and smooth integration of renewables into the system.

Technology-specific policies need to consider the local resources available as well as the development of strong distribution chains. Further reduction in the levelised cost of generating renewable energy will also come from reducing "soft" costs (associated with installation, connection, etc.). These are among the key reasons for the difference in deployment costs in different countries and regions. Figure 5.3 provides an overview of the relevance of the different policies covered in this report to some generating and non-generating technologies.

5.4 ASSET OWNERSHIP

The development or reform of renewables policies affects all players involved in a country's power generation, delivery and consumption segments. Still, some policies have a more direct impact on stakeholders in a certain segment of the energy value chain. It is important to understand these impacts and to deploy measures that can mitigate any unintended consequences which put at risk the broader long-term sustainability of the energy system.

With increasing deployment of decentralised renewable energy systems, in particular PV, the ownership structures of the energy sector are undergoing a transition in many countries. Many of these systems are owned by individuals or community-based organisations. This redistribution of asset ownership within the energy sector, as well as the increasing role of renewables in meeting the electricity demand, is affecting traditional utilities in some countries (*e.g.*, in Europe and some U.S. states). Nearly all of the policies analysed in this study are directly relevant to utilities since a focus of this study has been markets where renewables have achieved sufficiently enough market penetration to pose a challenge for energy industry incumbents. These utility-relevant policy types include: fostering grid scale storage projects, establishing capacity markets, and others.

FIGURE 5.3 POLICIES BEST SUITED FOR CERTAIN TECHNOLOGIES

	ELIGIBLE TECHNOLOGIES				
	WIND	**SOLAR**	**OTHER RENEWABLE ENERGY TECHNOLOGIES**	**SMART METERS**	**STORAGE**
POLICIES	Integrating "real time capacity corridors" into the feed-in tariff reducion structure (1.2.1.)			Grid development plans - India (4.2.1.) and Germany (4.2.2.)	
	Holding auctions for power contracts (1.2.3.)			Demand response programmes (4.2.7.)	
	Implementing spending caps on support for renewables (2.2.1.)			Smart grid implementation and smart meter rollouts (4.2.4)	
	Designing flexible tax policies (1.2.4.)	"Value of Solar" tariffs (3.2.2.)			Grid scale energy storage (4.2.5.)
	Offshore wind connection liability arrangement (4.2.3.)	Permitting net metering (3.2.1.)			
		Building third-party metrics into feed-in tariffs (1.2.2.)			Integreting residencial storage in the system (3.2.3.)
		Integreting residencial storage in the system (3.2.3.)			

The analysis reveals that, irrespective of the level of economic development and market maturity, we are likely to observe (and in some markets already are observing) a shift away from the traditional central supply of power to a much more diverse and distributed portfolio of generating assets. With the advent of small-scale generation, community-wide systems, as well as increasingly relevant IPPs, the role of the utility is changing.

In markets with high levels of renewables penetration, the most forward-looking utilities are re-thinking their business models. Meanwhile, markets with less advanced energy infrastructure now have the very real potential to leapfrog the traditional "utility-transmission-consumer" model directly to more diversified systems. All of these need to be considered up-front when a new regulation is being designed, and utmost consideration should be given to the impact that this shift in generating asset ownership may have on generators, transmission system operators, governments and consumers. Figure 5.4 attempts at illustrating who owns the generating assets that is affected by the different policies.

5.5 PUTTING THE PRISMS TO WORK

This report sets out to provide an overview of the different renewable energy policy adaptation tools available to policy makers. The prisms outlined above have been designed to allow a basic "filtering out" of policies that may be inappropriate under certain circumstances. Taken together, however, these prisms have the potential to allow policy makers to hone in on the best regime for their jurisdiction.

The four prisms can be combined to produce a wide variety of results. This sub-section offers just one example of how the prisms can be overlaid against one another to yield potentially useful information. While it is not intended to capture the complexities of policy-making, the below example merely illustrates how context-specific factors can influence the selection of appropriate policy mechanims.

