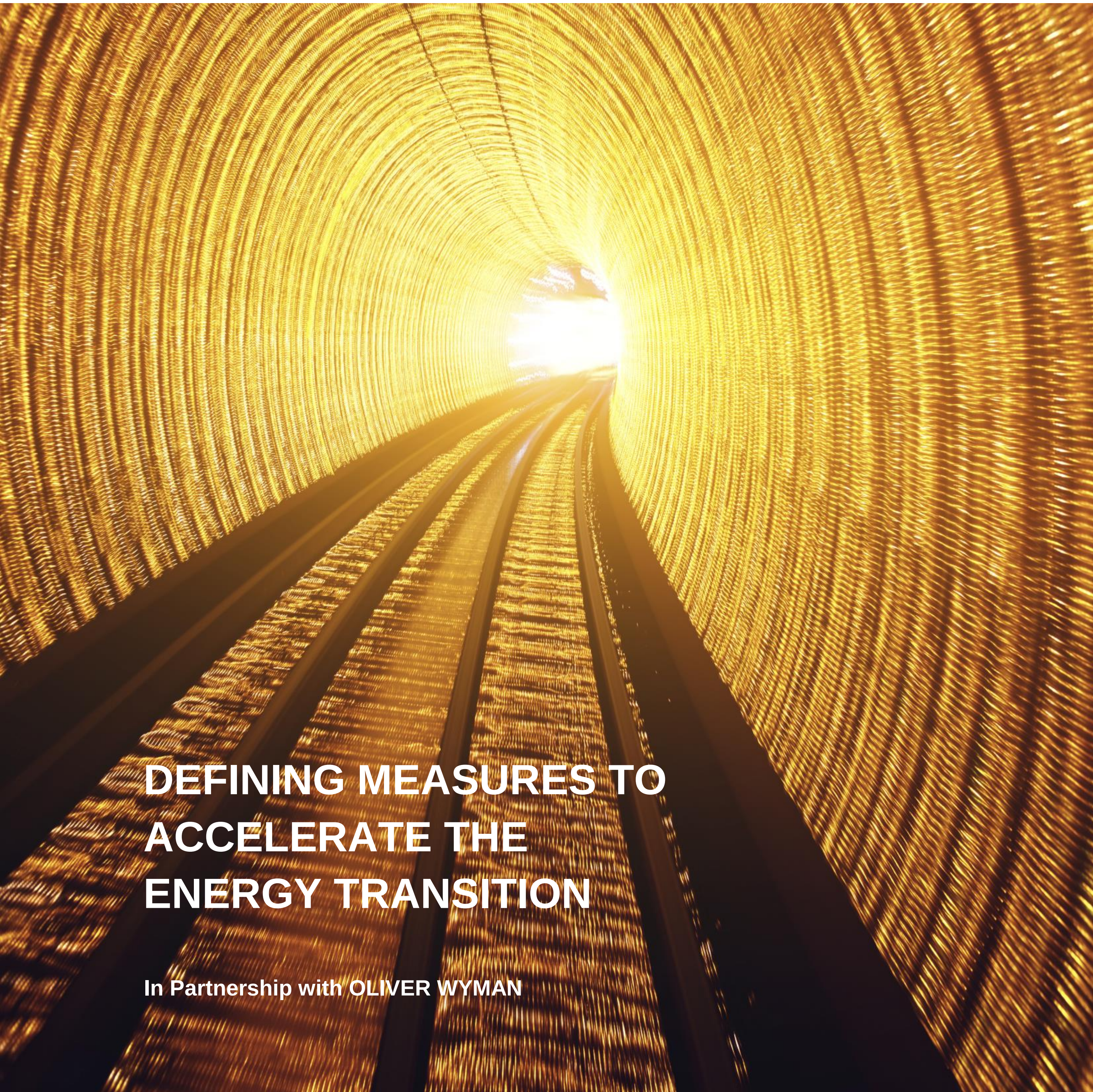
WORLD
ENERGY
COUNCIL

World Energy Trilemma | 2016



DEFINING MEASURES TO ACCELERATE THE ENERGY TRANSITION

In Partnership with OLIVER WYMAN

ABOUT THE WORLD ENERGY COUNCIL

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with over 3,000 member organisations in over 90 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders. We inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world's energy policy dialogue.

Further details at www.worldenergy.org and @WECouncil

ABOUT WORLD ENERGY TRILEMMA 2016

The World Energy Council's definition of energy sustainability is based on three core dimensions: energy security, energy equity, and environmental sustainability. Balancing these three goals constitutes a 'trilemma' and is the basis for the prosperity and competitiveness of individual countries.

The World Energy Trilemma Report 2016, prepared in partnership with global consultancy Oliver Wyman, a subsidiary of Marsh & McLennan Companies, identifies five focus areas to drive progress on the energy trilemma.

Developed through interviews with policymakers and private sector energy leaders, analyses of five years of the Energy Trilemma findings, and associated wide assessment of energy strategies, the report offers guidance in the complex task of translating the trilemma goals of security, equity and sustainability into tangible actions.

FOREWORD

In our research for this year's World Energy Trilemma report, we, that is the World Energy Council and our project partner, global consultancy firm Oliver Wyman, set out to ascertain what the data we have assembled over the last five years tells us about how energy policy can best address the challenges of securing the trilemma goals of security, environmental sustainability, and equity.

What we found underlined the importance of some key themes featured in our reports. There is no simple linkage between any specific policy and performance on the three energy dimensions of the trilemma. This is perhaps not too surprising, since what works in any particular country depends both on its individual circumstances and the quality of execution of policies. Moreover, when it comes to reconciling growing demand for energy with the (relatively recent) emphasis on reducing greenhouse gas emissions to mitigate the impact of climate change, and doing so affordably, we all still have a lot to learn. We therefore have taken the opportunity to highlight the lessons emerging from innovative policies to address the energy trilemma.

First among these is the need to provide clarity to the market. This is particularly important in devising strategies to finance the transition to a low carbon energy system and to expand access to modern energy services, since investors need to be able to assess their proposed commitments against long term trends, whether in supply and demand, technology development, or the evolution of policy.

When it comes to implementation, we will need to push forward in critical areas using a staged approach, with an eye to the longer term but also the ability to learn by doing and to adapt our incentives as circumstances change. We need to get better at co-ordination - including looking beyond the energy sector to meet climate and energy goals, which will require changes right across the economy to our transportation, manufacturing, construction and agricultural sectors.

Innovation will be at the heart of how we meet these challenges cost effectively, and governments need to be strongly supportive of private sector investment in innovation and research, development and demonstration. While disruptive new technologies will appear in the future, we already have the range of tools to do what is needed - but getting them all to market quickly is a different matter.

The fundamental nature of the changes we need to make requires us to adopt a change management approach in communicating policies and setting expectations. No longer can we act as if change of this significance will be cost free and completely straightforward - there will be setbacks along the way which need to be allowed for. Politicians have a grave responsibility to foreswear short term point scoring, based on oversimplified approaches, when setbacks occur.

Industry too must play its part, and it will be better able to do so if policymakers stimulate a broader industry engagement. This will need to embrace the new types of company who are driving such rapid change in the energy sector if policy and regulation is to keep up to date with changing business models and business/customer relations. These in turn will require new forms of customer engagement calling for increased communication with the public. Social acceptance of change on this scale and at this pace can only be secured with a great deal of conscious effort from all government and business leaders.

Overall, the challenges seem daunting. But we benefit from a sophistication of understanding of how to tackle them which is unprecedented. What we must do now is convert that understanding into effective policies. The trilemma process is designed to facilitate the dialogue among all stakeholders which is a precondition of early and effective action.

Joan MacNaughton
Executive Chair, World Energy Trilemma

TABLE OF CONTENTS

FOREWORD	1
TABLE OF CONTENTS	3
EXECUTIVE SUMMARY	4
INTRODUCTION	7
FIVE YEARS OF ENERGY TRILEMMA ASSESSMENTS AND INDICES	12
FIVE FOCUS AREAS TO MAKE PROGRESS ON THE TRILEMMA	25
1. TRANSFORMING ENERGY SUPPLY	27
2. ADVANCING ENERGY ACCESS	51
3. ADDRESSING AFFORDABILITY	63
4. IMPROVING ENERGY EFFICIENCY AND MANAGING DEMAND	74
5. DECARBONISING THE ENERGY SECTOR	85
CONCLUSIONS	100
APPENDIX: EXPERT INTERVIEWS	105
ACKNOWLEDGEMENTS	107

EXECUTIVE SUMMARY

The energy sector is at a transition point and faces a range of growing challenges. Countries have committed to reducing greenhouse gas emissions (GHG) under the 2015 climate change agreement (COP 21), putting a renewed focus on the decarbonisation of the energy sector. In addition, energy services must expand to meet rising global energy demand in many emerging economies and provide more than 1 billion people with needed access to modern energy services. At the same time as transforming market designs and expanding energy infrastructure, energy security and reliability must be maintained and strengthened in a context of increasing risks and resilience challenges.

The energy industry and energy leaders have been implementing changes and making strides to meet these challenges. To meet the goals of 2020 and beyond, governments must enact and continue to push the evolution of energy policies and financing solutions that support rapid transitions and expansion of energy infrastructure. Through interviews with policymakers and private sector energy leaders, an analysis of five years of the Energy Trilemma Index, and associated wide assessment of countries' energy strategies, this 2016 World Energy Trilemma report has identified five focus areas to drive progress on the energy trilemma and offers guidance in the complex task of translating the trilemma goals of security, equity and sustainability into tangible actions.

FIVE FOCUS AREAS TO ACCELERATE THE ENERGY TRANSITION

1. TRANSFORMING ENERGY SUPPLY. Policymakers and decision takers must set clear and straightforward energy targets and build a broad consensus for the transition in energy supply and demand. This process must include new entrants to the energy sector and early engagement with affected communities. Taking an adaptive approach by launching pilot projects and regularly analysing policy effectiveness is crucial for the successful delivery and implementation of policies.

2. ADVANCING ENERGY ACCESS. Many emerging and developing economies continue to struggle to expand energy infrastructures to support advanced energy security, reliability and access. To increase private sector investments in infrastructure expansion and modernisation, countries are reforming regulatory frameworks to decrease the cost of doing business, and to increase competitiveness in the electricity market. In tandem, distributed generation through solar and wind renewables is bringing energy access to rural and remote communities that cannot currently be cost-effectively connected to the grid.

Solely expanding energy access infrastructure is not enough. Countries must look to a range of innovative mechanisms that enable affordable access for people to utilise the benefits of modern energy for income-generating activities. Innovative mechanisms include pay as you go business models and mobile banking solutions to promote the take-up of renewable-powered energy services.

3. ADDRESSING AFFORDABILITY. Many countries with lower gross domestic products (GDPs) and low rankings on the energy equity dimension are struggling to ensure energy affordability while financing or creating the investment conditions to support energy infrastructure expansion. Over the short term, subsidies can be vital for lower-income consumers and supporting social and economic programmes. Energy subsidies can be costly to deploy, are contentious to remove, and tend to decrease overall performance on the energy trilemma over the long term. The case studies in this report demonstrate how long-term subsidies can erode the profitability of utilities, stall improvements in energy infrastructure and stimulate inefficient energy use.

4. IMPROVING ENERGY EFFICIENCY AND MANAGING DEMAND. Energy efficiency and managing energy demand continue to be globally perceived as top action priorities with huge potential for improvement. As highlighted through the case studies, cost savings alone are often insufficient to stimulate the adoption of energy efficiencies or behaviours. Policymakers must align the interests of asset owners, users and regulators, and continue to implement a combination of energy efficiency standards, performance ratings, labelling programmes and incentives. They must also increase awareness across all industrial sectors, and encourage consumers to continue to focus on greater energy efficiency.

5. DECARBONISING THE ENERGY SECTOR. The groundbreaking conclusion of COP 21 added increasing momentum to the global transition to low-carbon energy. Dynamic and flexible renewable energy investment policies are the key to responding to evolving market dynamics and technological developments. Meeting COP 21 climate goals will require a clear path to a meaningful carbon price signal and changes beyond the energy sector and across the economy. Governments have a role in building the necessary consensus for change.

RECOMMENDATIONS

There are lessons emerging from innovative and tried-and-tested policies to overcome barriers and make progress on the energy trilemma:

Policy matters: Policy choices and creating a regime to support a robust energy sector are critical to lasting energy trilemma performance regardless of a country's resources or geographic location.

Time matters: Policies and investments intended to change energy supply and demand at a national level will take time and will likely be disruptive. Countries must act now to progress on the trilemma with secure, equitable and environmentally sustainable energy to support a thriving energy sector, a competitive economy and a healthy society.

OTHER RECOMMENDATIONS INCLUDE:

- Improved coordination and looking beyond the energy sector to meet climate change goals is critical.
- Policymakers should provide clarity to the market with succinct and aligned signals when devising policy strategies in order for investors to assess their commitments against long-term trends.
- Governments need to be strongly supportive of private sector investment in research, innovation and development.
- A change-management approach in communicating policies and setting expectations should be adopted to take into account technology changes and any setbacks that may occur in the future to avoid stakeholder backlash.
- Desired transitions in the energy sector must be accompanied and stimulated by transitions in regulatory frameworks. 'Energy 2.0' must be enabled by 'regulations 2.0'.

INTRODUCTION

The energy sector is at a transition point and faces a range of growing challenges. Globally, energy demand is predicted to grow by one-third over 2015–2040, primarily in non-OECD countries.[1]

The primary drivers of this demand are: a global population growth from 7 billion today to 9 billion by 2040; a projected 150% growth in the global economy in the same time period; and trends in increasing urbanisation and mobility. For example, between 2014 and 2040, it is expected that almost 1 billion vehicles will be added in developing countries, as well as 47 million new commercial vehicles in the OECD, and 229 million in developing countries.[2]

In addition, many countries, especially in Sub-Saharan Africa, will need to expand electrification and access at a pace that exceeds the local population growth to provide modern energy services to the estimated 1.1 billion people who currently do not have access to modern energy services.[3]

At the same time, the energy sector needs to adapt to emerging risks – such as increasing volatility of weather patterns and cyber risks – and new market structures and frameworks to integrate new technologies – all in a context of increasing price volatility.

These trends, coupled with commitments to decrease the environmental impact of the energy sector, currently responsible for 35%–40% of global greenhouse gas (GHG) emissions, will put strains on energy systems.

Many countries have already made progress in improving their provision of secure, affordable and environmentally sustainable energy. But there is much more to do. All energy sources currently available at scale entail challenges in meeting the three goals of the energy trilemma (see Figure 1: Outlook, challenges and opportunities for energy sources).

[1] International Energy Agency (IEA) (2015), World Energy Outlook 2015 (Executive summary)
[2] Organization of the Petroleum Exporting Countries (OPEC) (2015), The World Oil Outlook 2015
[3] IEA and the World Bank (2015), Sustainable Energy for All 2015 – Progress Toward Sustainable Energy

FIGURE 1: OUTLOOK, CHALLENGES AND OPPORTUNITIES FOR ENERGY SOURCES

ENERGY SOURCE	GLOBAL OUTLOOK	CHALLENGES	OPPORTUNITIES
Fossil fuels	• Fossil fuels, including coal, natural gas, and oil, dominate the world's global total primary energy supply through 2050 • Fossil-fuel based energy generation is the source of 30–40% of global GHG emissions[1]	• Import dependence can leave a country exposed to limited suppliers or volatility in fuel costs • Countries are committed to decreasing reliance on high-GHG emitting fossil fuels and increasing focus on natural gas and renewables in energy generation	• Increasing diversity of energy supply can help increase energy security and environmental sustainability
Hydro	• Hydropower contributes to over 16% of global power supply and supplies 76% of all renewable energy[2] • Emerging economies have the potential to double hydroelectric production by 2050, often using small-scale hydro[3]	• The resource can be variable due to weather patterns and current and projected impacts of climate change on hydrological conditions • Managing water resources over transnational boundaries presents political issues, such as tensions over water rights on the Nile, Colombia, Mekong and Xingu rivers	• Hydropower provides a low-GHG emitting renewable power and helps balance fluctuations in demand and supply[4]
Non-hydro renewables	• A growing segment of global electricity supply is expected to play a key role in expanding energy access in many developing economies • By 2040, it is projected that renewables-based generation will be 50% in the European Union, around 30% in China and Japan, and above 25% in United States and India[5]	• These resources are not yet at scale and generation can be intermittent • Continued technological developments in storage and batteries, and effective market reforms are needed to stimulate investments in renewable generation and the grid	• Renewables emit little or no GHG emissions, and typically require less water to generate power
Nuclear	• 31 countries already have nuclear power and a number of them, including India and China, are looking to build new nuclear power units • An additional 20 countries are looking to develop nuclear power[6]	• Social accessibility is an issue • The technology requires high capital outlay – up to 10 times as much compared to an equivalent sized gas plant • Plants have long construction periods of up to ten years • Long term revenue is uncertain as nuclear competes against out-of-market subsidies for other carbon-free generation sources	• Nuclear can be an economical and reliable way of generating large amounts of base load electricity without producing CO2 • The marginal cost of electricity is low but construction, decommissioning, and waste disposal costs are high

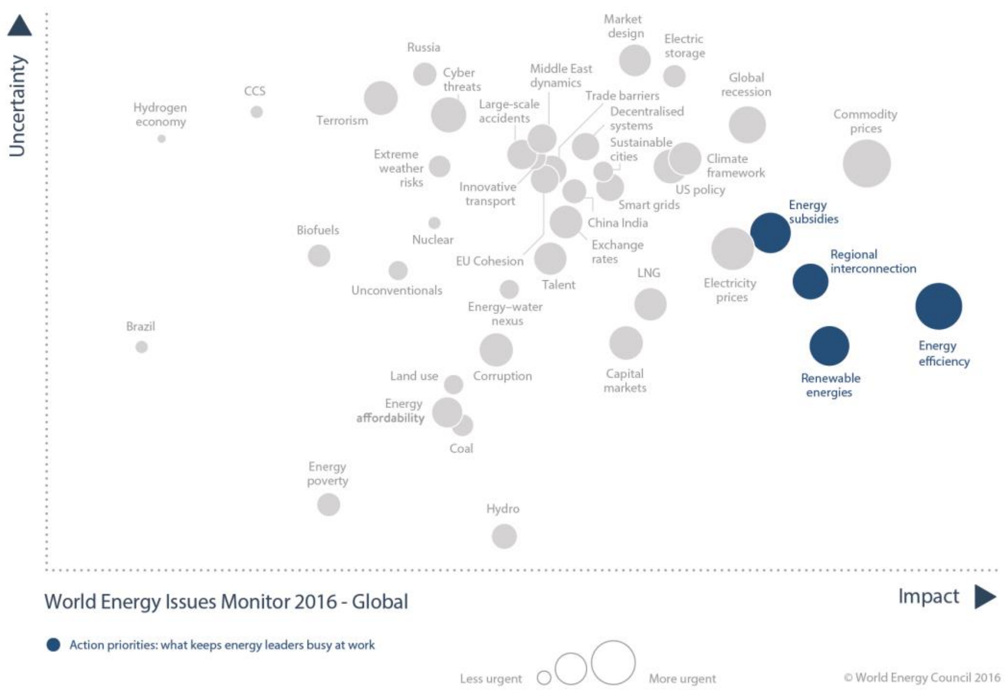
1. IEA WEO 2015, Executive Summary.
2. World Energy Council, Hydropower 2015 Status.
3. IEA, Hydropower subtopic: https://www.iea.org/topics/renewables/subtopics/hydropower/
4. IEA, Hydropower subtopic: https://www.iea.org/topics/renewables/subtopics/hydropower/
5. IEA WEO 2015, Executive Summary.
6. World Nuclear Association, February 2016: Emerging Nuclear Energy Countries.

Source: World Energy Council / Oliver Wyman, 2016

Future energy goals have to be ambitious. Countries will need to deliver and balance their energy trilemma goals while responding to recent international developments. These include the first ever G20 Energy Ministers Meeting in 2015, the December 2015 annual conference of parties (COP 21) agreement and the proclamation of the United Nation's Sustainable Development Goals (SDGs) which included a focus on energy access.

These energy ambitions are reflected in the outcomes of the World Energy Issues Monitor, which shows that renewable energies and energy-efficiency improvements have become key action items for energy leaders globally (see Figure 2: World Energy Issues Monitor – Key action priorities).

FIGURE 2: WORLD ENERGY ISSUES MONITOR – KEY ACTION PRIORITIES



Source: World Energy Council (2016), World Energy Issues Monitor 2016

The 2016 World Energy Trilemma report, prepared in partnership with global consultancy Oliver Wyman, along with the Global Risk Centre of its parent Marsh & McLennan Companies, aims to support policymakers in the complex task of translating the trilemma goals of energy security, energy equity and environmental sustainability, into implementation actions. Leveraging five years of World Energy

Trilemma reports and indices and a wide assessment of country energy strategies, the 2016 report identifies five areas where countries have focused efforts to drive progress on the energy trilemma goals:

1. transforming energy supply
2. advancing energy access
3. addressing affordability
4. improving energy efficiency and managing demand
5. decarbonising the energy sector.

Within each focus area, selected policy tools are analysed, highlighting the barriers from policy design to implementation and the learning from policy initiatives across the world. Policy examples from a variety of countries illustrate how best to manage the trade-offs and spill-overs within the energy trilemma framework of security, equity and environmental sustainability. As one policymaker noted, “Policymakers need to consider trade-offs according to country context.” But neglecting one dimension of the trilemma can result in unintended consequences and higher future costs in economic, social and environmental terms, while improvements on a single dimension can often have positive impacts on the overall trilemma results.

This report has a strong focus on the decarbonisation of the electricity sector. Electricity generation is a key source of GHG emissions. While progress has been made in many geographical areas to reduce carbon intensity, there is an expectation for electricity to play a growing role in heat and transport. Some estimates suggest that electric vehicles could be 35% of new car sales by 2040, and other research predicts that the rapidly falling costs of lithium-ion battery costs, (which have dropped 65% since 2010), could spur a faster adoption of electric vehicles. The resulting transitions and growth trajectory of the electricity sector will have a huge impact on the world’s economy and environment. How countries drive electrification, promote efficient use of electricity, and the regulations surrounding electricity will be key.

The link between a country’s performance on the Energy Trilemma Index and the steps required to improve is not always self-evident. A country’s performance often involves a number of interrelated factors, of which policy is one part. These factors include technology development, market forces, institutional arrangements, and corporate and consumer values, among others. While existing institutions, markets and capabilities are taken into account, the report focuses on policies. As noted in the 2011 World Energy Trilemma report, “Policymaker choice is a key discriminating factor of energy performance: while countries may exhibit similar contextual positioning and resource endowments it is ultimately the choices made by policymakers that cause the energy performance scores of otherwise similar countries to diverge."[4]

Supported by interviews with energy leaders in policy and regulatory fields as well as the private sector, the report concludes with key findings and recommendations for policymakers to overcome barriers to improve performance on the energy trilemma and sets out priorities for the energy sector for 2016 onwards.

---

[4] World Energy Council (2011), Policies for the Future

FIVE YEARS OF ENERGY TRILEMMA ASSESSMENT AND INDICES: A RETROSPECTIVE

The annual World Energy Trilemma reports and indices from 2010 to 2015 uniquely captured the priorities that were jointly identified by global energy leaders from public and private sectors, across developed, emerging and less developed nations. This sixth year of energy trilemma assessments provides an opportunity to review and identify where and how countries have focused efforts to make progress on the trilemma and to highlight policy learnings to support energy goals over the next five years (see Box 1).

BOX 1: DEFINING THE THREE DIMENSIONS OF THE ENERGY TRILEMMA

Energy security: Effective management of primary energy supply from domestic and external sources, reliability of energy infrastructure, and ability of energy providers to meet current and future demand.

Energy equity: Accessibility and affordability of energy supply across the population.

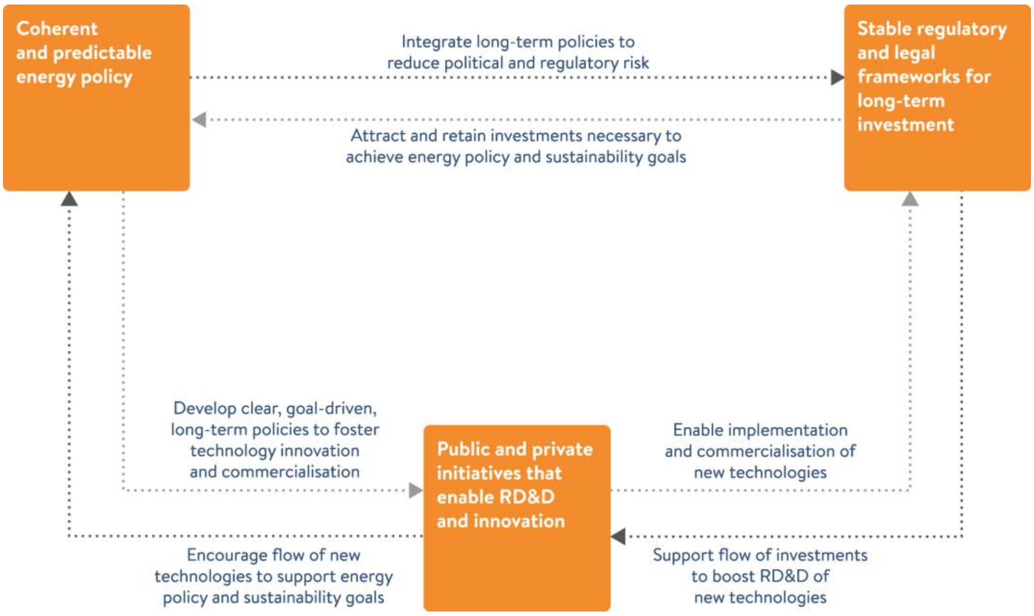
Environmental sustainability: Encompasses achievement of supply- and demand-side energy efficiencies and development of energy supply from renewable and other low-carbon sources.

The broad context and key interconnected policy areas to support the transition to sustainable energy systems and balance the energy trilemma were set out in the 2012–2014 World Energy Trilemma reports. Three key policy areas remain essential for creating an attractive foundation for energy investments (see Figure 3: Three key interconnected policy areas).

Predictable and durable energy policies that go beyond the political cycle and have clearly defined goals are the cornerstones of a sustainable energy system. To support the formulation of policies, the energy industry needs to be proactive in sharing knowledge and taking a strong role in change management with regards to energy use. Policymakers must ensure that energy policies: are integrated with adjacent policy areas (for example, environment, industry, and transportation); include the promotion and support of energy efficiency; and are generally supported by citizens.

Against this policy backdrop, there is a need to implement consistent, predictable regulatory and legal frameworks to support long-term investment in energy infrastructure. These include the effective use of market-based economic instruments to ensure a fair marketplace for all energy technologies. Alongside this, there is a role for carefully selected mechanisms to correct market failures such as 'green' or infrastructure banks. Green bonds, well-designed public-private partnerships, and carefully applied subsidies, can also be important.

FIGURE 3: THREE KEY INTERCONNECTED POLICY AREAS

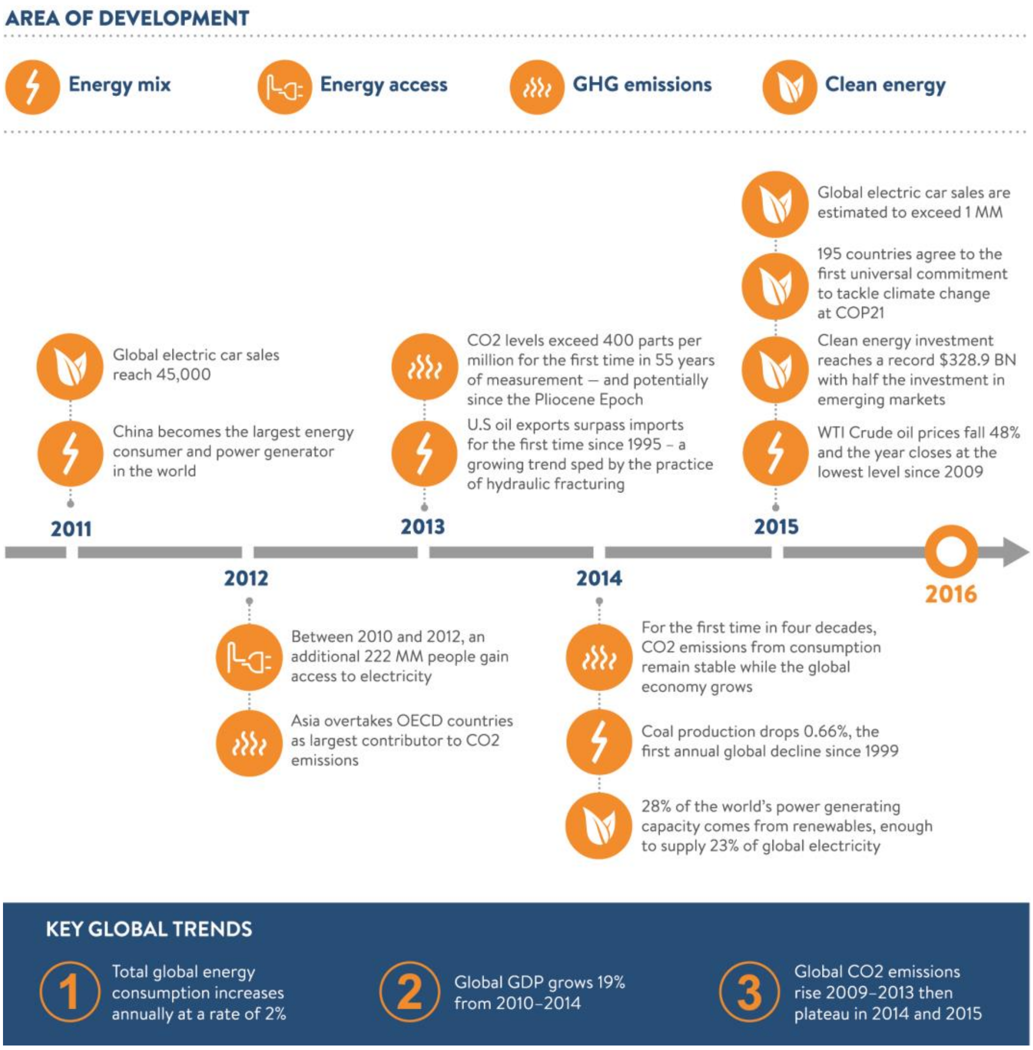


Source: World Energy Council (2012), World Energy Trilemma: Time to get real – the case for sustainable energy policy

Public and private initiatives that enable innovation as well as research, development and deployment (RD&D) projects are essential to transform the way energy is produced and used. Industry must lead the way in bringing forward technological innovations.

The key messages and learning over the five years of energy trilemma research have remained strongly consistent and are reiterated and strengthened in this current analysis. The consistency remains, despite the significant number of foreseen and unforeseen global developments that have affected the energy sector and, with that, the energy trilemma dimensions over the period. These developments highlight the challenges in developing lasting policy in an evolving context (see Figure 4: Policymaking during key global energy developments 2010–2015).

FIGURE 4: POLICYMAKING DURING KEY GLOBAL ENERGY DEVELOPMENTS 2010–2015



Source: World Energy Council/Oliver Wyman, 2016

This challenge is reinforced in the results of the annual Energy Trilemma Index from 2010–2015. The Index comparatively ranks 130 countries on their ability to provide a secure, affordable and environmentally sustainable energy system, and awards countries a balance score, highlighting their effectiveness in managing the trade-offs between the three energy trilemma dimensions.[5] Based on an analysis of 60 data sets used to develop 23 indicators, the Index displays the aggregate effect of energy policies applied over time (see Box 2).

BOX 2: CHANGES TO THE ENERGY TRILEMMA INDEX METHODOLOGY

The Energy Trilemma Index, formerly known as the Energy Sustainability Index, was first introduced in 2009, ranking close to 90 countries. This ranking has been expanded to include 130 countries and greater detail about countries' performance on the specific trilemma dimensions by adding a 'balance score' and an index 'watch list' to give an indication of countries that are expected to display trend changes in the next few years.

To make the Index an even more valuable, widely-used tool for the various stakeholder groups, the World Energy Council, in partnership with global management consultancy Oliver Wyman, has conducted a review of the Energy Trilemma Index, involving a select task force of experts from 18 different countries, covering all continents. The new Index 2.0 methodology (currently under development) reflects global energy sector insights captured through six years of trilemma research. It leverages improved data sets and addresses pressing issues that impact on energy sector dynamics. Results, using the new Index 2.0 methodology, are expected to be released at the World Energy Congress 2016.

The Index 2.0 methodology will use a set of 34 indicators and approximately 100 data sets to rank countries on their trilemma performance (compared to 23 indicators and 60 data sets in the current Index methodology).

---

[5] In 2013, the Energy Trilemma Index was expanded to include an additional 37 countries (not members of the World Energy Council) with sufficient available data to provide a comparative ranking of 129 countries. A 'balance score' was added to indicate how well countries manage the trade-offs between the three energy trilemma dimensions and identify top performing countries with an 'AAA' score. The methodology was improved over time, with a particular focus on the assessment of the social equity and environmental impact mitigation dimensions (see World Energy Trilemma: 2012 Energy Sustainability Index for details.) Index rankings were calculated retrospectively with the improved methodology to allow a year-to-year comparison.

Detailed analysis of the annual Index does not reveal a ‘magic formula’ or specific policy or types of policies that drive Index performance. Yet reviews of country performance yield a number of findings:

- Achieving significant and measurable changes in a country’s energy trilemma profile and altering the balance between the dimensions can take a number of years. This is despite the progress and sometimes seemingly rapid developments in the energy sector, such as the significant developments in US shale gas. Policies intended to drive measurable and lasting changes in energy supply and demand or GHG emissions can take 5–10 years to materialise, as infrastructure takes several years to develop and build. The key lesson for countries focused on the year 2020 and achieving their COP 21 commitments is to start now.

- Few countries are fully balanced across all areas of the energy trilemma, and overall progress on the trilemma is usually led by developments in one dimension. Indigenous resources, such as fossil fuels, or availability of large-scale hydropower can have a significant impact on the overall trilemma profile, resulting in high security ratings or high environmental sustainability ratings. However, a comparatively balanced trilemma profile depends on focused policies and a robust regulatory and legal environment.

- Energy policy choices and the ability of a country to develop, implement and regulate the energy sector have the biggest impact on overall energy trilemma performance. High gross domestic product (GDP), or rich fossil fuel resources, can facilitate aspects of energy performance, but countries across the economic spectrum and geographies perform well in aspects of the energy trilemma. Policy choices and creating a regime to support a robust energy sector are critical to lasting energy trilemma performance.

Figure 5 shows the top performers in terms of the overall ranking on the Energy Trilemma Index across the last five years. It is important to note that the Index is comparative and ranks countries’ performance in relation to each other. Overall, many countries have improved aspects of energy performance over the review period and the Index has been useful to help identify areas for improvement. Leading countries have also improved, thus maintaining high overall rankings in relation to others.

Across the 130 countries included in the Energy Trilemma Index, only 12 have ranked in the top 10 overall: 10 of those countries are in Europe and 9 are also members of the Clean Energy Ministerial group (initiated in 2009).

While there are differences among these top performers regarding the countries’ endowment of natural resources and geographic spread, they all are members of the OECD (mostly European) with strong, post-industrial economies (GDP per capita greater than US$33,500). The top performers have a relatively high percentage of renewables (close to or higher than 10%) and/or nuclear power in their electricity generation. However, there are also a number of non-OECD and lower GDP countries that consistently rank high. In Latin America, these include Uruguay, Colombia and Costa Rica which have a steady upwards trends 2011-2015 and rise to top 20 Index positions in 2015. These countries have been able to leverage renewables, especially hydro, to drive energy performance and have also put a strong focus on developing consistent energy policies. Qatar has also consistently ranked high, ranking in the top 20 in three out of the past five years.

FIGURE 5: ENERGY TRILEMMA INDEX RANKINGS: TOP 10 COUNTRIES, 2011–2015

	2011	2012	2013	2014	2015
1	Switzerland	Switzerland	Switzerland	Switzerland	Switzerland
2	Denmark	United Kingdom	Denmark	Sweden	Sweden
3	Sweden	Sweden	Sweden	Norway	Norway
4	United Kingdom	Austria	Austria	United Kingdom	United Kingdom
5	Austria	Denmark	United Kingdom	Denmark	Austria
6	Norway	Norway	Canada	Canada	Denmark
7	France	New Zealand	Norway	Austria	Canada
8	Canada	Germany	New Zealand	Finland	France
9	New Zealand	France	Spain	France	Finland
10	Germany	Canada	France	New Zealand	New Zealand

Source: World Energy Council/Oliver Wyman, 2016

Other common features of top ranked countries include a strong regulatory and country context in which energy policy is developed and implemented. This highlights that policies, and the institutional capacity to develop and implement them, is critical to attracting investment and ensuring effective energy performance.

The reasons behind the strong European presence in the top ranked Index countries which is shown in Figure 5 are varied and difficult to link to any single policy or group of policies. However, the EU's long-term climate and energy strategy, implemented through the 20-20-20 targets, introduced in 2008, may have played a strong role in driving the performance of the predominantly European top 10 energy trilemma performers (see Box 3). For example, European countries represent 19 of the 21 countries that have decoupled economic growth (GDP) and CO_2 emissions growth over the period 2000–2014.[6]

BOX 3: EUROPE'S 20-20-20 TARGETS: IMPACTS AND LESSONS

In an important step towards decarbonising the economy, in 2008 the EU committed to climate and energy goals to be reached by 2020. These targets, known as the '20-20-20' targets, aim for: a 20% cut in emissions of GHG, compared with 1990 levels; a 20% share of the final energy consumption coming from renewables; and a 20% increase in energy efficiency. Overall, it is hoped that the goals would help the region achieve the energy trilemma goals of secure, equitable, and environmentally sustainable energy.

There are mixed views as to whether Europe will achieve the 20-20-20 targets and whether some of the progress is the result of external factors, rather than policy efforts. For example, continued deindustrialisation and the lingering effects of the financial crisis through 2010–2011 have tempered emissions and energy demand growth in certain countries. In terms of the energy consumption goal, variations in measuring energy efficiency may make it difficult to determine if the 20% reduction target is met. A number of countries, including France and the United Kingdom, will also have some challenges in meeting the target of 20% renewables in final energy consumption over the next four years.

There have been criticisms of the costs to stimulate renewable energy growth – for example, an estimated €40.5bn will be spent in France supporting the renewables power sector for 2012–2020. There are also concerns over the costs to consumers and the impacts these policies have had on the financial viability of the overall power sector. Specifically, the electricity market has been distorted, with drops in wholesale prices undermining investments in wholesale capacity, such that some modern gas plants are not viable, but old (and dirtier) coal plants with lower marginal costs are able to operate profitably.