FIGURE 5.4 POLICIES AFFECTING CERTAIN ASSET OWNERS

<table>
<tr><th rowspan="2"></th><th colspan="4">MAIN ASSET OWNERS</th></tr>
<tr><th>PRIVATE OWNERS/ COMMUNITIES</th><th>BUSINESSES</th><th>IPPs</th><th>UTILITIES</th></tr>
<tr><td rowspan="14">POLICIES</td><td colspan="4">Integrating "real time capacity corridors" into the feed-in tariff reducion structure (1.2.1.)</td></tr>
<tr><td colspan="4">Building third-party metrics into feed-in tariffs (1.2.2.)</td></tr>
<tr><td colspan="4">Implementing spending caps on support for renewables (2.2.1.)</td></tr>
<tr><td colspan="4">Demand response programmes (4.2.7.)</td></tr>
<tr><td colspan="2">Permitting net metering (3.2.1.)</td><td colspan="2" rowspan="3"></td></tr>
<tr><td colspan="2">Integreting residencial storage in the system (3.2.3.)</td></tr>
<tr><td colspan="2">"Value of Solar" tariffs (3.2.2.)</td></tr>
<tr><td colspan="2"></td><td colspan="2">Holding auctions (1.2.3.)</td></tr>
<tr><td colspan="4">Designing flexible tax policies (1.2.4.)</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Grid development plans – India and Germany (4.2.1.) and (4.2.2.)</td></tr>
<tr><td colspan="2">Offshore wind connection liability arrangements (4.2.3.)</td></tr>
<tr><td colspan="4">Smart grid implementation and meter rollout (4.2.4.)</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Grid scale energy storage (4.2.5.)</td></tr>
<tr><td colspan="2">Capacity mechanism (4.2.6.)</td></tr>
</table>

EXAMPLE: A MIDDLE-INCOME COUNTRY WITH STRONG LOCAL WIND RESOURCES AND LOW RENEWABLE ENERGY PENETRATION SEEKS A SUPPORTIVE POLICY WHERE THE COSTS ARE NOT BORNE BY TAXPAYERS.

Consider a country that has identified excellent wind resources along its coastline. The country is middle income and has yet to install wind capacity. What type of policies might be most appropriate?

At least five of the policies identified in this report can potentially be supportive for wind project development:

» Integrating "real-time capacity corridors" into the feed-in tariff reduction structure (1.2.1)

» Holding auctions for power contracts (1.2.3)

» Designing flexible tax policies (1.2.4)

» Implementing spending caps on support for renewables (2.2.1)

» Offshore wind connections liability arrangement (4.2.3)

However, not all of these policies are appropriate for middle-income nations. Offshore wind connection liability arrangements are a best fit for high-income countries. Meanwhile, spending caps on support for renewables are generally most needed in countries with medium-to-high levels of renewable energy penetration. That leaves the following three policy options:

» Integrating "real-time capacity corridors" into the feed-in tariff reduction structure (1.2.1)

» Holding auctions for power contracts (1.2.3)

» Designing flexible tax policies (1.2.4)

Now consider that the country policy maker also wants to shield local taxpayers from bearing the costs associated with the new policy. That eliminates the potential for using most flexible tax policies to support the local wind industry, and leaves just two policy options: integrating "real-time capacity corridors" into the feed-in tariff reduction structure (1.2.1) and holding auctions for power contracts (1.2.3).

Finally, suppose that the policy maker wants to make sure that the new policy he or she implements exclusively affects utilities or IPPs and not other asset owners. That eliminates the potential for integrating "real-time capacity corridors" into feed-in tariff reduction structures. And it leaves holding auctions as the most viable policy option, given the circumstances.

This is but one example of how these prisms can be used in conjunction with each other to narrow down policy options to one that is potentially most appropriate.

5.6 FINAL THOUGHT

The renewable energy industry today finds itself at a critical juncture. Technology costs have decreased rapidly, making them increasingly competitive against fossil fuel-based conventional generation. Yet the development of renewable energy and increasing its share in the national (and global) energy mix cannot be fully achieved purely on the grounds of cost competitiveness. Without doubt, governments need to take measures to introduce adequate policies which allow for a smooth, system-level integration of renewables in a cost-efficient manner, while maintaining the long-term reliability of the energy system.

For their part, many policy makers remain steadfast in their commitment to renewable energy, but they often face substantial fiscal constraints in sufficiently supporting the sector. These circumstances have prompted a wave of renewable energy public policy innovation. While many of these new measures are reactive and have been crafted in response to renewable capacity boomlets, they do have the potential to serve the industry well over the longer term – provided that they offer the level of flexibility, longevity and certainty required. Additionally, the potential for cross-regional exchange of lessons learned from policy-making experiences is significant as more countries embark on the pathways of energy system transition.