---

[6] Aden N (2016), "These 21 countries are cutting carbon while growing GDP", GreenBiz (6 April, 2016)

With more ambitious energy targets set for 2030, policymakers will need to put a greater focus on energy market design, regional energy markets, and energy demand management in transportation and buildings, as well as getting the right prices on carbon.[7]

Looking at the performance of different regions, North America – led by US and Canada, with Mexico generally ranking at about the 40th position in the Index – is the next strongest geographic region after Europe. The United States and Canada rank high in the Index, but all three North American countries are in the lower Index rankings for the environmental sustainability dimension due to comparatively high emissions per capita. All have made COP 21 commitments which should help the transition to a low-carbon energy sector. In addition, Mexico's broad structural reforms should result in wider improvements over the next 5–10 years.[8]

Latin America and the Caribbean (LAC) countries have a mixed performance in the Index. The region includes both net energy importers and exporters, including Organization of the Petroleum Exporting Countries (OPEC) members Ecuador and Venezuela. Overall, LAC is an energy-rich region with large oil and gas deposits and great natural endowments of exploitable renewable energy. A number of countries, including Colombia, Uruguay, Costa Rica, Ecuador, Brazil and Peru, have been able to leverage strong hydropower capabilities to achieve an overall top third placement in the World Energy Trilemma. LAC countries are also looking to build wind power capabilities (for example, Brazil's competitive bidding process to stimulate wind power), increase regional interconnections, and – most critically – to attract investment. Many countries have focused on establishing a clear and transparent regulatory regime for energy investments (see Box 4).

BOX 4: COLOMBIA LAW 1715 – RENEWABLE ENERGY DIVERSIFICATION

Law 1715, enacted in 2014, promotes the research, investment in, and use of, renewable energy to comply with international commitments, such as the Statute of the International Renewable Energy Agency (IRENA). The law does not have specific targets for the share of renewables in the energy mix. However, the government's Mining and Energy Planning Unit set a goal to

[7] Deloitte (2015), Energy Market Reform in Europe; Zachmann, G, Elements of Europe's Energy Union, Bruegel (9 September, 2014)
[8] Mexico Energy Reforms: Risks and Opportunities, Marsh, June 2015

install 143 megawatts (MW) of solar power by the year 2028 in its 2015 National Energy Plan Colombia. The main mechanisms to incentivise renewable use are tax (income and value-added tax exemption), accounting (accelerated depreciation), and customs exclusion benefits. For the residential sector, the law creates the Non-Conventional Energy and Efficient Energy Management Fund to finance self-generation projects. With the policy coming into effect in February 2016, the impacts remain to be seen. The cost of hydroelectricity generation is low compared to the high cost of implementation of non-hydro renewable technologies, presenting a potential barrier to investment. In general, public awareness of the need for, and benefits of, clean energy is relatively low. The law itself demonstrates a promising step towards diversifying Colombia's energy system and positions the country well to improve on the security and environmental sustainability trilemma dimensions. As a next step, the country may explore deeper economic incentives, such as feed-in-tariffs, net-metering, and utility sale auctions– models that have helped Chile and Peru transform their energy supply.[9]

Asia's energy trilemma profile includes a diverse array of economies, with less-developed countries (Nepal and Pakistan), rapidly developing economies (China, India, Indonesia), and highly-developed nations (Japan, Korea, New Zealand). Many of the region's countries are in the lower half of the Index, although Malaysia and Japan are high-ranked. As the region works to expand and increase energy access it has to manage the environmental impacts of high coal use across the region. Nevertheless, the region has seen some of the most significant energy developments over the past few years, with progress in expanding energy access and energy infrastructure. China and India have seen some of the largest growth in solar (China: 19 GW solar PV in 2014; and India: 4 GW) and wind power (China: 92 GW in 2014; and India: 20 GW by 2014).[10] In 2014, almost half of global investment in renewable energy was made in Asia and the trend continued in 2015, with US$102.9bn investment in renewables in China.[11]

The Middle East and North Africa (MENA) countries have had a mixed performance on the Index, with oil-rich countries ranking higher on energy equity

[9] Urueta C and Valencia F M (2016), "Blog: The Role of Renewables in Colombian Energy Security", Iwana Energy (11 February, 2016)
[10] Renewable Energy Policy Network for the 21st Century (REN21) (2015), The First Decade: 2004 – 2014, 10 Years of Renewable Energy Progress
[11] United Nations Environment Programme (UNEP) (2016), Global Trends in Renewable Energy Investment 2016

and relatively well on energy security. Less-oil-rich countries, including Yemen and Tunisia, remain in the lower part of the Index. All the countries perform comparatively poorly in environmental sustainability rankings (rated C or D). In most cases this is due to high emissions intensity or high energy demand relative to GDP growth. The performance of the region has also felt the impact of political upheavals and conflicts that have affected many countries over the period 2010–2015. It is interesting to note, that a number of countries in the region are expected to improve with regards to all three dimensions of the enery trilemma in response to policy changes following the extended period of low oil prices. For example, Saudi Arabia is expected to improve on all aspects of the energy trilemma.

Throughout the period of the Index, Sub-Saharan Africa countries have remained in the bottom half of the Index, with only Angola (leveraging fossil fuel reserves) and Gabon achieving a top 60 ranking over the years. The region has the potential for high energy performance based on available resources (fossil fuels, hydropower and renewables) but development remains challenged as countries face institutional and infrastructural barriers to making efficient use of resources, and investors are deterred by the perceived political risks and ethical weaknesses. Significant progress on the energy trilemma will depend on improvements in the country context and the indicators of political strength (including regulatory quality) and societal strength (including control of corruption and rule of law).

Energy security

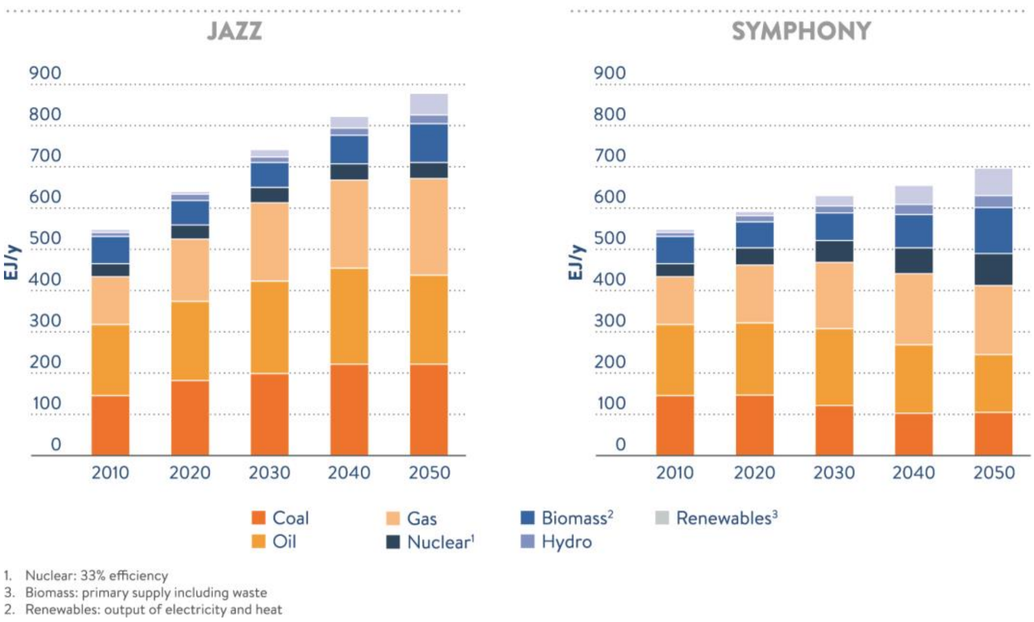
Energy security considers management of primary energy supply and the ability to meet current and future demands. By considering these elements, and not only whether a country has high fossil fuel reserves, the energy security dimension of the trilemma highlights that energy security can be as much about how a country is sourcing, diversifying and using energy.

Looking at the trends in the energy security rankings over 2011–2015, a wide array of countries from all geographic regions and GDP groups are in the top 10 rankings. Yet, it is a comparatively small group of 21 countries that feature in the top 10 in terms of the energy security dimension over the five years.

In the energy security dimension, many countries – such as Russia, Australia, US, Kazakhstan and Qatar – have high fossil fuels reserves, including coal, oil, gas and unconventional energy sources. Yet some notable fossil fuel economies, such as Saudi Arabia and the United Arab Emirates (UAE), are not ranked highly due to their high rate of energy consumption growth. Other countries, such as Ecuador, Canada and Denmark, are able to leverage renewables in electricity supply to drive high energy security rankings. The remarkable developments in US shale gas production have supported the country’s continued high ranking for energy security. The US position has also been helped by a continued focus on managing energy demand, and expansion of renewable energy supply.

The five years of the Index highlight the continued important role of fossil fuel reserves or large-scale hydropower in ensuring a high ranking for energy security. The next five years will reflect the growth and expansion of solar and wind energy, and an array of countries may be able to improve their energy security accordingly (see Figure 6: Total primary energy supply: outlook to 2050).

FIGURE 6: TOTAL PRIMARY ENERGY SUPPLY: OUTLOOK TO 2050



Source: World Energy Council (2013), World Energy Scenarios: Composing energy futures to 2050

Energy equity

Energy equity relates to the accessibility and affordability of energy supply across the population. Fiscal policies are critical in this respect, including taxation criteria across energy sources and carriers, as well as progressive taxation policies to alleviate burdens on less-affluent citizens. For example, policies charging almost full renewable energy source (RES) support costs to electricity consumers by taxes and levies may not be coherent with equity goals.

Over time, the top 10 rankings have remained dominated by the US and Canada, countries that have tapped indigenous energy resources and enacted policies to maintain affordable energy – especially affordable transportation fuels. Other top 10 countries have maintained low energy prices for economic growth and social development, such as the UAE or Saudi Arabia. These countries have subsidised energy prices but this approach can have negative impacts on the energy security and environmental sustainability dimension of the trilemma. Other countries in the top 10 are high GDP countries with 100% electricity access. (Oman is the exception, where an estimated 93% of the rural population has access to electricity.)

The most interesting stories around energy equity are not shown in the top ranked countries but in the lower rankings, where countries have made progress in improving access to, and the quality of, electricity supply. As discussed above, countries such as China and India have made significant improvements in expanding energy access to millions of people.

Environmental sustainability

The environmental sustainability dimension encompasses achievement of supply-and-demand energy efficiencies and development of energy supply from renewable and other low-carbon sources.

The top ranked countries in this dimension reflect the role of hydropower in enabling low GHG emissions in energy use. Nearly all the countries in the top 10 over the years have a high percentage (close to 50% or more) of hydro in electricity generation. The exceptions to this are France (which uses nuclear power for 75% of its electricity generation) and Denmark (which has developed wind power).

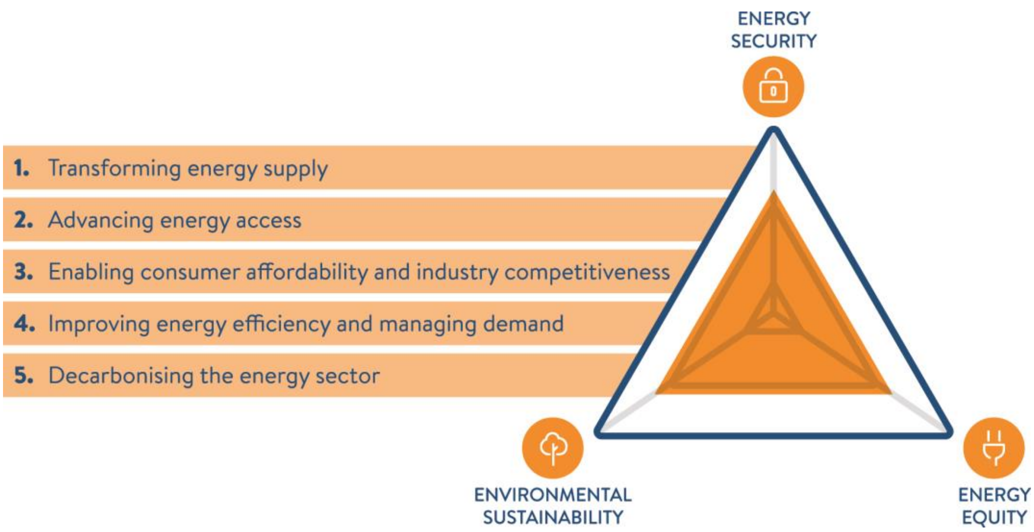
Investments in renewable energy grew at a record pace in 2015, with most of the investments in developing countries. These developments, along with a growing focus on demand management, may allow more countries to minimise or stall growth in CO_2 emissions, in line with COP 21 commitments. However, investments in renewable energy alone are not sufficient to reduce GHG emissions. Demand management in transportation and buildings are also key areas, and a greater focus on carbon capture and storage (CCS) may be necessary.

POLICYMAKER CHOICE IS A KEY DISCRIMINATING FACTOR OF ENERGY PERFORMANCE.

FIVE FOCUS AREAS TO MAKE PROGRESS ON THE ENERGY TRILEMMA

Drawing on case studies and interviews with energy leaders, this 2016 report identifies five focus areas necessary to make progress on the energy trilemma (see Figure 7: Five focus areas to achieve energy goals within a balanced energy trilemma).

FIGURE 7: FIVE FOCUS AREAS TO ACHIEVE ENERGY GOALS WITHIN A BALANCED ENERGY TRILEMMA



Source: World Energy Council/Oliver Wyman, 2016

Effectively implemented, policy levers aimed at one dimension of the energy trilemma can have a positive impact on all three dimensions. However, case studies highlight that policy strategies need to be considered through a trilemma lens to avoid unintended consequences that inhibit the achievement of overall energy goals, or deliver them at higher costs. For example, Argentina's 2001 freeze on electricity tariffs had the goal of ensuring energy affordability in a period of economic crisis and high unemployment. However, over time, the freeze stunted the profitability of the energy sector, and consequent investments in maintenance, operations and expansion undermined future energy security (see Box 15 on page 68 – Brazil lighting for all).

Fossil-fuel endowed countries such as Saudi Arabia, which have stimulated economic and social development through low energy costs, have both energy security challenges – driven by high energy consumption growth rates – and environmental sustainability challenges – driven by high and rising carbon emissions. A focus on energy security in fast-growing economies like China has led to the urgent need to take specific actions to curb high pollution levels and to remediate environmental impacts to date. Decarbonisation strategies designed without taking into account available resources and costs can be difficult to deliver and sustain, as the examples of the costs in France and Germany illustrate (see Box 3 on page 18). For example, in France, an estimated €40.5bn will be spent supporting the renewable power sector in 2012–2020.

1 Transforming energy supply

Transforming energy supply for many countries will include diversifying primary energy supply and electricity generation and driving the transition towards a low-carbon energy supply.

Diversifying primary energy supply and electricity generation

Effectively implemented, increased diversity in energy supply and electricity generation – including increases in low-carbon electricity supply, (nuclear, hydro, wind and solar) – can enable reductions in GHG emissions in electricity generation as well as increasing energy security. Indeed, one of the key factors driving energy supply and generation diversity is policy for renewable energy targets. At the country level, diversity in electricity generation is also driven by goals to increase indigenous energy supplies and reduce the effects of geopolitics or global energy markets on energy security. In the private sector, residential and large business consumers are also looking to minimise volatility in energy costs or decrease their environmental footprint. For example, a growing number of companies across diverse sectors are signing utility-scale power purchase agreements for renewable energy and are pledging to procure 100% of their electricity from RES.[12]

A focus on energy supply diversity can also enable improved resilience of the overall energy system to current and future shocks and risks such as extreme weather events, hydrological changes, and the growing complexity of the energy-water-food nexus.

Despite the benefits, increasing the diversity of energy supply and generation is challenging. It requires time, resources and money to make the necessary changes in energy infrastructure and assets that often have lifespans of 30 to 70 years. There are also economic, political and social impacts to be managed (see case study on Italy). For example, Poland has more than 100,000 miners, and concerns over the economic impact of job cuts in the coal industry, associated with efforts to decrease GHG emissions, has lead the new Polish government to lobby the EU for more aid for the continent's biggest coal industry.[13]

---

[12] See RE100.org – a collaborative, global initiative of influential businesses committed to 100% renewable electricity, working to massively increase corporate demand for renewable energy.
[13] Strzelecki, M and Krasuski, K, "Ikea leads green revolution in land of Europe's dirtiest power", Bloomberg (23 February, 2016)

ITALY

TRANSFORMING ENERGY SUPPLY

POLICY AND GOAL

The 2013 National Energy Strategy sets Italy's 2020 energy targets. Reducing dependency on foreign energy supply (from 84% to 67% of total energy needs) and increasing renewable capacity (19–20% share of final energy consumption) are two of the strategy's security components.[1] In addition to expanding renewables, the strategy calls for doubling domestic supply of hydrocarbons, increasing energy efficiency, diversifying the source and routes for imported gas, and increasing storage capacity to reduce energy import reliance.[1]

IMPLEMENTATION

The supporting "Storage" Decree (2010) and "Sblocca Italia" (Unlock Italy) Decree (2014) introduced significant amendments to stimulate energy production and infrastructure investment, including simplifying the approval procedures for pipelines, gas terminals, natural gas infrastructure networks and storage, and domestic production of oil and gas.[2] Sblocca Italia is credited for pushing the Trans Adriatic Pipeline (TAP) development forward after years of deadlock. To encourage renewable electricity generation, Italy has used a variety of incentives including green certificates, feed-in tariffs, market premiums, and reverse auctions. Mechanisms in place to incentivise energy efficiency include white certificates, tax deductions, and the "Conto Energia Termico" (Thermal Energy Account).

ACHIEVEMENT

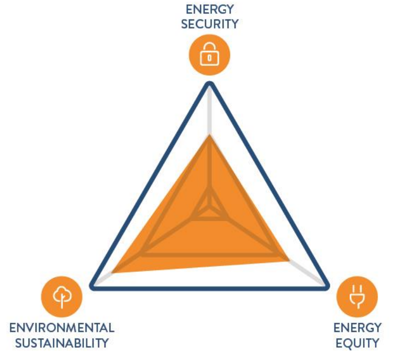
Italy has made advances in diversification in gas supplies and gas storage capacity, although domestic gas production has been decreasing over the past five years. Renewable energy in 2014 reached 39% of total electricity consumption, and construction of the TAP is adding a sixth source of gas imports (Azerbaijan). The Storage Decree has been the main driver of year-on-year increases in capacity offered by the main Italian storage system operator, Stogit, between 2011 and 2014.[3] Italy has also made progress in energy efficiency: in the period 2006–2013 about 23.5 M Energy Efficiency Certificates were released and 17.6 Mtep of primary energy saved. Through these efforts, Italy has improved its ranking in the Security dimension of the Energy Trilemma Index. Despite impressive renewable growth, the country's scores remain relatively low, mainly as a result of the lack of domestic fossil fuel resources.[4]

CHALLENGES

Local community opposition and lengthy investment authorisation processes hampered deployment of large infrastructure projects. Regional governments are unaligned on the Sblocca Italia decree, and have driven the repeal of certain procedures that transfer decision-making power to the central government.[5]

1. Italian Ministry of Economic Development, 2013: Italy's National Energy Strategy: For a more competitive and sustainable energy.
2. Associazione A Sud, Salvatore Altiero and Marica Di Pierri, 2015: Italy's case in the global emergency: development, social justice and the environmental crisis.
3. Associazione A Sud, Salvatore Altiero and Marica Di Pierri, 2015: Italy's case in the global emergency: development, social justice and the environmental crisis.
4. Calculation from Snam Rete Gas, Ten Year Development Plan, 2015.
5. A referendum on April 17th also sought to repeal procedures in the Sblocca Italia degree relating to oil drilling, but failed to receive the necessary quorum.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
33	27	28	29	31

LESSONS LEARNED

1. Early engagement of affected communities is critical in preventing project delays.
2. Deregulating policies must clarify how policies should be implemented between local, regional, and national governments to reduce complexity for investors and regulators.
3. Countries can improve the efficient use of existing infrastructure (e.g. liquefied natural gas (LNG) terminals) while future looking projects move through regulatory processes.
4. Alignment with EU energy security priorities and strong public commitment from government leaders creates momentum to secure large infrastructure projects.

BOX 5: UAE VISION 2021 TO DIVERSIFY THE ENERGY MIX

The UAE has been trending upward on the Energy Trilemma Index for security and equity over the past three years, and was on the 2015 Index positive 'watch list' for its efforts to diversify its energy mix and remove fossil fuel subsidies. The policy goals include a target to increase the low-carbon energy contribution of renewable energy and nuclear power to 24% of the overall energy mix by 2021. The Emirate of Dubai has a specific goal of generating 7% of total power output from RES by 2020, and 15% by 2030.[14]

The main mechanisms to drive low-carbon energy supply include:

- **government-driven investment in large infrastructure projects**
- **technical assistance and cooperation agreements with international energy agencies and governments – for example, the International Renewable Energy Agency (IRENA), United Nations Environment Programme (UNEP), and Korea (Republic) – to support technology deployment, and develop related policies and procedures**
- **economic support mechanisms are still limited but include net metering and slab tariffs (tariffs rise on higher rate of energy use), to improve the competitiveness of solar energy.**

In addition, the UAE's two largest emirates, oil-rich Abu Dhabi and the commercial capital Dubai, have employed multidimensional strategies for energy diversification. Abu Dhabi is further advanced, having established the Masdar Institute in 2006, with a broad mandate – from funding clean energy research and deployments, to developing a sustainability curriculum for universities. Dubai's approach has been more narrowly focused on technology implementation and sustainable infrastructure, to position itself as a 'green' city.[15] Given the country's reliance on fossil fuels, governance structures had to be built or strengthened to support the energy diversification initiative. These include the Emirates Nuclear Corporation, Federal Authority for Nuclear Regulation, Regulation and Supervision Bureau, Dubai Supreme Council of Energy, and the Abu Dhabi Water & Electricity Authority (ADWEA). Several projects – completed and in the pipeline – demonstrate that the UAE is continuing its strong momentum

[14] Mittal S, "UAE reiterates target of 24% clean energy share by 2021", Clean Technica (30 October, 2015)
[15] Luomi, M (2015) The International Relations of the Green Economy in the Gulf: Lessons from the UAE's State-led Energy Transition, Oxford Institute for Energy Studies

towards renewable energy: by 2021, a 5.6 GW nuclear plant and 3 GW solar plant will be active.

The main challenges to date include:

- **limited institutional capacity for policymaking, regulation and enforcement of energy mix targets**
- **the diversification model is highly dependent on public investments in large-scale utility projects**
- **the non-binding clean energy targets and low transparency in policymaking compared to some OECD countries may decrease the attractiveness of private investment in long-term infrastructure projects[16]**
- **lack of public awareness of the value of energy efficiency and energy diversification.**

Driving the transition towards a low-carbon energy supply

Given the benefits of diversity in electricity supply, potential increase in resilience and lower GHG emissions, many countries are focusing on a transition in their energy generation systems towards more low-carbon generation. For example, in 2015, President Obama announced a target of 20% non-hydro renewables in the energy supply by 2030 for the USA. The transition is also being driven by the ageing of infrastructure in many developed countries. In Europe, the total installed capacity of steam power plants in Europe is around 2,300 GW (2011) and 40% of them will be retired in the next two decades. In the US, 51% of the electricity generating capacity was built before 1980. About 74% of all coal-fired power plants are at least 30 years old, and the average life of such plants is 40 years, although some units have operated for more than 50 years, depending on maintenance and updates to meet changing regulations.

The transition to a low-carbon energy system will include a comparatively high percentage of non-hydro renewables and greater decentralisation of energy infrastructure. However, intermittency of renewable energy from solar and wind power is a significant challenge for energy security, which requires consistent and reliable energy generation. The expansion of wind and solar generating capacity is pushing the present supply infrastructure to the limits of its maximum performance

[16] Husain, M and El Katiri, L (2014), Prospects for Renewable Energy in GCC States, Oxford Institute for Energy Studies

capability. For instance, in Germany and the US, grid constraints make it increasingly difficult to provide an adequate balance between generation and load due to the high renewables share, resulting in disconnection of generators in order to maintain stability of the electricity grid. Today's grids in some regions are at the limit of being able to handle any additional intermittent input. The investment required for electricity grids by 2030 is estimated to be as high as US$6.5bn. Consequently, a new challenge is how to identify and implement the best solution from the possible options to address intermittency, including electricity storage (see Box 6), high voltage transmission lines, optimisation across a broader area, demand-side response and combined cycle gas turbines back-up.[17]

How the Grid 2.0 will work is an area that needs greater focus. As one energy executive remarked, "We spend a lot of time looking at how to holistically consider the increase in renewables, the impact on the grid, other connectivity issues and how all these pieces fit together. There is so much opportunity on that front for all countries in terms of tackling environmental sustainability, as well as meeting security and equity goals."

BOX 6: OUTLOOK ON E-STORAGE[18]

- **Storage is seen as a game-changer that could contribute to solving the intermittency challenge of wind and solar electricity generation.**

- **Storage creates additional value through its function to level the load. It enables deferral of grid investment, especially at congestion points, and creates the possibility of price arbitrage for operators.**

- **There are a number of different energy storage technologies that cover short-term and long-term applications. The power versus energy density of a storage device is thereby a key element in matching the technology with the appropriate application.**

- **Diverse approaches to energy storage are adopted according to end use. For example, supercapacitators and flywheels are well suited to situations where deployment of stored energy lasts for minutes or less, such as situations of peak shaving, valley filling or load shifting, whereas, pumped hydropower storage solutions are more suitable to situations that involve adequate reserve capacity and support storage of large amounts of energy to use over daily time periods. In addition, the maturity of pumped hydropower makes it much more likely to be**

[17] World Energy Council (2013), World Energy Perspective: Energy efficiency technologies
[18] World Energy Council (2016), World Energy Resources: E-storage: Shifting from cost to value

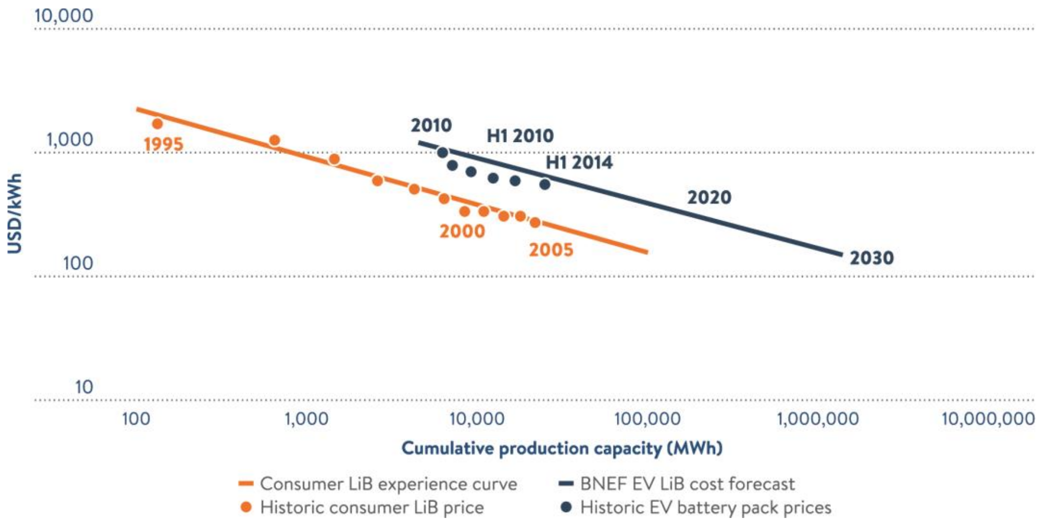
used in the context where reliability is key, such as the balancing of national power systems.

- **Rules for an effective market participation of storage should be introduced also to benefit from the positive impact of installations coupled with renewable energy source units in terms of production shifting and balancing reduction**

- **Market rules should ensure that plants be able to grant grid services to the network (primary and secondary regulation) on a level playing field.**

- **Energy storage solutions are often considered hand-in-hand with high capital costs. However, the production costs for a number of different storage technologies are expected to reduce drastically as production increases. Figure 8 illustrates the historic and projected prices for lithium-ion batteries, which shows that, with increasing capacity, the cost per kWh has reduced steadily. And the costs of energy storage technologies are forecast to reduce by as much as 70% by 2030.**

FIGURE 8: EXPERIENCE CURVE FOR LITHIUM-ION BATTERIES



Source: Bloomberg New Energy Finance (BNEF), 2015

- **At the same time, huge improvements have been made in the energy density of batteries – a battery's ability to store energy given its weight or volume. The technology for increasing the density of energy storage in batteries has improved according to the materials used for construction. For example, a lithium battery can store 100–250 Wh per**

kg, more than twice as much as nickel-cadmium. Furthermore, a new battery is being developed, using lithium-air fuel cell, which is not only smaller and lighter, but can potentially produce more than 300 Wh per kg.[19, 20]

Another consequence of high renewables penetration is the volatility of prices on the spot markets for electricity, which increasingly often reach very low or even negative values under strong wind and low load demand conditions. This, in turn, puts real financial pressures on 'traditional' utility models. The intraday market in Europe helps the integration of renewables by providing more accurate forecasts of spot prices to consumers and producers (see Box 7).

BOX 7: THE INTRADAY MARKET IN EUROPE[21]

The intraday market has revealed its potential to integrate rising shares of renewables by helping producers and consumers make use of more accurate forecasts and optimise their positions closer to real time, thereby providing a high level of flexibility. This particularly helps market actors adapt to variations of availability of wind and sun. The Swiss and German intraday markets are the most developed in the EU. International standards and common market processes are most important to establish an intraday market's cumulating liquidity. Intraday markets ensure non-discriminatory market rules by distributing risks equally between all market participants – both conventional and renewable generation. Such market structures can deliver higher security of supply, given sufficient cross-border capacity and higher environmental performance, thanks to the market integration of renewables generation. Countries could derive a benefit from expanding their cross-border-transmission capacity and harmonise import/export procedures to reduce limiting factors for intraday market processes.

However, several examples exist where high shares of renewables are successfully accommodated in power systems. Market design is key to successfully operating with large amounts of wind power and other variable renewables. Market rules should take into account RES power's inherent characteristics of variability and limited predictability. Intraday and balancing

[19] "Energy Storage: Charge of the lithium brigade", The Economist (30 May, 2015)
[20] Lambert, F, "Samsung unveils new high energy density battery prototype, says it could allow electric vehicles range of 373 miles", Electrek, (13 January, 2016)
[21] Epex Spot (2014), Annual Report 2014: A day ahead with Epex Spot

markets are the cornerstones for cost-efficient market and grid operation with large amounts of RES power.

For RES energy, priority dispatch has been an important tool to facilitate its integration into the power system. In a transition phase, the related indirect benefits for existing non-programmable RES plants should continue to be applied to retain investors' confidence. Alternatively, they could be transformed into a direct benefit of an equivalent value.

The definition of clear rules for efficient curtailment procedures is also a pre-condition for delivering a 'fit for RES' market. In particular, transmission system operators should be more transparent in showing the reasons for curtailing any generator, and compensations for curtailments should factor in the day-ahead price and incentive lost.

In mature markets with high penetration levels of RES power, future regulatory frameworks and power market design could consider increased exposure of RES generators to market risks. However, this requires a fair market price with a fully transparent, fair and well-functioning power market.

The need for 'back-up' or alternative energy supply (such as fossil-fuel) in electricity systems with an increasing volume of intermittent supply can drive up overall energy costs. The impact of potentially rising energy costs on low-income consumers and the industry during the energy infrastructure transition is a concern. For example, faced with declining hydropower output during a 2014–2016 drought, Brazil had to utilise thermal plants as base load, leading to an increase in fuel imports. The higher use of thermal plants led to higher consumer electricity bills, yet benefits of ongoing structural changes in the energy infrastructure are not yet apparent to consumers. As was noted, "… on a structural level, the policy is pursuing all three aspects of the trilemma, although this is subject to short-term cycles where equity and environmental sustainability are negatively affected."

An alternative approach to managing temporary shortfalls in electricity supply was taken in the UK in the winter months. The National Grid, the British power transmission network operator, introduced the Demand-side Balancing Reserve service (DSBR) to manage energy demand in peak hours. Under the DSBR, National Grid committed to provide payments to large energy users that committed to reduce electricity use in peak hours. This could be achieved by switching to back-up generation or by switching off non-essential electronic appliances. The benefit of such a demand-side response market is that it enables network operators to keep costs down by avoiding expensive energy imports, or by not having to leave peaking power stations to remain on standby.[22] Indeed, in the winter of 2014–2015 tenders for companies to participate in the voluntary DSBR scheme were raised for an estimated 330 MW.

Perhaps the biggest single issue in the development of the future energy system is ‘change management’, especially in countries with established energy infrastructure. How to move from the current infrastructure to an efficient, reliable and secure low-carbon infrastructure without compromising energy security or equity is the question. As one energy executive noted, “… it is a hard task to have a reasonable plan for the transition period… and it is important to align future commitments to capture the historic development trajectory of major players in the energy world with an understanding of impacts on energy companies.”

For example, in observing the vast shifts in technology, consumer expectations and energy prices, many commentators have warned of the ‘death spiral’ for the traditional utility model – as utilities lose market share to distributed generation, they may react by increasing prices, which would drive more customers away and erode their business further. However, forward-looking utilities are increasingly taking advantage of distributed generation trends to develop a new business model, based on collaborative offerings. Offerings can stem from new partnerships, ranging from joint ventures to community renewable generation and energy-efficiency programmes. Some leading utilities have already begun to embrace the new energy system. For example, in some parts of the US, customers can participate in a community generation programme, where they buy or lease interests in a solar garden system and get credit on their power bills for the electricity produced.[23] As countries craft policies that shake utilities from their traditional models, they must look outward to learn how other utilities are developing adaptive, collaborative businesses (see Box 8).

It is critical that regulatory frameworks are crafted to maintain a vital energy sector, stimulate renewable energy, ensure necessary investment levels across the sector, and manage energy costs and security. This 21st century energy system will require a number of elements to function fully effectively. These include the revision of energy policy and regulations, such as reforming energy tariffs to support the function of baseline utilities, while enabling increased residential solar distribution. Technology developments needed include investments in expanding distribution and transmission networks, end-to-end detailed data from generation

---

[22] BBC News, “National Grid to pay firms to use less power” (23 September, 2014); SSE Enterprise (n.d.), Demand-Side Response; National Grid (n.d.), Contingency Balancing Reserve
[23] Oliver Wyman (2014), The New Utility Business Model: Coming to a neighborhood near you

and via grid to load, and improved energy storage. Along with new elements, a range of new players are entering the energy and energy technology sectors, for example, information technology companies are increasingly investing in RD&D for energy storage or are leading investments in renewable energy. As one energy executive noted, “You need to have the courage to make changes and adapt the whole process to the things you learn throughout the transition process.” Reflecting a different approach, another energy leader noted, “Realistically, if we wouldn’t have started with renewables before making a decision on the grid, we probably would have never started with renewables. Sometimes you need to make critical pressure to ensure things move forward.”

BOX 8: ENERGIEWENDE – A STUDY OF ENERGY TRANSFORMATION

Germany’s ambitious plan to transform its energy system, Energiewende, has required significant and costly changes to Germany’s incumbent energy system. The programme as a whole contains more than 20 quantitative energy targets from 2020 until 2050, in emissions reduction, energy efficiency, renewables and nuclear phase-out. The main policy targets include:

- **a reduction in GHG emissions by 40% by 2020 and 80– 95% by 2050 – compared with the 1990 level**
- **an increase in the share of renewable energy in total energy consumption to 30% in 2030 and 60% in 2050**
- **an increase in the share of renewable energy in total power consumption to 50% in 2030 and 80% in 2050**
- **improved energy efficiency: Halving primary energy consumption by 2050 compared with the 2008 level.**

While the backbone of the plan originated in 2000 in the Renewable Energy Sources Act (EEG), Energiewende gained traction in 2011, with the Energy Concept policy (2010).

In just a few years since the plan was devised, progress has been made on multiple fronts, but the broad structural changes to the energy system have involved both foreseen and unforeseen changes to the existing power generation base. Changes have also had other impacts on energy costs and neighbouring energy systems.

In electricity generation, the share of renewables has increased from 7% in 2000 to nearly 27% in 2014 – putting the country on track to meet its target for increasing the share of renewable energies, and possibly over-reaching the target in 2025. In heat consumption, the 12% share of renewables is already close to the 14% target for 2020. It is projected that emissions could be reduced by 28% compared to the 1990 level by 2020. Primary energy consumption was 7.4% lower in 2015 compared to 2008.

As energy generation has decentralised, grid congestion has spiked. The early focus and the speed of the expansion on renewables, and solar photovoltaic (PV) development in particular, have been difficult for the system to effectively absorb – both on a cost basis and a technical basis. At times, the grid cannot manage loads, due in part to disparities in generation location and demand centres. Another challenge is the asynchronous expansion and modernisation of the grid with the much speedier development of decentralised renewable energies. As a result of delaying grid enhancements, the full integration of renewables will take 7–8 years longer, and require an estimated US$110bn in investment in the high and low voltage grid systems.[24] German policymakers stress that addressing each pillar of the energy transition in tandem was not politically or economically feasible – instead, policymakers set the transition in motion by focusing on renewables.[25]

A key current challenge is how to deal with increased emission shares from coal power plants since the nuclear phase-out. Indeed, despite the increase of renewable energy, the emissions from power generation in general have increased in Germany since the Energiewende. While conventional power is still critical to ensure grid reliability, the rise in renewables has also reduced the utilisation of conventional power plants, heavily decreasing prices on the wholesale market. The price decline in electricity wholesaling has affected all conventional power plants (including those in Germany and in neighbouring countries connected to the German power grid), eroding profitability. According to Oliver Wyman analysis in 2014, conventional power generation and storage will need investments in the order of US$58bn by 2033 to ensure security of supply. Under current conditions, the utilities' market share in power generation capacity will probably decline by one-third, to less than

---

[24] Fritz, T, Manteuffel, D and Staeglich, J (2014), "Sustainable Energy: Financing Germany's energy transition", Oliver Wyman Energy Journal Vol. 1
[25] Oliver Wyman interviews

50% by 2033.[26] German utilities surveyed are significantly critical of energy policies: 83% view amendments made to the renewable energy law in 2014 as ineffective or counterproductive. In addition, only 30% of utilities expect that the expansion of both network and storage capacity needed to make the energy transition workable will be realised in the foreseeable future.[27] To keep conventional generation viable and encourage financing, Germany has to redesign the structure of its electricity market to fairly compensate back-up energy providers. Of particular focus is how to make gas power plants more attractive instead of the CO_2 intensive coal.

Excess energy from renewables in the German grid has also raised costs and decreased electricity reliability for neighbouring countries. The Polish and Czech grids have been impacted by unscheduled loop flows that occur when electricity flows from the northern areas of Germany through Eastern European markets back into southern Germany. As a result, they have installed technologies that enable transmission system operators to physically push back electricity flows if necessary. This approach sets back the principle of integration in the European internal energy market.