As discussed, there is no one-size-fits-all approach to renewable energy policy-making. Legislators and regulators must be guided by their unique local economic and political circumstances while taking into account the availability of natural resources to fuel renewable energy projects. However, important insights can be gained by looking across borders for best-practice examples. There exists a short but rapidly expanding track record of how certain schemes have performed, and these "lessons learned" can be integrated into further policy-making. As such, the transition towards a renewable energy-dominant power sector is a systemic one, involving a broad range of stakeholders; hence, policy-making will benefit from an all-inclusive approach that considers costs and benefits across the sector.

This report took a structural approach to surveying the landscape of innovative thinking about renewable energy policy which is now very much under way. The frameworks constructed were intended to highlight to policy makers approaches which have been adopted in certain contexts and that therefore may be considered under similar circumstances. These "prisms" can serve as rudimentary tools for those at the initial stages of designing policy schemes.

There are inherent limitations on any conceptual mechanism intended to guide policy-making. In reality, policies or policy types generally do not fit neatly into clearly defined boxes. Ultimately, the most important decisions which policy makers must take are fundamentally qualitative.

Still, there is value in imposing a structural framework on such discussions. Our modest hope is that this report and the tools it offers shed useful light on the critical questions confronting policy makers globally. In the best of circumstances, we hope that it guides better-informed policy-making.

References

ABEEólica (Associação Brasileira de Energia Eólica) (2013), "Monthly Data Report of Wind Power – Public", October 2013, *www.portalabeeolica.org.br/pdf/Monthly-Data-Report-of-Wind-Power-Public-October-2013.pdf.*

Agora (2013). Kapazitätsmarkt oder Strategische Reserve: Was ist der Nächste Schritt? (Capacity Market *or Strategic Reserve*: *What is the Next Step*?), s.l., Agora Energiewende.

Austin Energy (n.d.), "Austin Energy's Residential Solar Rate", *www1.eere.energy.gov/office_eere/pdfs/libby_austinenergy.pdf.*

BDEW (Bundesverband der Energie- und Wasserwirtschaft e.V.) (Federal Association of Energy and Water Industries) (2013), "Strengthening Markets, Securing Supply Conceptual Framework for Implementing a Strategic Reserve in Germany", *www.bdew.de/internet.nsf/id/25273740766E25F1C1257BB9005222B5/$file/130628_ExpertDialogue_StrategicReserve.pdf.*

BNEF (Bloomberg New Energy Finance) (n.d.), Propreitary datasets.

BNEF (2012a), "Israel links tariffs to equipment cost for new PV quota", 17 August 2012, *www.pua.gov.il/Sip_storage/FILES/8/2588.pdf*

BNEF (2012b), Q4 2013 Energy Smart Technologies Market Outlook.

BNEF (2013), "European renewables: distribution automation wins?", 20 March 2013.

BNetzA (n.d.), "Expansion of the electricity transmission networks", *http://www.bundesnetzagentur.de/cln_1432/EN/Areas/Energy/Companies/ElectricityGridExpansion/ElectricityGridExpansion-node.html.*

Brazilian Wind Energy Conference (2013), "Brazilian wind: back on track", *www.cleantechinvestor.com/events/en/blogbwec2014/803-brazilian-wind-back-on-track.html.*

BSW (Bundesverband Solarwirtschaft) (2013), "Information on Support Measures for Solar Power Storage Systems", BSW-Solar Information paper, 30 August 2013, *www.solarwirtschaft.de/fileadmin/media/pdf/infopaper_energy_storage.pdf*

CEA (Central Electricity Authority) (2013), "Large scale grid integration of renewable energy sources- way forward", *www.cea.nic.in/reports/powersystems/large_scale_grid_integ.pdf.*

CEA (2014), Executive Summary Power Sector Mar-14, Government Of India, Ministry of Power, Central Electricity Authority, New Delhi, *www.cea.nic.in/reports/monthly/executive_rep/mar14.pdf.*

CEM (Clean Energy Ministerial) (n.d.), "Solar PV: Reducing Soft Costs", *www.cleanenergyministerial.org/Events/CEM4/Roundtables/Solar-PV-Reducing-Soft-Costs.*

CEPS, MAVIR, PSE SA (Polskei Sieci Elektroenergetyczne), SEPS (Slovenska Electrizacna Prenosova Sustava) (2013), "Joint study by EPS, MAVIR, PSE and SEPS Regarding the Issue of Unplanned Flows in the CEE Region in Relation to the Common Market Area Germany – Austria", January, *www.pse.pl/uploads/pliki/Unplanned_flows_in_the_CEE_region.pdf.*

CRS (2013), "Production Tax Credit Incentives for Renewable Electricity: Financial Comparison of Selected Policy Options", *www.nationalaglawcenter.org/wp-content/uploads//assets/crs/R43340.pdf.*

CSE (Centre for Science and Environment) (2014), "State of Renewable Energy in India: A Citizen's Report", CSE, New Delhi, pp. 198.