The transition remains an affordability challenge for industry and residential consumers. While there is a burden-easing model for energy-intensive businesses (to remain competitive), residential consumers and small and medium-sized businesses (SMBs) had experienced higher costs on their bills – although there was no increase in the reallocation charge in the past year, nor is an increase expected. It is estimated that Germany's renewable sector is subsidised with €19.4bn per year and residential electricity prices increased by more than 30% in 2008–2013.[28] The financial burden for SMBs is expected to rise, irrespective of the EEG reform in 2014.[29] In some aspects, the increased prices have stimulated the adoption of energy-efficiency behaviours and technologies – reinforcing overall energy goals and minimising the cost burden on consumers.

---

[26] Fritz, T, Manteuffel, D and Staeglich, J (2014), Power Generation Disruption: Germany's case for change, Oliver Wyman,
[27] Sopher P (n.d.), "Lessons learned from Germany's Energiewende", RELP: Renewable Energy Law and Policy Review
[28] Von Henning K, "Verbraucher werden 2015 eine Milliarde Euro mehr EEG-Umlage bezahlen", Wirtschafts Woche (1 February, 2014)
[29] Verband Der Chemischen Industrie e.V. (VCI), Making the Energiewende Affordable, 24 February, 2016

Germany's experiences provide lessons and insights for policymakers in other countries:

- **Consider the price signals and the effects on the economic viability of the overall energy system in providing incentives for investment in renewable energies.**
- **An 'energy-only-market' may not be sufficient to guarantee security of supply in a period of energy transition. An additional capacity market or a capacity reserve may be necessary to ensure security of supply in the long term.**
- **The extension of the grid system should happen at the same time as the expansion of renewable-based power generation capacity.**
- **Consider how the cost for the system changes can be fairly distributed and how the changes can be financed.**
- **Monitor the pace and direction of the transformation regularly and take measures to steer a sustainable course.**
- **When setting national goals, factor in the impact on the regional electrical and political system.**
- **Public acceptance is crucial to furthering the policy through political cycles.**
- **Utilities that reference to the resist the restructuring process will lose valuable time in updating their business models.**
- **Align the overall policy design with the ultimate objective (greenhouse gas emission reductions).**

Progress will also depend on research and development. For example, the Mission Innovation initiative launched at COP 21 is an important commitment to this area. Each of the 20 participating countries, including China, India and the US, will seek to double its governmental and/or state-directed clean energy research and development investment over five years. New investments will be focused on transformational clean energy technology innovations that can be scaled to varying economic and energy market conditions in participating countries and globally. This RD&D focus by governments is getting an additional push from private sector and business leadership under the Breakthrough Energy Coalition. To date, this group involves 28 entrepreneurs, investors, and businesses from 10 countries, with collective holdings of US$350bn to drive innovation – from the laboratory to the marketplace.

FIGURE 9: TOWARDS A LOW-CARBON ENERGY SYSTEM

AREAS OF CHANGE		ENERGY SUPPLY	ENERGY DEMAND
Hard infrastructure	Generation	Renewable energy supported by conventional generation	
		Co-generation systems	
		Efficiency upgrades for existing conventional plants	
	Storage	Efficient storage technologies	
	Transmission	Real-time system intelligence	
		High voltage direct current systems	
	Distribution	Smart grids	
	Consumption		Smart metering
			Smart appliances
			Demand response technology
Soft infrastructure	Governance/ stakeholder engagement	Governance structure of energy bodies minimizes impact of political cycles	Public support for green energy transformation
		Clear jurisdiction and accountability among state and federal government	
	Policy	Renewable energy financing	Energy saving schemes
	Markets	Utility sector reform	Dynamic customer pricing
		Local energy markets	
	Capabilities	Interregional and international transmission planning	
		Advanced instrumentation, planning, and forecasting of distribution	

Source: World Energy Council/ Oliver Wyman, 2016

The ‘right’ sequence of developments to enable this energy system of the future is subject to further learning, and countries are taking various steps and actions to move forward (see Figure 9: Towards a low-carbon energy system). For example, New York and California are currently the leaders in the US in developing a comprehensive strategy for distributed energy resource (DER) deployment and stimulating a change to the regulated investor-owned utility model. Though the states’ goals are similar – mitigate the industry’s climate impact, enhance DER integration in the electricity grid, and improve system security and customer confidence – their approaches diverge. California is using energy policy mandates, while New York's Reforming the Energy Vision (REV) process aims to enable market structures to encourage customer and DER deployment.[30]

In contrast to New York's broad, ambitious plan, California has pursued grid integration through several piecemeal laws. The current effort is largely in response to Assembly Bill 327, which mandated that the state's investor-owned utilities develop distribution resource plans to improve DER integration in the grid. The requirement does not explicitly direct utilities to explore how they will need to change their business models in response to DERs. However, New York's REV initiative creates a distributed resource market where a distributed system provider, would function as a system operator. The success of the states' approaches rest on the transformation of the traditional utilities, and the quality and amount of customer and system data available to the industry.[31]

Both states know that regulators and utilities need future-looking planning to achieve a distributed and optimised grid. However, the role of the utilities in the transformation is being shaped differently according to the policy instruments used. In California, the DER deployment process is largely utility-driven, privately financed and technology focused. Assembly Bill 327 requires utilities to build distributed resource plans, based on scenario modelling, and define the criteria for the optimal location for DER deployment. In contrast, New York's Staff Straw Proposal suggests that utilities articulate how they will transition to being a distributed system provider, and how they will respond to DER contributions that could be competitive to traditional infrastructure investments.[32]

In DER deployment, customer and system information will be critical to help customers manage their usage, and for DER providers to target service gaps. California is more advanced, having rolled out advanced metering infrastructure, as well as data sharing tools such as Green Button. New York has innovative initiatives that may soon catch up with California, including a bilateral information exchange system between DER providers and distributed system providers, and a distributed system platform (similar to the smartphone platform market) that connects customers, third-party service providers, and energy service aggregators.

---

[30] Crosby M and Cross-Call D, "New York and California are building the grid of the future", Rocky Mountain Institute (RMI) (18 February, 2015)
[31] Ibid.
[32] Ibid.

In both states, customer engagement is central to the adoption of DERs and the utilities' changing role in the market.[33]

As the rest of the country considers how to leverage DER, California's and New York's grids offer a model for emulation. In April 2015, the president of California's Public Utilities Commission announced that the state's power grid was comfortable managing solar and wind energy, reaching 40% of its daily generation on a number of occasions, and that the state was on track to handle 100% renewable generation.[34] Currently, 17% of New York's electricity comes from renewable sources[35], and the state has strengthened its commitment to DERs with a new plan to reach 50% renewables by 2030.[36]

Other changes that need to occur in the electricity system include: a shift from the one-way network of the past to one that is equipped for two-way load flow; and increased use of information in the power network in the transition to a smart system. A smart system will allow two-way transfer of information between power provider and customer, and even power transfer to the grid from users capable of providing electrical generation. Advanced metering infrastructure will allow greater efficiency and accuracy in billing, while eliminating error and significant labour costs of manual meter reading. The communications infrastructure can also enable new advanced functionality, such as smart home appliances, electric vehicle recharging, data acquisition systems, and so on. Smart system deployment will have a direct impact on GHG emissions through more efficient operation of the grid and optimal integration of DER.[37]

Smart meters are one component that will support a higher efficiency and interconnected electricity system. The meters send information on energy usage directly back to the energy supplier, enabling real-time dynamic adjustments in electricity generation. Pricing can be more flexible, including time-of-use (TOU) pricing. The information provided to consumers is supposed to support energy-efficiency choices and modifications in household energy use and behaviour. This in turn, will support demand management and improved energy security.

---

[33] Ibid.
[34] Martin C and Crawford J, "California power grid seen able to handle 100% renewables", Bloomberg, (15 April, 2015)
[35] New York State Department of Environmental Conservation, How New York uses renewable energy, www.dec.ny.gov/energy/83070.html
[36] Fairbrother C and Cross-Call D, "New York proposes plan to reach 50% renewables", Clean Technica (4 February, 2016)
[37] World Energy Council (2013), World Energy Perspective: Energy efficiency technologies

The EU has called on all members to provide smart meters by 2020, as long as there is a positive economic case to do so. The UK is about to start a roll-out of 53 million smart meters into residences and small businesses by the end of 2020, at an estimated cost of £11bn. There are already 2 million smart meters installed in the UK.

Smart meter roll-outs have been challenging and there are criticisms about whether, in the short-term, they do result in cost and energy savings for consumers. In Australia, the net cost was AUS$320mn (£170mn) paid by consumers through higher energy bills.[38] In Ontario, Canada, the roll-out of smart meters was subject to much criticism (see case study on page 46 – Canada: Ontario smart meter roll-out). In the UK, there are concerns that the first wave of smart meters will not be able to communicate with a planned new national communications network designed to allow the transmission of data between smart meters and all energy suppliers. There are further questions about whether all locations will have the necessary wireless signal, and whether the price of the smart meters can be recouped by consumers through modified energy use.

While the roll-out of smart meters has largely proven to be challenging, there have been some successes. Italy, for example, was the first country in Europe to roll-out smart meters on a large scale. From 2001–2006, €2bn was invested to replace traditional electromechanical meters with new modern electronic devices. During the project, 32 million customers were equipped with new meters, managed by an automated meter management solution. Following the introduction of smart meters, the average number of minutes of service interruption per customer per year dropped from 128 minutes to 41 minutes, and the related costs for distribution system operators (DSOs) decreased from €80 per customer to (currently) €52 euros per customer per year. The remote management system allows operators to reduce operational costs, and consumers are now able to manage their energy consumption. The Italian tariff scheme has allowed the investment in new smart meters and the replacement of old ones while keeping cost reduction benefits for customers.

A key lesson that emerged from the Italian success story is that a large-scale roll-out of smart meter technology can be done. This contrasts to the approach taken in the UK. While this results in high upfront investment costs for utilities, it also provides quicker access to consumer data and enables utilities to gain faster control of their energy network. This helps to achieve a faster return on

---

[38] Curwen L, “Will smart meters be worth the money”, BBC Radio 4 Moneybox (26 March, 2016)

investment.[39] Another lesson that emerged from Italy's experience is that the active involvement of consumers is a necessary step towards successful adaptation of a new technology. This allows for the opportunity to address customers' concerns on data collection and monitoring households' energy habits, and for suppliers to educate customers on the potential to reduce their energy bills through TOU pricing.[40]

Another effective roll-out of smart meters was achieved in Spain (13 million meters) and Latin America. Utilities in Romania, Russia, the Philippines, Hong Kong and China are also examining the technology.

The smart meter experiences in Australia and Canada stress that consumer engagement is vital to realising the benefits of smart meter deployment. As one executive noted, "Explaining the value equation to the general public is a challenge; you need to do it earlier and explore options and alternatives and make sure people have a good grasp of the issues."

In Ontario, the government activated TOU pricing for all consumers after the smart meter roll-out was complete. During implementation, the benefits were widely promoted in government and distributors' public relations campaigns. In contrast, Australia operates an opt-in system for TOU pricing, which has had lower than expected subscribers, with three-quarters of consumers being unaware of the benefits of TOU in 2014. Another key difference is the cost passed on to consumers to cover the installation of the meters. In Australia, initial resistance to the programme was fuelled by the cost structure, where the consumer would pay for the meter and its installation as a line item on their bill. The costs ranged from AUS$109–$226 (per meter per annum). In Ontario, the distributors carried the cost of the meter and deployment. From the consumer's perspective, both countries have fallen short of their original targets to change usage patterns, generate cost savings for consumers, and conserve additional energy.

Interviews with energy executives around the world highlighted the growing importance of public engagement and participation in developing energy policy and gathering support for future initiatives. As one energy executive noted, "The public's overall energy literacy has greatly increased around the world." Public support for the shift in the energy system is increasingly critical, especially in an

---

[39] Scott M, "How Italy beat the world to a smarter grid", Bloomberg, (17 November, 2009)
[40] The Business Council for Sustainable Energy/US Agency for International Development (2004), Increasing Energy Access in Developing Countries: The role of distributed generation

CANADA

IMPROVING ENERGY EFFICIENCY AND MANAGING DEMAND

POLICY AND GOAL

In 2004, the Ontario Ministry of Energy mandated the use of smart meters as a mechanism to support a shift to time-of-use (TOU) rates for electricity pricing. TOU rates were aimed at stimulating energy conservation and managing the province's energy supply more efficiently. The target was to install 800,000 smart meters in homes and small businesses by the end of 2007 and all remaining customers by the end of 2010, with TOU rates implemented in 2012.

IMPLEMENTATION

The rollout was implemented by local distribution companies (LDCs) in two stages:[1] First, residential customers represented by urban distribution companies received meters, followed by industrial and commercial customers with peak loads of 50 kW to 200 kW, and new installations. In phase 2, remaining distributors deployed meters to commercial and residential customers.[1] While the roll out progressed rapidly, the programme cost twice the government's estimate, drawing criticism over the purported benefits.[2]

ACHIEVEMENT

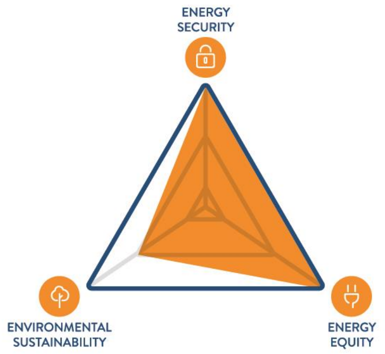
A sample of 140,000 customers from six LDCs offers some preliminary findings from the first two years of full implementation (2012–2014). For residential customers, TOU pricing has had a small, but clear impact in shifting peak consumption to off-peak and mid-peak periods. TOU pricing has not had a clear effect however on the General Service Class (non-residential customers and primarily small businesses). There was no benefit in terms of conservation from residential customers, and negligible effects from the General Service Class.[3] While Canada sustains high scores in the Energy Trilemma Index, the Ontario programme has not boosted their relatively lower sustainability scores.

CHALLENGES

Given the speed of technology change and the scale of the roll out, the technical, interoperability, and privacy standards of the smart meters have come into question. In March 2016, the province's largest utility announced it would pull 36,000 meters due to data transmission limitations in rural geographies.[4] Where smart meters are functional, the price difference between peak and off-peak periods has not been substantial enough to incentivise customers to change behaviour patterns significantly.[5] In 2014, Canada's Auditor General published a highly negative report on the programme, citing cost digressions, lack of governance and oversight, and few consumer or environmental benefits as key failures.[6]

1. Ontario Energy Board, 2005: January 26th Press Release, Smart Meter Implementation Plan: Report of the Board to the Minister.
2. Metering and Smart Energy International, 2014: December 11th, Smart meters: Canada's auditor says "few benefits" from US$1.7 BN rollout.
3. The Brattle Group, Ahmad Faruqui, Neil Lessem, and Sanem Sergic, 2014: Year Two Analysis of Ontario's Full Scale Roll-out of TOU Rates, Prepared for the Ontario Power Authority.
4. National Post, Kelley Egan, 2016: January 13th, "Astonishing": Hydro One pulling plug on 36,000 rural smart meters after years of complaints.
5. The Brattle Group, Ahmad Faruqui, Neil Lessem, and Sanem Sergic, 2014.
6. Metering and Smart Energy International, 2014.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
8	10	6	6	7

LESSONS LEARNED

1. Mistakes in implementation erode political will for energy system changes, and skew perceptions of the legitimate benefits smart meters could provide.
2. Better evaluation of the economic and technological viability of the smart meter programme could have been enabled by a controlled, representative pilot.
3. Local constituencies need to be engaged in terms of the economic costs and benefits.
4. Cost-benefit analyses should be thorough and conducted before project approval to maintain the integrity of analysis.
5. Proactively engaging customers in data privacy issues mitigates social/political impediments to deploying smart meters.

age of increasing social media and rising global public awareness and energy focus (see Box 9). As one executive noted, "At first, wind and solar were well received, but with time they met resistance, particularly from communities that did not directly benefit from those projects directly… I think we underestimated some of the community involvement, and everyone involved in infrastructure has had the same experience, as, thanks to social media, it is easier to get people organised."

Particular attention to the impact of certain projects on local communities has been a crucial factor in determining their feasibility (see case studies from Latin America, Canada and Italy). General support from the wider public can also determine the success or failure of certain strategies. For example, widespread concerns of the public around nuclear electricity generation have pushed some countries to eliminate the technology from their generation mix. Also, Germany's Energiewende rests on a high level of support from 70–80% of the surveyed population. As one policymaker noted, " … a cumbersome but inclusive and transparent process ensures limited surprises once the policy comes online."

Similarly, Switzerland launched a public consultation process on the country's energy strategy to 2050. The need to revise the country's energy strategy was driven by changes in the energy landscape in Europe and the government's decision to withdraw gradually from nuclear power.[41] Given the country's strong tradition of direct democracy, public buy-in is essential if new policies are implemented that affect the pre-existing rules and regulations on a national and local level. Based on the substantial changes the energy strategy proposes, a public consultation is an essential part of the process of getting the new energy strategy approved in the national referendum in autumn 2016 (referendum on nuclear exit) and spring 2017 (referendum on electricity efficiency).[42]

Public support is also important in determining the impact of a policy on other trilemma dimensions. The willingness of consumers to pay for environmental policies will determine policymakers' options for the deployment of low-carbon technologies. For example, an Oliver Wyman survey found that, despite popular acceptance of Energiewende, 80% of German households consider the resulting rise in on-grid electricity prices to be a severe burden. Although a majority is generally willing to invest in renewables (wind, PVs and geothermal are popular), as many as two-thirds report that they will only do so if they receive some kind of subsidy. Even then, 40% are not prepared to invest more than US$1,100 in green

[41] Swiss Federal Office of Energy (SFOE), (n.d.), Energy Strategy 2050
[42] Ibid.

technologies. Nearly two-thirds of surveyed households expect their investments to pay off within three to five years.[43]

BOX 9: CHILE'S PROCESS TO DEVELOP COP 21 INTENDED NATIONALLY DETERMINED CONTRIBUTIONS (INDCS)

Chile adopted an innovative public consultation approach to develop its COP 21 INDCs. Overall the process took 18 months. Much of the discussion on the technical analysis occurred prior to the public consultation, through a process involving numerous stakeholders called Mitigation Action Plans and Scenarios (MAPS). The MAPS programme is a collaboration among developing countries to establish an evidence base for transitioning to carbon-efficient economies.[44]

There was also a wide public consultation with the support of Chilean President Michelle Bachelet, lending additional authority to the process, and highlighting the importance of providing and incorporating feedback into the submission.[45] Civil society, the private sector and academia were invited to comment on specific emission-reduction ideas in a consultation period lasting from December 2014 to April 2015.[46] In addition to creating an online forum, The Office of Climate Change and the Environment Education Division of the Ministry of Environment carried out informational workshops in a number of cities across the country, and presented to the National Advisory Council and to members of parliament.

Officials noted that, before embarking on this ground-breaking process, they undertook benchmarking and due diligence by examining what works in public consultation processes in other countries, particularly in Europe. There were also some questions as to whether a public consultation process would be effective. As one official noted, "When we started the process, we had some doubts – for example, would we be able to identify common goals? But we learned we could do it." The process helped to identify that main lines of consensus were available, such as the need to ensure affordability while reaching the targeted goal of 70% of renewable energy

---

[43] Fritz, T, Manteuffel, D and Staeglich, J (2016), "Power Generation Disruption Germany's case for change", Oliver Wyman Energy Journal
[44] Global Economy and Development at Brookings (2015), Global Views: Policy Paper 2015–03, The Brookings Institute
[45] Ibid.
[46] Levin, K et al, (2015), Designing and Preparing Intended Nationally Determined Contributions (INDCs), World Resources Institute/UNDP

supply by 2050. The process also highlighted the importance of focusing on better management of relationships with local communities around the energy project.

Overall, it is hoped that this wide and broad engagement will help drive support and policy consistency for the country's energy 2050 goals over political cycles.

FINDINGS AND RECOMMENDATIONS

Diversifying primary energy supply and transforming the electricity generation sector to accommodate new technologies and lower GHG emissions goals is challenging. There is no single 'correct' road map to accomplish these goals and each country must chart a course and determine energy policies aligned to its overall economic and social goals.

The review and analysis of selected countries' policies and approaches reveals the following lessons:

- **Diversification of energy supply is increasingly critical to energy security:** High volumes and availability of indigenous energy supplies, fossil fuels or hydropower, are not sufficient to ensure energy security. Diversification is key to address some of the emerging risks linked to climate change, such as higher occurrence of extreme weather events and increasing volatility of weather patterns affecting water and food supply.

- **Consider the interaction of regulatory regimes in policy design and implementation:** Complex regulations and overlapping requirements and jurisdictions between state, national and international agreements can deter investment and delay policy implementation.

- **Carefully consider the sequencing of actions to support an infrastructure transition:** Energy reform can be piecemeal and gradual (as in grid development in California, or build momentum through a broad, ambitious plan (such as the UAE, or Germany's Energiewende). The approach depends on the political conditions and the need to deliver strong investor signals on the market's transition to green energy. During the period of energy transition and disruption, it may be necessary to move forward in stages, and there must be careful consideration of the sequencing of infrastructure extensions. However, to minimise confusion and mixed signals to potential investors, policymakers should set clear energy targets and goals, while acknowledging and building consensus for the transition.

- **Pilot approaches, including cost-benefit analysis can be an effective approach to identify implementation challenges and lessons learned before a larger-scale roll-out:** Mistakes in implementation erode political will for energy system changes and skew perceptions of the legitimate benefits that new energy technologies and infrastructure could provide.

- **Engage and stimulate new entrants to the energy and energy technology sectors:** Private sector participation is crucial to driving innovation, including decreasing costs of technologies to support a transition in the energy supply and generation.

- **Early engagement of affected communities is increasingly critical:** Community backlash can erode support for energy infrastructure projects, cause delay, and raise the risk profile for future investments. The government, private sector and civil society must be engaged throughout the project – from scoping through to implementation – to address local community concerns and design incentives for local community participation. Regulators and utilities should know that promoting smart grid-enabled programmes may increase overall net system benefits, but create variable experiences for individuals, based on the incentives to participate. To maintain credibility, consumer messaging must be carefully managed in technology roll-outs.

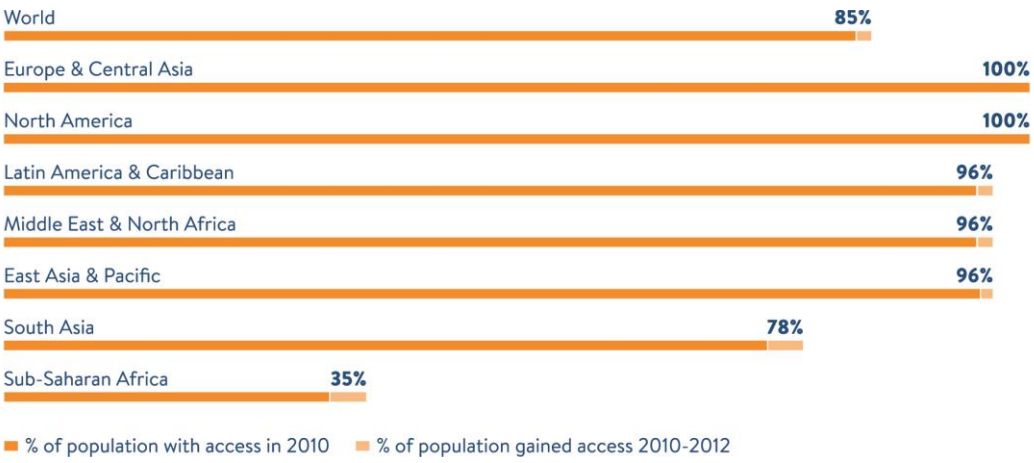
- **Utilities do not have to be the losers in the energy transition.** Policymakers can help them plan ahead and develop strategies to evolve with the market (as we saw with the New York and California grids policies). This will ensure that the transition towards a decarbonised system takes place in a sustainable way and all components, including conventional and renewable generation, grids and distributed facilities can be developed cost effectively.

2 Advancing energy access

To advance energy access many countries need to increase and expand their energy infrastructure and enable connectivity to modern energy.

As estimated 1.1 billion people do not have access to electricity and, while millions have been provided with modern energy over the past decade, access in many regions is still significantly lagging (see Figure 10: Percentage of population with energy access, 2010 and 2012).

FIGURE 10: PERCENTAGE OF POPULATION WITH ENERGY ACCESS, 2010 AND 2012



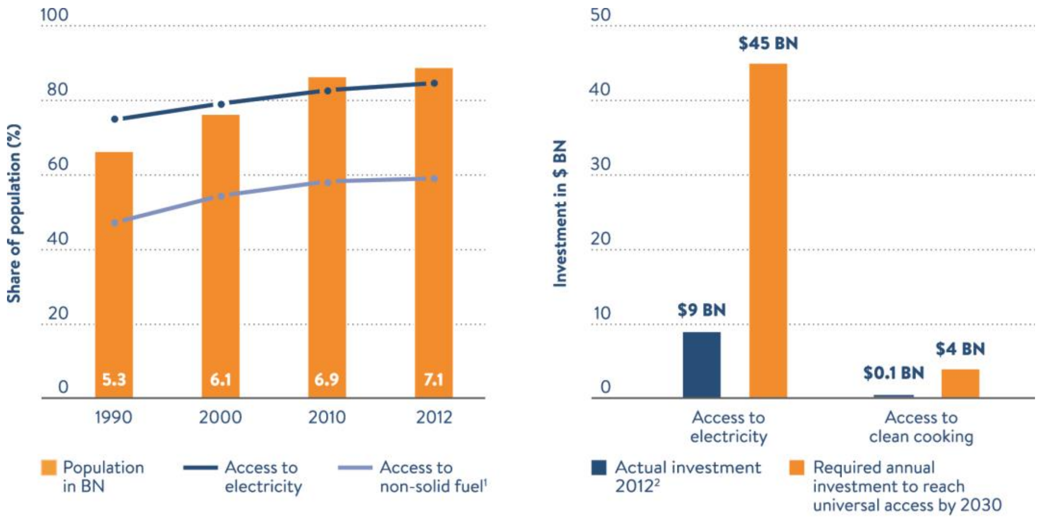
Source: IEA and the World Bank (2015), Sustainable Energy for All 2015 – Progress toward sustainable energy

Increasing access to electricity has multiple economic and social benefits. Access to clean cooking, enabled by modern energy supplies, can reduce the use of forest/firewood and costly diesel, reducing health problems from indoor pollution and safety hazards from explosions.[47] For example, the World Health Organization estimates that indoor air pollution was linked to 4.3 million deaths in 2012 in households cooking over coal, wood and biomass stoves.[48]

[47] World Health Organization (2016), Household air pollution and health, Fact sheet No 292
[48] Ibid. This estimate is based on information about pollution exposure among the estimated 2.9 billion people living in homes using wood, coal or dung as their primary cooking fuel, as well as evidence about air pollution's role in the development of cardiovascular and respiratory diseases and cancers.

As the world economy and population grows, global energy demand is predicted to increase, and even double, by 2050. To keep pace with this demand, cumulative investment requirements in electricity generation alone will be between US$19.3trn and US$25.7trn between now and 2050.[49] Looking at the broader energy infrastructure, an estimated cumulative investment of US$40.2trn is required across the energy infrastructure supply chain over the period 2014–2035, with an additional US$8trn investment needed in energy efficiency. This is equal to an annual investment of US$1.7trn (rising to US$2.5trn by 2035).[50] (See Figure 11: Trends in access to electricity and non-solid fuel and annual global investment in universal access to modern energy services).

FIGURE 11: TRENDS IN ACCESS TO ELECTRICITY AND NON-SOLID FUEL (LEFT) AND ANNUAL GLOBAL INVESTMENT IN UNIVERSAL ACCESS TO MODERN ENERGY SERVICES (RIGHT)



1. Non-solid fuels include liquid fuels (e.g. kerosene, ethanol, and other biofuels), gaseous fuels (e.g. natural gas, liquefied petroleum gas, biogas), and electricity.
2. The total assumes 2010 investment in access figures for 2012.

Source: IEA and the World Bank (2015), Sustainable Energy for All 2015 – Progress toward sustainable energy

---

[49] World Energy Council (2013), World Energy Scenarios: Composing energy futures to 2050; The lower number refers to the Council's 'Symphony' scenario, which focuses on achieving environmental sustainability through internationally coordinated policies and practices, while the higher number reflects the World Energy Council's 'Jazz' scenario, which focuses on energy equity, with priority given to achieving individual access and affordability of energy through economic growth.
[50] IEA (2014), World Energy Investment Outlook; The 2°C scenario would require double the investments in low-carbon technologies and energy efficiency.

The 2014 World Energy Trilemma report explored the issues around financing energy systems and identified key challenges. Despite the size of investment necessary for global energy investments, financial leaders noted: “We have vast amounts of money – it’s a question of the risk-adjusted cost of capital.” They also pointed to the impacts of political or regulatory risk in deterring investments or raising the cost of capital in many countries that desperately need to expand energy access.

The research also pointed to two other practical challenges: a deficiency of ‘bankable projects’ and a lack of human resources to build, operate and maintain energy infrastructure in many countries. Many factors can limit the availability of bankable projects. In some instances, there are constraints on investments due to restrictions on foreign direct investments. Focusing on the development of necessary technical, financial and management skill sets is crucial to support energy projects around the world. Preparing a project and arranging for funding can account for between 5–10% of a project’s costs and adds several years to the project’s development. It is critical to increase the number and speed of projects.

Expanding energy infrastructure

If low-carbon sources are used, increased generation capacity improves energy security, supporting energy independence, without hampering environmental sustainability.

The regulatory and policy frameworks for energy investments are critical to expand generation capacity. For many countries, efforts to increase overall energy infrastructure have resulted in the opening of their markets. Competition, privatisation, unbundling of energy production and distribution, and the creation of independent regulatory bodies have been key pillars of liberalisation policies worldwide, occurring at different times, speeds and levels. Mexico has been one of the latest countries to open up its oil and gas (O&G) sector to private investments, following reforms to its Constitution in 2013 (see Box 10).

BOX 10: MEXICO CONSTITUTIONAL REFORMS TO INCREASE ENERGY SECTOR ELECTRICITY CAPACITY

Mexico has maintained a steady position in the upper third of countries in the Index over the years. The energy reform programme is a positive step to strengthen its position, though it will likely take years before the full impacts are felt. The Development Program of the National Electricity System – Programa de Desarrollo del Sistema Eléctrico Nacional (PRODESEN) calls for an increase in installed electricity capacity from the 2015 level of 65,452

to 125,436 MWe by 2029. This additional power capacity will come from a mix of fossil fuel (46%) and clean energy (54%). In parallel, transmission capacity in terms of 69, 161, 230 and 400 kV lines will increase from 111,475 to 135,074 kV. There is a significant amount of uncertainty around the future of renewable energy investments and deployment, stemming from the recent and sweeping nature of reforms in the energy sector:

- **The projected 2029 capacity in PRODESEN is based on available data and includes projects completed, but not operational, those under construction, approved and under consideration. In reality, long-term projects may be cancelled or have setbacks, making it difficult to assess scenarios of energy demand and the required investment.**

- **By 2018, the only renewable energy incentive will be a new programme of Clean Energy Certificates. It is unclear how the market will react, and whether the programme will be successfully implemented.**

- **The new laws also make it easier for foreign and domestic companies to participate in the country's oil and, gas industry. The state-owned oil company will not be privatized; however, greater participation and competition in exploration and production will be enabled through regulated contract and tendering processes.**

- **Electricity reforms are happening in the context of broader transformational reforms in the Mexican energy market: Structural reform from state monopolies to a competitive market, and GHG emissions reform from a high to a low-carbon sector. As such, the overlapping nature of reforms will increase the complexity of the processes involved, and introduce uncertainties that will increase the financing cost of new investment.**

Technology developments are offering increased opportunities to rapidly expand energy infrastructure. Distributed generation (DG) can offer more reliable power to consumers and lower transmission and distribution losses, resulting in more reasonable costs for consumers and producers. DG includes fossil fuel and renewable energy technologies. Uptake of DG from renewables in developing countries has traditionally been inhibited by higher upfront costs compared to fossil fuel technologies, unfavourable tariff structures compared to subsidised fuels, and their intermittent nature, requiring the use of batteries or back-up power.[51]

[51] The Business Council for Sustainable Energy/US Agency for International Development (2004), Op. cit

NAMIBIA

ADVANCING ENERGY ACCESS

POLICY AND GOAL

The Off Grid Energisation Master Plan (OGEMP) was launched in 2007 to provide energy access from renewable energy and energy efficient appliances to those without energy access from the grid. Most rural households rely heavily on biomass for their basic energy needs, with the rate of rural electrification around 25% as of 2012.

IMPLEMENTATION

The policy introduces the concept of "energy shops" in urban and rural areas with high population density and low access to electricity. The energy shops offer information and sell equipment around energy solutions, such as solar water pumps, and efficient wood stoves. The shops also serve as payment collection centres for a national off-grid financing mechanism created by OGEMP, the Solar Revolving Fund, which offers credit financing for renewable energy technologies and products.[1]

In 2010, The Desert Foundation of Namibia carried out a pilot of the energy shop concept. Ten entrepreneurs in six regions across Namibia with different local conditions were selected. After providing technical and business training, the entrepreneurs were given solar business systems which could provide electricity for mobile phone charging, electric lantern charging, hair cutting, and lighting, along with solar and wood-saving stoves. Based on monitoring the operation and social implications of the pilot energy shops for eighteen months, the Foundation made recommendations for a country-wide rollout.[2]

ACHIEVEMENT

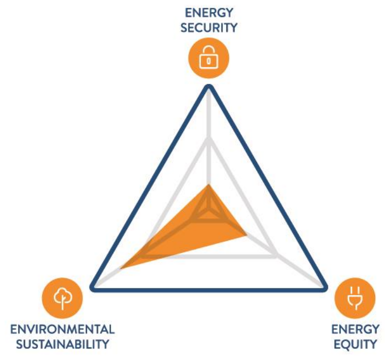
The first energy shop was launched in 2011, and the network has been gradually expanded yearly. By 2012, thirteen energy shops were opened, out of a planned 180 shops in the 20 year plan.[3]

CHALLENGES

Energy shop owners have faced difficulty in accessing affordable and quality stock, and face technical and financial support issues with local renewable energy suppliers.[4] The financial performance of shops in the pilot was influenced by the proximity to the grid, and the business savvy of the shop owners in marketing and merchandising the store.[5]

1. World Bank, Sustainable Energy for All, 2012: Namibia Rapid Assessment and Gap Analysis.
2. Desert Research Foundation of Namibia, 2010: Wisions of Sustainability, Report: Energy Shops – using solar AR PV energy to provide business opportunities.
3. Ministry for Foreign Affairs of Finland, Miika Rämä, Esa Pursiheimo, Tomi Lindroos, Kati Koponen, 2013, Research Report: Development of Namibian energy sector.
4. Polytechnic of Namibia, Helvi Ileka, 2012: Establishment of energy shops under the Off-grid Energisation Master Plan.
5. Desert Research Foundation of Namibia, 2010.
6. Polytechnic of Namibia, 2012.
7. Desert Research Foundation of Namibia, 2010.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
91	92	90	88	78

LESSONS LEARNED

1. Areas which cannot have access to the grid in the near term can achieve at least partial electricity access with new approaches employing renewable technology.
2. An energy shop concept can bring access to modern technology to off-grid communities, with the joint effort of policy makers, renewable energy suppliers, international support, and local entrepreneurs.[6]
3. Entrepreneurs who sell modern energy services in off-grid areas must be equipped with business training to advertise and educate the community on the services and the benefits available to them.[7]
4. A thorough pilot testing the viability of an off-grid electrification model is critical to assessing the financial feasibility and social impact of a potential national program.

However, the latest global developments (including elimination or reduction of subsidies thanks to the low oil price and a drop in the cost of solar panels) should support the improvement in the cost of DG with renewable energy technologies even without taking into account the clear environmental benefits not currently featuring in the cost equation. Increasingly, countries do not have to pay a premium to provide environmentally sustainable energy and the trade-off between meeting energy demand and the environment is dropping.

In 2015 there was an increase of nearly 30% in renewable power capacity since 2014. In 2015 the highest figures to date were reached for installation of renewable power capacity, with 64 GW of wind and 57 GW of solar PV commissioned during the year. Renewable energy investment surged in China, Africa, the US, Latin America and India in 2015, driving the world total to its highest ever figure of US$328.9bn – up 4% from $315.9bn (revised) in 2014, beating the previous record, set in 2011, by 3%.[52]

Enabling connectivity

With 1.1 billion people worldwide without access to electricity, grid extensions, particularly to remote and poor regions, do not always represent a feasible solution. Rural households currently depend on kerosene and other products that substitute for electricity, spending about US$18 billion each year. Off-grid renewable energy systems are often more effective and cheaper solutions for providing access to rural areas without the financial burdens of grid development and maintenance. They also have a low impact on the environment as growing energy demands are met.[53] (See also the case study on page 61 – India: Advancing energy access.)

In addition, policymakers need to consider a range of mechanisms to enable people to access, afford and utilise the benefits of modern energy. Affordable electricity rates do not benefit the poorest consumers if they cannot purchase a modern stove or lighting to use the electricity. The rapid expansion of cell phone technology, coupled with innovative pay as you go models and global efforts to design affordable and energy-efficient appliances, is creating new opportunities to allow low-income consumers to access and use modern energy (see also Box 11).

---

[52] Bloomberg New Energy Finance (2016), "Clean energy defies fossil fuel price crash to attract record $329bn global investment in 2015" (14 January, 2016)
[53] International Renewable Energy Agency (IRENA) (2015), Off-grid Renewable Energy Systems: Status and methodological issues

For example, global cell phone penetration rates are high, even in poor countries, with an average of 91.8 subscriptions per 100 inhabitants and, Africa has 73.5 cell subscriptions per 100 people.[54]

BOX 11: NEW BUSINESS MODELS IN AFRICA – PAY AS YOU GO ELECTRICITY BILLS[55]

Off-grid solutions represent the most feasible solution to electrifying rural areas, and pay as you go models provide several advantages to customers with low or variable incomes. Globally, it is estimated that an additional 3 million pay as you go solar home systems will be sold by 2018-19.[56] Instead of regular, fixed payments, customers pay small amounts in advance for the service they use. These solutions often entail a package of appliances and the associated power supply. This enables consumers to purchase the appliances and technology necessary for modern energy access that would otherwise be cost-prohibitive. As one energy executive noted, "Often the problem is affordability and not only access. People need the physical access to electricity and be able to pay for it."

Several countries in Africa provide a number of success stories in this area. M-KOPA Solar, which operates in Kenya, Uganda and Tanzania, and Off Grid Electric, in Tanzania and Rwanda, offer packages of appliances, such as LED lights, a mobile phone charger and a radio, all powered by a solar panel and a battery. Payments are processed via mobile phones, allowing customers to pay in small instalments, making it more financially attractive than purchasing kerosene to fuel older appliances. Customers can also upgrade by purchasing a diverse range of other appliances.