DECC (Department of Energy and Climate Change) (2012), "Feed-in Tariffs Scheme: Government response to Consultation on Comprehensive Review Phase 2A: Solar PV cost control", *www.gov.uk/government/uploads/system/uploads/attachment_data/file/43079/4309-feedin-tariffs-scheme-phase-2a-consultation-paper.pdf.*

DECC (2013), "Levy Control Framework and Draft CfD Strike Prices", *www.gov.uk/government/uploads/system/uploads/attachment_data/file/209361/Levy_Control_Framework_and_Draft_CfD_Strike_Prices.pdf.*

Dutch Ministry of Economic Affairs (n.d.), *www.rvo.nl/subsidies-regelingen/sde/nieuws*, accessed March 2014.

Eirgrid (2012), "Demand side unit workshop", Eirgrid, 26 July, *www.eirgrid.com/media/DSU%20Workshop%20Slides%20-%2026%20July%202012.pdf.*

European Commission (2013), "Paper of the Services of DG Competition containing draft Guidelines on environmental and energy aid for 2014-2020", *www.ec.europa.eu/competition/consultations/2013_state_aid_environment/draft_guidelines_en.pdf.*

Eurostat (n.d.), "Eurostat", European Commission, *http://epp.eurostat.ec.europa.eu/,* accessed November 2013.

German onshore grid development plan (2013), http://www.netzentwicklungsplan.de/en/content/grid-development-plan-2013-second-draft

German offshore grid development plan (2014), http://www.netzentwicklungsplan.de/_NEP_file_transfer/Neue_Netze_fuer_neue_Energien_2_Entwurf.pdf

GlobalData (2014), "GlobalData Power database [Internet]", accessed 2014 May 25, *http://power.globaldata.com/* (registration required).

GSE (Gestore Servizi Energetici) (2014), Personal communication with Luca Benedetti, GSE, May 25 2014.

GWEC (2012), "India Wind Energy Outlook 2012", *www.gwec.net/wp-content/uploads/2012/11/India-Wind-Energy-Outlook-2012.pdf*

GWEC (2014a), "ABEEólica celebrates record levels of wind power in Brazil", *http://www.gwec.net/abeeolica-celebrates-record-levels-wind-power-brazil/.*

GWEC (2014b), "Global Wind Report: Annual Market Update 2013", *http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf.*

IEA (International Energy Agency) (2014), "The Power of Transformation: Wind, Sun and the Economics of Flexible Power Systems", IEA,Paris, pp.239.

International Council on Clean Transportation (2014), "Driving Electrification: A Global Comparison of Fiscal Incentive Policy for Electric Vehicles", *www.theicct.org/sites/default/files/publications/ICCT_EV-fiscal-incentives_20140506.pdf.* IRENA Costing Alliance (n.d.), *http://costing.irena.org/,* accessed May 2014.

IRENA (International Renewable Energy Agency) (2012), "Electricity storage: technology brief", *www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E18%20Electricity-Storage.pdf.*

IRENA (2013a), "Renewable Energy Auctions in Developing Countries", *www.irena.org/DocumentDownloads/Publications/IRENA_Renewable_energy_auctions_in_developing_countries.pdf.*

IRENA (2013b), "Renewable Energy and Jobs", *www.irena.org/rejobs.pdf.*

IRENA (2013c), "Smart Grids and Renewables: A guide for effective deployment". *http://www.irena.org/DocumentDownloads/Publications/smart_grids.pdf*

IRENA (2014), Renewable Energy and Jobs – Annual Review 2014, IRENA, Abu Dhabi.

IRENA and CEM (2014), The Socio-economic Benefits of Large-scale Solar and Wind: an econValue Report, IRENA, Abu Dhabi.