As well as favouring access to electricity from small-scale renewables, such schemes aim to tackle another fundamental challenge in developing countries – energy is not treated as a private good, but as a right. By providing the kit of appliances, consumers are more inclined to believe that they are paying for the goods themselves, rather than the electricity needed to operate them. However, should customers fail to pay, the service is disconnected remotely.

---

[54] International Telecommunication Union (ITU) (2015) ICT Facts and Figures: The world in 2015
[55] "Power to the powerless", The Economist (25 February, 2016)
[56] Consultative Group to Assist the Poor (CGAP) (2014): Access to Energy via Digital Finance: Models for innovation

The business models of the companies supplying solar home systems can be identified in two main models:

- **the lease-to-own model: Households eventually own the system as soon as the price is paid**
- **a micro-utility model: The company provides electricity but owns the equipment that produces it.**

In both cases, pay as you go schemes are based on actual consumption, although several conditions could apply through terms of payments or the length of supply contracts, especially for the lease-to-own model. When ownership is transferred to customers, the costs of the service should reflect the cost of the system as a whole.

A similar system can be found in India. The supplier Simpa Networks offers customers two-year contracts with a commitment to buy at least 25 days of service every month. Payments, however, can be distributed over time, matching each household's needs.

Such innovative business models need an enabling environment to promote their expansion. This will require governments to support traditional grid extensions and also focus on policies to promote entrepreneurship and alternative grid technologies. It can be challenging for policymakers to identify the right measures to enable off-grid models. Many mechanisms that work for traditional grid developments may not achieve the desired effects for off-grid models.[57] However, some principles that work for traditional grid solutions also apply to off-grid solutions, such as reducing investment risks and promoting the availability of capital (see Box 12).

---

[57] Doukas, A and Ballesteros, A (2015), Clean energy access in developing countries: Perspectives on policy and regulation, World Resources Institute (WRI)

BOX 12: SELECTED FACTORS TO ENABLE OFF-GRID SOLUTIONS[58]

Reducing investment risk

- Create transparency on the power system development and electrification plans to avoid investment in areas that are subject to traditional electrification plans.
- Develop a clear legal and regulatory framework for mini-grids. While permits or licences and tariff provisions, which apply to traditional utilities, are not applicable to off-grid solutions, they can apply to mini-grid solutions as they act in the same way as utilities and can prove to be an inhibiting factor.
- Develop a clear energy strategy to provide clarity to investors. For example, subsidies in one area, such as fossil fuels, can undermine the competitiveness of off-grid solutions.

Availability of capital

- Facilitate the availability of capital by addressing lending guidelines. Central bank and reserve bank lending guidelines on providing finance for specific activities or sectors can play a positive role.
- Facilitate the availability of capital by addressing foreign investment barriers.
- Create transparency for mobile money tariffs and regulations, as this could influence the competitiveness of off-grid solutions relying on mobile payments.

[58] Adapted from Doukas, A and Ballesteros, A (2015), WRI, Ibid.

INDIA

ADVANCING ENERGY ACCESS

POLICY AND GOAL

Targeting 100% rural village electrification and eventually electricity to all households over five years, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme incentivises states to develop access projects by financing them through a 90% government grant and a 10% loan provided by the Rural Electrification Corporation (REC).

IMPLEMENTATION

Once state access projects are approved, the project cost is delivered in four phases to ensure full execution. The primary approach to rural electrification was through grid extension and, where not feasible or not cost-effective, through Decentralised Distributed Generation (DDG) systems. The policy was complemented by the Remote Village Electrification (RVE) Programme (2005) targeted at electrifying remote villages with a population of fewer than 100 inhabitants and where DDG projects are not implemented by the RGGVY, using mainly renewable energy sources to provide basic lighting. The scheme was extended to 2012 and, during the 11th plan period, stronger political will to achieve the 100% target ensured the apolitical implementation and monitoring of the projects. The RRGVY has now been subsumed in the new rural electrification scheme launched in July 2015, the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), focusing on feeder separation (rural households and agriculture) and strengthening of sub-transmission and distribution infrastructure.[1]

ACHIEVEMENT

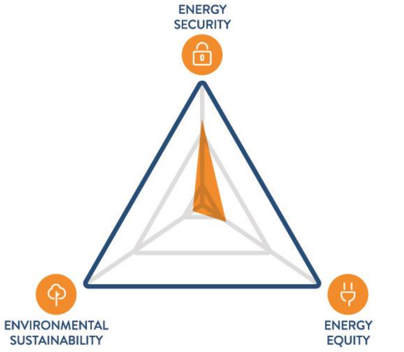
According to a sample survey of RGGVY beneficiaries, the scheme has largely succeeded in providing electricity to villages and hamlets in rural areas.[2] In the study sample, 93.3% of households and 53% of villages were electrified, and 89% of beneficiaries were paying electricity bills regularly.[3]

CHALLENGES

At first, implementation was slow due to India's rural distribution system, characterised by low-density with high technical and commercial losses leading to a high delivery cost. Some cases of government corruption and mismanagement of funds have further afflicted the system.

1. Government of India, Ministry of Power Press Information Bureau, 23 July 2015: Prime Minister to Launch Deendayal Upadhyaya Gram Jyoti Yojana in Patna.
2. Government of India, Planning Commission, Programme Evaluation Organization, 2014: Evaluation on Rajiv Gandhi Grameen Vidyutikaran Yojana.
3. It is important to note that given India's population growth, there is still much work to be done: In the 2011 census 74 million rural households were without access to modern lighting services, a marginal decline from 78 million in the 2001 census. See: P. C. Maithani and Deepak Gupta: Achieving Universal Energy Access in India: Challenges and the Way Forward, 2015.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
115	117	115	122	107

LESSONS LEARNED

1. A combination of grid extension, enhancement of village electrification infrastructure and DDG projects is an effective multi-pronged strategy to expand electrification.
2. Progressive project financing helps secure project completion by minimising theft and corruption risks.
3. A partnership where the federal government sets clear guidelines but state governments implement policies puts the onus of deployment on the party most familiar with local dynamics.
4. Strong political will is necessary to ensure apolitical implementation.

FINDINGS AND RECOMMENDATIONS

The world's population needs more energy infrastructure to provide modern energy services to the estimated 1.1 billion people who do not have access to electricity. However, merely expanding energy infrastructure is not enough to ensure energy access. Innovative mechanisms that allow low-income consumers to pay for electricity and appliances are needed.

- **Efforts to increase overall energy infrastructure have resulted in many countries opening their markets.** Competition, privatisation, unbundling of energy production and distribution, and the creation of independent regulatory bodies have been key pillars of liberalisation policies worldwide, occurring at different times speeds and levels. These need to be carefully designed to ensure sustainable development.

- **Energy access still lags behind targets and needs greater investment to meet growing population needs.** Financing and maintaining grid extensions has been a hurdle, but alternative technologies and financing approaches can provide cost-effective and environmentally-friendly solutions. Alternative technologies therefore prove to be capable of addressing a country's energy trilemma performance in a balanced manner.

- **Off-grid solar power, paid by the consumer through mobile pay-as-you go models, is an example of a successful alternative approaches.** Such solutions often include a package of appliances, in addition to the power supply, enabling customers to gain access to electricity systems and also make use of them. An estimated 3 million additional pay as you go solar home systems will be sold between 2014 and 2019. This shows that innovation, driven by the private sector, to develop alternative technologies and business models is a major driver to increasing overall energy access and affordability.

- **An enabling regulatory and policy framework is needed to ensure private sector innovation in alternative technologies and business models.** While enabling access to capital and reducing regulatory risk are important for innovative business models for alternative technologies, many policy mechanisms which have proven to be effective for traditional grid solutions may not necessarily work when applied to off-grid and mini-grid solutions.

3 Addressing affordability – prices and industry competitiveness

The affordability of energy for consumer affordability and to ensure industrial competitiveness is key concern. The top scoring countries in the energy equity dimension of the Energy Trilemma Index include countries where low fuel prices are enabled by indigenous energy resources, including hydro and fossil fuels, as well as countries where the low price is supported by consumption subsidies. For example, in the 2015 Index, the US, Canada and Saudi Arabia respectively ranked 1st, 2nd and 51st for energy equity, and yet ranked 95th, 71st and 120th for environmental sustainability. In fact, very low-cost energy services tend to have negative effects on the security and environmental dimensions, because incorrect consumer price signals can increase energy consumption.

Prices and consumer affordability

Subsidies can critically influence access to energy and the development of energy infrastructure. Consumption subsidies can have an impact on the price for the consumer, and deployment subsidies can help early stage technologies become competitive. Their goals, impact and challenges will be quite different. In 2014, fossil-fuel subsidies amounted to US$490bn, while renewable energy support (deployment) amounted to US$135bn.[59] In many developed countries, some of the ambitious renewable energy programmes are financed through consumers, and higher prices can erode their purchasing power. However, some policymakers argue that higher bill prices can be offset by lower consumption. As one energy executive suggested, “If you compare end-customer prices across countries, you have to consider purchasing power and household incomes. Also energy-efficiency improvements lead to lower consumption, meaning the burden on households is equal.”

Consumer subsidies can be vital to enabling energy access for lower-income consumers and also play a role in social and economic programmes (see case studies on page 69 – Brazil: Enabling consumer affordability and industrial competitiveness, and page 70 – Philippines: Enabling consumer affordability). However, consumer subsidies can be costly to deploy, especially if made available across the whole population. Countries have struggled to cut subsidy costs in the face of public opposition (see Box 13 detailing efforts by Malaysia, Indonesia and Saudi Arabia).

[59] IEA (2015), World Energy Outlook 2015, page 343. Subsidies to aid the deployment of renewable energy technologies in the power sector were US$112bn in 2014 (plus US$23bn for biofuels).

BOX 13: FUEL SUBSIDY REFORMS

In Malaysia, fuel subsidy reforms stalled in 2010 amid public resistance. By 2012, however, the cost of subsidies for petrol, diesel, and liquefied petroleum gas (LPG) reached US$7.4bn, requiring a change to the subsidy programme.[60] Reforms were passed in 2013, but due to protests from the public, political opposition, trade unions, and non-governmental organisations, these were made partial and reversible by successive governments. A key failure point was waiting to mitigate the impact of the reform after it was announced: the specifics to deliver cash transfers to the poor were articulated through the 2014 budget, eight weeks after the rate increase was proposed.[61] Despite only securing partial reform, the government estimated that they would save US$1bn over the next year. The government was able to remove subsidies entirely in 2014 as oil prices declined. Drawing on experience, the subsidy system was dismantled while social programmes were increased, in order to ease the burden on low-income households.[62]

Indonesia has subsidised fuel (gasoline, diesel, kerosene, and LPG) since the oil crisis of the1970s. The subsidies have been a highly political issue in the country[63], and in 2012 amounted to 21% of the central government's budget, and 2.6% of the country's GDP. The subsidy program was reformed in 2005 and 2008, in response to a sharp rise in the fiscal cost, given high oil prices at the time. When world oil prices rallied again, the government tried to raise fuel prices in 2012, but was unable to do so given strict conditions placed on fuel hikes as part of the Budget Law.[64] The political leverage to finally cut gasoline subsidies at the start of 2015 was facilitated by record low international oil prices (dropping below the subsidised rate) since June 2014. Diesel subsidies remain, though the country is considering removing them this year.[65] The finance minister has estimated that the government would save approximately US$15.5bn from ending fuel subsidies.[66]

---

[60] Palatino, M (2014) "Why Malaysia reduced its fuel subsidy", The Diplomat (9 October, 2014)
[61] Bridel, A and Lontoh, L (2014), Lessons Learned : Malaysia's 2013 fuel subsidy reform, Global Subsidies Initiative (GSI)/International Institute for Sustainable Development (iisd)
[62] International Growth Centre (n.d), Low Oil Prices : An opportunity for fuel subsidy reform
[63] Cochrane, J (2013) "Indonesia struggles to end fuel subsidies", The New York Times (2 May, 2013)
[64] Diop, N (2014), Why is Reducing Energy Subsidies a Prudent, Fair, and Transformative Policy for Indonesia?, World Bank
[65] Setiaji, H (2016), "UPDATE 1-Indonesia may seek to remove diesel subsidies in 2016 budget

Saudi Arabia has been one of the largest fossil fuel subsidisers in the world, with subsidies amounting to over US$62bn according to International Energy Agency estimates in 2014. Of that, 75% is for oil.[67] In December 2015, Saudi Arabia announced the first round of its energy reforms, which includes raising the price of gasoline. The reforms are significant, given that the country's stability has historically rested on its welfare state. Compared to 2015, the subsidy reductions are expected to cut costs by 12%. Prices are being increased by 60% for petrol, approximately 66% for gas and around 130% for ethane.[68] Given the relatively modest rise in prices (in January 2016, the cost of high grade gasoline was US$0.90/gallon compared to US$0.60/gallon in 2015), the fuel prices have not been met with public outcry.[69] Including future reductions, the subsidy reform in gasoline, electricity, and water is expected to generate US$30bn a year by 2020. The subsidy cuts are part of a broader five-year plan to create a more efficient economy and rein in a deficit that reached 15% of the country's GDP this year.[70]

However, by leveraging new technologies, such as cell phones or special banking accounts, governments are targeting subsidies to the most in-need segments of their populations (see Box 14).

Generally speaking, deployment subsidies have proven to be a valuable tool for developing certain industries and redirecting investments. However, these types of subsidy programmes need to be well-structured to provide investor confidence, and taper as deployment of the subsidised technology improves, to contain costs and to avoid needles expenditure. For example, following the 2008 financial crisis, the Spanish government drastically cut its subsidies for solar power and capped future increases. In 2012, the Spanish government went further, placing a moratorium on renewable energy subsidies with the aim of saving several billion euros owed under the policy. These challenges were not signalled in advance and applied to operations already developed. This abrupt change severely damaged

revision – minister", Reuters (24 March, 2016)

66 "Indonesia's economy: A good scrap", The Economist (8 January, 2015)

67 Barany, A and Grigonyte, D (2015), "Measuring Fossil Fuel Subsidies" ECFIN Economic Brief, Issue 40, March 2015

68 Mills, R (2016), "The energy subsidies dam has finally broken in the Middle East", The National (8 May, 2016)

69 Reed, M (2016) "Saudi Arabia reins in runaway energy subsidies", The Fuse (11 January, 2016)

70 Kerr, S. (2015), "Saudis face fluel price jump under new austerity plan", Financial Times (30 December, 2014)

investor confidence. Arguably the original subsidy design was flawed in not providing for review as costs fell or deployment rose.

BOX 14: INDIA – DIRECT BENEFIT KEROSENE SUBSIDIES

In January 2016, the Indian government announced the launch of the direct benefit transfer scheme for distribution of kerosene subsidy in 26 districts across eight states. As of 1 April 2016, the populations of rural areas will have to pay the market price of Rs 43/litre ($ 0.65/litre) of kerosene. The subsidy, Rs 31/litre ($ 0.47/litre) will be paid directly into the bank accounts of eligible beneficiaries.[71]

A similar scheme was already in place for liquefied petroleum gas and it has been extended to kerosene to better target beneficiaries, eliminate theft and black-markets and cut down on adulteration of the cheap fuel with diesel. With more than half of the kerosene sold being stolen, the aim is to eliminate subsidised kerosene from the supply chain. In 2014–15, misappropriation of kerosene cost oil marketing companies Rs 24,000 million ($3.61 million) on subsidised kerosene sales (amounting to one-third of their total under-recoveries).

But there are challenges with the plan, for example, the amount of subsidy each household can claim is determined on the basis of current kerosene usage. This would be about double their actual usage. Further, high subsidies to kerosene could also hamper any incentive for users to shift to cleaner forms of lighting, such as solar.

In developing countries, ensuring that customers can afford the electricity tariff once energy projects are completed remains a challenge. Tariffs reflect the cost of building and maintenance for the networks to make the project viable, and this may be unaffordable for local populations in remote areas. Government subsidies can create unmanageable financial burdens for poorer countries.

Affordability strategies vary across countries, depending on whether energy policy is considered a social policy or not. For example, access policies are normally part

---

[71] Pal Singh, S (2016), "Direct transfer of kerosene subsidy: All you need to know", Business Standard (2 January, 2016; "From April 1, Kerosene subsidy directly in bank accounts", The Times of India (1 January, 2016)

of a country's key anti-poverty reforms, such as the Light for All initiative in Brazil that connected 11 million people to the grid (see Box 15). Elsewhere, such as in Nordic European countries, energy prices are not considered key levers for social welfare. However, energy leaders cautioned that, although affordable energy provides many benefits to society, there are limits on how the energy sector and its policies can be used to promote other policies and broader economic goals. As one energy leader noted, "When energy is used to address macroeconomic problems such as inflation, industrial development, job creation, etc., then energy infrastructure decisions are based not on technical issues, but more political/macroeconomic ones, creating distortions in energy policy implementation." (See Box 16 on page 72 – Argentina: Electricity tariff freeze impacts on energy investments)

BOX 15: BRAZIL LIGHTING FOR ALL

Brazil has had difficulties balancing the energy trilemma: although performing well in terms of energy security and environmental sustainability, energy equity still lags behind.

Between 2003 and 2009, the government provided 11 million people with access to electricity through the Luz para Todos – Light for All – programme. As of January 2016, 15.6 million rural residents throughout the country had access to electricity.

Some funding came from the Energy Development Account and the Global Reversion Reserve. The remainder was shared between local governments and distribution network operators. Total investment amounted to R$22.7bn, of which R$16.8bn came from the federal government.

The extent of the connection is only part of the programme's success. The overall impact of electrification is also measured on the basis of welfare improvement. For instance, the programme has generated around 489,000 new jobs, and spurred technological development and network interconnectors.

In August 2015, the federal government issued the Programa de Investimento em energia elétrica with R$186bn to increase the total energy supply, with a preference for low-carbon generation and to strengthen the transmission and distribution system.

BRAZIL

ENABLING CONSUMER AFFORDABILITY AND INDUSTRY COMPETITIVENESS

POLICY AND GOAL

The Brazilian government made a significant effort to reduce electric power tariffs with Provisional Measure n. 579 of 11 September 2012. This provisional measure established the reduction of electricity tariffs and the extension of concessions for generation, transmission and distribution of electricity. The aim was to improve the competitiveness of the economy, affordability of electricity supply for the population, and to reduce inflation.

IMPLEMENTATION

The policy consists of two main measures:

1) Abolishing the general reserve reversion tax, fuel consumption tax, and a 25% reduction in energy development tax. These taxes were previously enacted to subsidise investments in the electricity sector and help fund improvements to Brazil's vast electricity grid.
2) Extending the generation and transmission concession agreements related to the amortised assets for another 30 years for the incumbent companies, while reducing the level of tariffs received by them. This measure involved 20% of installed generation capacity and 67% of the country's transmission lines.

ACHIEVEMENT

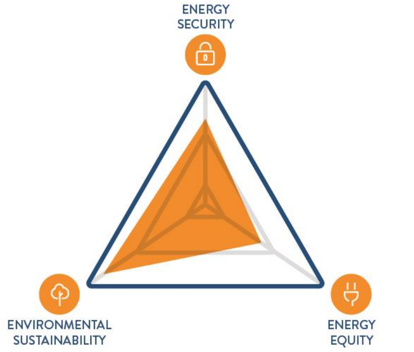
The Provisional Measure allowed for a reduction in electricity prices for consumers, increasing energy affordability.