MNRE (Ministry of New and Renewable Energy) (2014), "Physical Progress (Achievements)", *www.mnre.gov.in/mission-and-vision-2/achievements/.*

Nampoothiri, M. (2014), "Tamil Nadu Wind – A Victim Of Its Own Success?", www.re-solve.in/perspectives-and-insights/tamil-nadu-wind-a-victim-of-its-own-success/

Network-Transparenz (2014), TSOs' annual "EEG (Erneuerbare Energien Gesetz)-Umlage" announcements, *www.netztransparenz.de/de/EEG-Umlage.htm*

NGK Insulators (2013), "NAS Battery Energy Storage System", *http://www.eei.org/meetings/Meeting_Documents/Abe.pdf.*

NREL (2014), "Implications of a PTC Extension on U.S. Wind Deployment", *http://www.nrel.gov/docs/fy14osti/61663.pdf*

Oklahoma Legislature (2014), "An Act: Electrical power distribution requirements", Enrolled Senate Bill No. 1456, *http://webserver1.lsb.state.ok.us/cf_pdf/2013-14%20ENR/SB/SB1456%20ENR.PDF.*

Overseas Development Institute (2013), "Time to Change the Game: Fossil Fuel Subsidies and Climate", *www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8668.pdf.*

Pearson, N. (2014), "India Reconsiders Wind Forecasting on Inaccurate Results", *http://www.bloomberg.com/news/2014-03-07/india-puts-wind-forecasting-on-hold-on-inaccurate-results.html.*

PIB (Press Information Bureau) (2012), "Accelerated Depreciation for Wind Power Producers", 21 May, Ministry of New and Renewable Energy, *http://pib.nic.in/newsite/erelease.aspx?relid=84317.*

PIB (2014), "In a major achievement for the power sector, Southern Grid synchronously connected with the National Power Grid", 1 January, Ministry of New and Renewable Energy, *http://pib.nic.in/newsite/erelease.aspx?relid=102244.*

POWERGRID (2012), "Report on Green Energy Corridors: Transmission Plan for Envisaged Renewable Capacity", *http://www.indiaenvironmentportal.org.in/files/file/Report-Green%20Energy%20corridor.pdf.*

POWERGRID (2014), "Smart Grids Pilot Projects in India", *www.assocham.org/events/recent/event_960/Smart-Grid-Pilot-project-in-India.pdf.*

PUA (Israel Public Utilities Authority) (2013), "The Israeli Renewable Energy Market and Regulation: Current Status Report", *www.pua.gov.il/Sip_storage/FILES/6/3026.pdf* .

Pudjianto, D., et al. (2013) Grid integration cost of photovoltaic power generation, Imperial College, London.

PV Parity (2013), "How to support different photovoltaic applications in the achievement of competitiveness and beyond", *http://www.pvparity.eu/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/PVPARITY_docs/public/PVParity_Final_Report.pdf&t=1400850072&hash=8626cd597cfe9e9226f184e8bd47f48fb9fc41ad*

Rabago, R.R., et al., (2012), "Designing Austin Energy's Solar Tariff using a Distributed PV Value Calculator", *http://rabagoenergy.com/files/value-of-solar-rate.pdf*

REN21 (2013) "Renewables 2013 – Global Status Report", *www.ren21.net/REN21Activities/GlobalStatusReport.aspx.*

REN21 (2014) "Renewables 2014 – Global Status Report**",** *www.ren21.net/REN21Activities/GlobalStatusReport.aspx.*

SEDA (2013), "Briefing on RE Funding Mechanism for Feed-in Tariffs", *www.st.gov.my/index.php/en/download-page/category/107-briefing-session-on-electricity-tariff-in-peninsular-malaysia-19-december-2013.html?download=428:briefing-on-re-funding-mechanism-for-the-feed-in-tariff.*

SEDC (Smart Energy Demand Coalition) (2011), Demand response in Europe: Snapshot, SEDC, Brussels.

Solar Electric Power Association (2013), "Read the News". *www.solarelectricpower.org/read-the-news.aspx.*

Udasin, S. (2014), "Ministers approve renewable energy quota shifts to photovoltaic sector", The Jerusalem Post, 3 March, *www.jpost.com/Enviro-Tech/Ministers-approve-renewable-energy-quota-shifts-to-photovoltaic-sector-340231.*

U.S. Energy Information Agency (2014), "Market Trends: Electricity demand", Annual Energy Outlook 2014, *www.eia.gov/forecasts/aeo/MT_electric.cfm#cap_natgas*.

USAID India and MNRE (2014), "Assessment of the Role of Energy Storage Technologies for Renewable Energy Deployment in India", *http://www.pace-d.com/wp-content/uploads/2013/11/PACE-D-Energy-Storage-Report-Executive-Summary-Sec.pdf.*

World Bank (2013), "GNI per capita ranking, Atlas method and PPP based", *http://data.worldbank.org/data-catalog/GNI-per-capita-Atlas-and-PPP-table.*

World Bank (n.d.), "How we Classify Countries", *http://data.worldbank.org/about/country-classifications*, accessed March 2014.

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