CHALLENGES

The two measures caused a structural reduction of the mix of generation and transmission tariffs, decreasing the revenue of the power companies. Moreover, cyclical changes in the weather meant that lower than expected levels of rainfall caused a greater share of the electricity generation mix to come from fuel sources. This jeopardised the target 20% tariff reduction. As a result, tariffs have reversed quickly. A system of tariff flags was set to inform consumers of the necessity to increase power bills in order to cover the operational costs of providing electricity. This increase in final price was lower for low-income consumers.

Although the tax cut and concession agreements were meant to be implemented on a long-term basis, the recent tarriff reversal has remained in place, undermining the goal of energy affordability. Over the years, Brazil has had one of the highest electricity costs in the world. The country's main challenges are to grant an affordable tariff to all citizens, and ensure the conditions for sustainable and secure sources of energy at the lowest cost.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
43	44	34	30	37

LESSONS LEARNED

1 The structural actions aimed at lowering prices for consumers are limited compared to the detrimental effects of policy reversal, which requires further government action to relieve poorer consumers.

2 Although low final tariffs are desirable, they should also be stable or, as far as possible, predictable.

3 Energy strategies need take into account risks associated with climate change.

PHILIPPINES

ENABLING CONSUMER AFFORDABILITY

POLICY AND GOAL

Section 73 of the Electric Power Industry Reform Act (2001) provided a "lifeline," or subsidised rate of electricity for low-income residential consumers with up to 100 kWh monthly consumption. The programme was initiated to assist marginalised consumers retain access to modern electricity services after tariff reforms significantly raised household electricity bills.[1]

IMPLEMENTATION

The Lifeline Rate Subsidy is cross-subsidised by above-cost tariffs (P 0.1395/kWh)[2] charged to households above the minimum threshold of 100 kWh a month. The programme is managed by the coordinated efforts between the Department of Energy and Energy Regulatory Commission.

ACHIEVEMENT

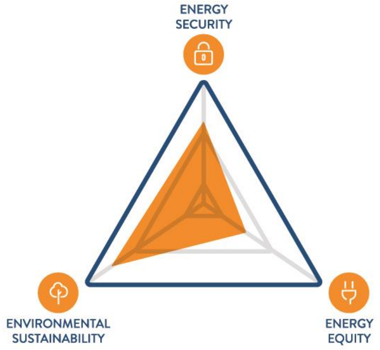
To date, approximately 3 million low-income households have benefitted from the Lifeline Rate Subsidy. The programme has been extended until 2021, 10 years past its original deadline.[3]

CHALLENGES

Wealthy households often have second residences that are seldom used and as a consequence may be eligible to lifeline subsidies. At the same time, the size of a household is not taken into account. As a result, some large, low-income households may be eligible for lifeline subsidies.

1. IMF, Case Studies On Energy Subsidy Reform: Lessons and Implications, 2013.
2. Asian Development Bank, 2012: Comparative Analysis and Policy Study on Residential Electricity Bills in Selected ADB Member Countries; Mostert, W., 2005: Financing rural electrification and renewable energy – basic principles for subsidy policy – Selected Essays.
3. IMF, 2013: Case Studies On Energy Subsidy Reform: Lessons and Implications.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
64	71	65	58	50

LESSONS LEARNED

1 Cross-subsidised lifeline rates are designed to be targeted and can help low-income residential consumers gain and retain access to electricity services without the need of large government expenditures.

2 In addition to consumption, subsidies should take the size of the size of the household into account, to prevent the unintended impact of having large low-income households subsidising the electricity bills of small, high-income households.

Industry competitiveness

As a key component of manufacturing costs, industry energy prices have an impact on economic competitiveness. For example, industrial consumers in Japan and Europe paid, on average, more than twice as much for electricity as their counterparts in the US; even Chinese industrial consumers paid almost double the US level. Part of the explanation for the price difference is the taxes and levies imposed by the state.[72] The gap in industrial electricity prices among the US, the EU and China are predicted to increase further. By 2035, electricity prices in the EU are projected to increase by 24% and become the highest among the major industrialised countries.[73]

Low energy prices are argued as necessary to promote the competitiveness of industry and a country's economy and thereby secure economic advantages. This becomes particularly important with regards to energy-intensive sectors such as primary metals (with iron and steel, and non-ferrous industries), chemicals, non-metallic minerals (glass, cement), and the paper industry.

This issue of economic competitiveness is particularly strong in debates in the EU, as US industries have benefitted from energy cost reductions with the shale gas boom. As a result of these concerns, in many instances, energy prices for industry often follow different taxation rules from energy for consumers (for example, Germany's Renewable Energy Act 2000 is basically only financed through households).

However, low energy costs may create poor incentives for the adoption of energy-efficient technologies or processes. Indeed, this could lead to an accelerated decarbonisation of the economy through a duplicate effect if 'clean' energy is produced at low cost in more efficient facilities. On the other hand a competitive economy and low energy costs can also avoid carbon off-shoring, which refers to the export of a country's carbon footprint by producing goods within the country they are consumed.

---

[72] Horváth K A (2014), The Effect of Energy Prices on Competitiveness of Energy-Intensive Industries in the EU, in Gubik A S and Wach K (eds), International Entrepreneurship and Corporate Growth in Visegrad Countries, Mickolc: University of Miskolc

[73] IEA (2013), World Energy Outlook 2013, New policies scenario

BOX 16: ARGENTINA: ELECTRICITY TARIFF FREEZE IMPACTS ON ENERGY INVESTMENTS

Argentina's experience demonstrates the other side of energy affordability. Although positioned relatively high in the Index, Argentina faces major challenges and is expected to drop lower in the rankings due to the lingering impacts of low prices for producers and high subsidies to consumers. Low electricity prices stem from a price freeze the government instituted in response to the 2001 economic crisis, through the Public Emergency and Exchange Regime Reform Act 2002. At the time, the law was critical in making electricity accessible in a context where around one in four Argentines was unemployed.[74] However, the freeze continued well past the crisis period, stunting the profitability of the energy sector, and consequently, investments under development.

A few trends highlight the extent of the impact: Compared to the 1992–2001 period, foreign direct investment in electricity, gas and water fell from 12% of total Foreign Direct Investment to 4% from 2002–2004,[75] and oil production declined by 30% since 1998, while natural gas production declined by 8% since 2006. Unable to keep up with demand, Argentina became a net energy importer in 2011 for the first time since 1984.[76] The cost of energy subsidies has been high. By 2015, electricity subsidies were around US$10bn, just under 2 percentage points of GDP.[77]

Mauricio Macri's November 2015 elected government promised an overhaul to the tariff system, announcing a US$4bn reduction in subsidies for 2016.[78] While the subsidies were successful in instituting affordability at a time when it was badly needed, there have been immense trade-offs in the development of the energy sector to maintain politically popular low rates for 14 years. The lack of investment in all energy sectors has become a major challenge, further intensified by the nationalisation of the oil company YPF

[74] Moffett, M (2002) "Self-reliance helps Argentines endure nation's economic ruin", The Wall Street Journal (20 December, 2002)
[75] Gallagher, K and Chudnovsky, D (2010), Rethinking Foreign Investment for Sustainable Development: Lessons from Latin America
[76] Sanchez, M and Lopardo, M (2015), "Argentina's election result spells optimism for infrastructure investment", KPMG Foresight: A global infrastructure perspective, 37th Edition – November 2015
[77] Buenos Aires newsroom (ed. Craft, D) (2016),"Update 1 – Argentina raises power tariffs in drive to slash subsidies", Reuters (29 January, 2016)
[78] Ibid.

(by expropriation of Repsol shares in Argentina's biggest oil company). The new management is struggling to attract the new investors necessary to exploit the large reserves of unconventional oil and natural gas in Argentina.

FINDINGS AND RECOMMENDATIONS

Top ranked countries in energy equity over the years 2010–2015 have been wealthier OECD countries or high-wealth oil states. But there are variations across the top-ranked countries: some have indigenous energy supplies, fossil fuelled and/or hydro-powered, such as Canada, the US and Switzerland, while other countries, such as France, have limited indigenous resources and have made use of nuclear power. Still others, such as Luxembourg or Hong Kong (China), have made use of strong regional power and energy interconnections to enable high rates of energy access and comparatively low costs. However, many lower ranked countries on the energy equity dimension have low GDPs and are struggling to build energy infrastructures and ensure affordable access to energy.

- **Subsidies can be vital to enabling access for lower-income consumers and also play a role in social and economic programmes.** They can, however, be costly to deploy, especially if they are made available across the whole population.

- **Innovative payment models, such as mobile banking solutions, provide a tool to better target subsidies.** They can thereby help to ensure that subsidies or vouchers quickly reach those consumers most in need of support and reduce costs for governments.

- **Subsidies can also be effective in promoting low-carbon technologies but must have a clear sunset from the start.** Changes to subsidy systems or subsidy cuts are often met with opposition by affected groups and difficult to introduce successfully. Designing criteria for subsidy reduction at scheme launch can avoid many of these problems.

- **Energy policies that aim to meet too many goals across a country's development targets (economic, financial, social, employment and so on) may be ineffective.** Policies designed to improve energy affordability and access must be designed with a view to overall energy trilemma performance so as to not be detrimental to energy performance over the long-term. The economy's competitiveness is greatly impacted on by energy affordability and needs to be taken into account when options to finance energy systems are considered.

4 Improving energy efficiency and managing demand

Improving energy efficiency and managing demand, including increasing the efficiency of energy generation, lowering losses in transmission and distribution networks, and providing for demand response has positive impacts on all aspects of the energy trilemma. Improving energy efficiency across an economy has huge economic and environmental benefits by reducing the amount of energy required (improving energy security) as well as potentially reducing emissions from energy generation and equipment and appliance use (environmental sustainability). For example, scenario modelling shows that energy-efficiency measures can contribute about 40% of the CO_2 abatement needed by 2050 to achieve emissions reduction consistent with a target of limiting global temperature increase to 2°C.[79]

Many countries have made significant improvements in energy efficiency across all economic sectors. This is shown in a decoupling of GDP growth from energy growth and a decoupling of GDP growth from GHG emissions increases. For example, in 2014 and 2015, for the first time in four decades, CO_2 emissions from consumption remained stable, while the global economy grew. Previously, only economic recessions had stalled GHG emissions.

There still remains considerable unused potential for energy-efficiency improvements along the entire energy value chain – from exploration and production to final use. In this respect electrification can improve the energy efficiency of sectors such as transport and heating and cooling. The oil and gas industry is the most energy-intensive of all industrial processes and has a great potential for energy-efficiency improvements (see Box 17). Improving productivity – the amount of energy delivered by electricity generation, transmission and distribution infrastructure – can have a significant impact on the amount of fuel needed to support the economy (see Figure 12: Causes of electricity generation and transmission and distribution losses).

BOX 17: IMPROVING EFFICIENCY IN OIL AND GAS PRODUCTION

With the fall in oil prices, oil and gas (O&G) companies can no longer afford to overlook efficiency in their production. Also, O&G production is becoming more difficult – increasingly, oil will have to be extracted from offshore or underground deposits, while gas will have to be transported long distances through pipelines or as liquefied natural gas (LNG).

[79] IEA (2014) Energy Technology Perspectives 2014

O&G production and oil refining became progressively more energy intensive through the 1990s as it became increasingly necessary to drill deeper to find O&G, to use secondary and enhanced O&G recovery techniques, and to exploit heavier oil deposits and older reservoirs. Historically, low-quality hydrocarbons have become substitutes for conventional oil, but these are more difficult to extract and refine into finished fuels, and are more expensive.[80] In refining there is a demand to process greater volumes of crude, while also converting most of that crude into end products, and reducing environmental impacts through energy-intensive processes such as greater desulphurisation. These enhancements consume more energy.

The O&G industry – the most energy-intensive industry – has a great potential for efficiency improvements. The O&G sector is consuming about 20% of its output for its own process needs.[81] Energy efficiency of O&G exploration and production is low by any standards, as it hardly reaches 20%. Several technology trends are already contributing to greater efficiency:

- **operating existing fields for longer and with more yield by injecting water or gas, to boost the pressure of the reserve**
- **using new extraction methods such as hydraulic fracking beyond the US**
- **reducing the energy intensity of extracting heavy oil from oil sands**
- **employing digital field technologies to increase and optimise production**
- **leveraging data to improve production processes.[82]**

With less easily accessible oil available, and a growing array of clean energy options in the market, it is clear that O&G companies must reduce production inefficiencies to be more competitive.

---

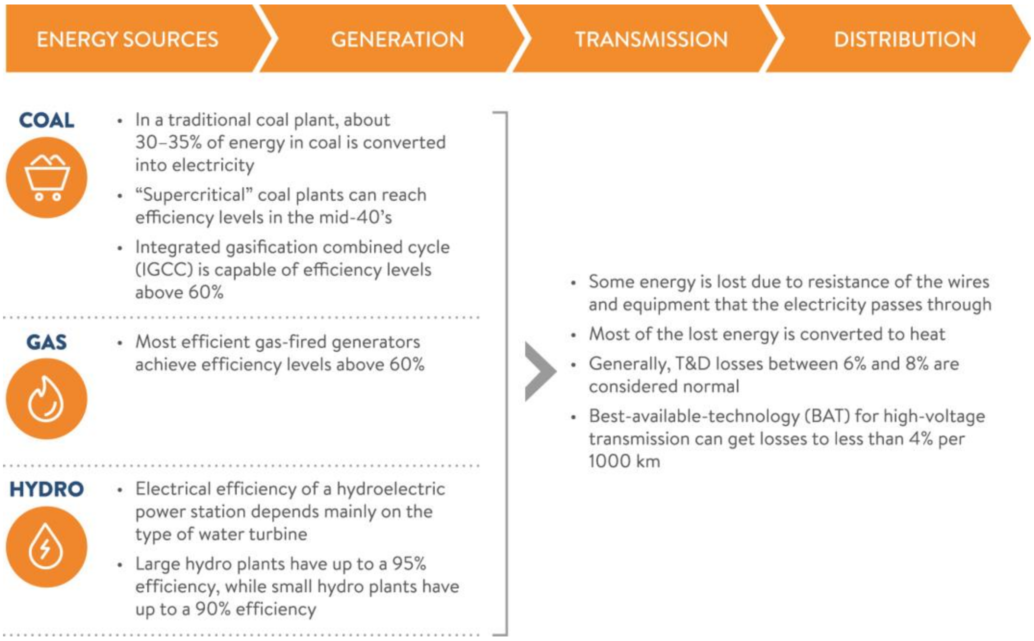
[80] Brandt, A (2011), "Oil depletion and the energy efficiency of oil production: The case of California", Sustainability 2011

[81] Data point and graphics from IPIECA (2012), Oil and Gas: Meeting Challenges Today... For Tomorrow; and World Energy Council (2013), World Energy Perspective: Energy efficiency technologies

[82] Kleinschmidt, A (2016), "The future of oil and gas: Why we will still need oil and gas in the future", Pictures of the Future: The Magazine for Research and Innovation (22 February, 2016)

In 2012, the OECD average transmission and distribution losses as a percent of generation were 7%. In many other countries the losses were higher, for example, 17% in Turkey, 10% in Indonesia and 6% in China. In India in 2014, transmission and distribution losses were estimated at 27% of electricity output and were a key component to the country's energy shortage.[83] Reducing energy loss offers significant benefits in terms of GHG emission savings in energy generation, and savings for the economy as well. For example, in 2005, the estimated 6% transmission and distribution loss in the US represented a cost of US$19.5bn to the overall economy.[84]

FIGURE 12: CAUSES OF ELECTRICITY GENERATION AND TRANSMISSION AND DISTRIBUTION LOSSES



Source: World Energy Council, 2013: Energy Efficiency Technologies: Overview Report; Eurelectric, Preservation of Resources Working Group, 2003: Efficiency in Electricity Generation

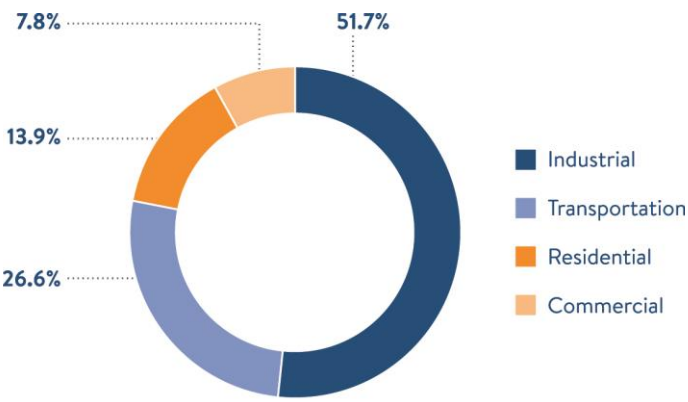
[83] US Energy Information Administration (eia) (2016), How much electricity is lost in transmission and distribution in the United States?, www.eia.gov/tools/faqs/faq.cfm?id=105&t=3; World Economic Forum (2016), Fuelling India's Potential
[84] ABB Inc. (2007), Energy Efficiency in the Power Grid, www.nema.org/Products/Documents/TDEnergyEff.pdf [Accessed 6 May, 2016]

With the productivity of energy generation based on converting a fuel (such as coal or natural gas) into heat, the efficiency of generation assets can vary due to a number of factors, including ambient temperature, technology used, age of the equipment, how well it is operated, the fuel source (for example, bituminous fuel to a low-sulphur sub-bituminous coal, natural gas or biomass)[85], or the addition of emissions equipment such as selective catalytic reduction systems or flue gas scrubbers.

Many potential energy-saving solutions are readily available today, with proven technologies. In power generation, for example, ultra-supercritical coal combustion technologies (650°C, 265 bars) and combined cycle gas turbine power plants are excellent examples of highly efficient processes as is power transmission with the latest ultra-high voltage AC and DC technology.

Energy management must go beyond the energy sector and include a range of technologies to drive energy improvements in key sectors (see Figure 13: World energy consumption by sector). These can include smart metering, efficient buildings, heat pumps, efficient motors; LED lighting and other appliances can also contribute to higher energy efficiency.[86]

FIGURE 13: WORLD ENERGY CONSUMPTION BY SECTOR



Source: EIA, 2013: International Energy Outlook, Reference tables

[85] European Environment Agency (2015), Efficiency of Conventional Thermal Electricity and Heat Production; and “Rijnmond CCGT declared bankrupt”, Power in Europe, Issue 713, 9 November, 2015
[86] World Energy Council (2013), Energy Efficiency Technologies, Annex III, Technical Report; Note: According to the IEA, carbon capture and storage must provide 20% of the global cuts in CO_2 emissions required by 2050; See also, Zero emissions platform (2012), Post 2020, CCS Will be Cost-competitive With Other Low-carbon Energy Technologies; ABB Inc. (2007), Op. cit

Smart cities bring many of these solutions and technologies together and so are able to effectively manage energy demand and improve energy efficiency. Cities are estimated to account for 75% of global CO_2 emissions and to consume 75% of natural resources, yet they only occupy around 3% of the world's land surface. By 2050, an estimated 80% of the world's population will live in cities.[87] This highlights the need to reduce energy consumption in cities through energy demand management and energy-efficiency measures. Smart cities are one way of achieving this, using an integrated approach involving the energy sector with other sectors, including transportation, real estate and buildings, water and waste management.

Electrification and automation of transport services offer attractive opportunities to combine lower fossil fuel consumption and high-tech solutions. In the UK, for instance, the Rail Technical Strategy has set the scene for a rolling programme of electrification and development of a high-speed network. The aims are also to guarantee a reduction of carbon and cost, and high levels of safety, among others. From an energy point of view, an extensively electrified network has reduced reliance on fossil fuels. Furthermore, sensors, energy storage technologies and smart-grid technologies would monitor and manage energy use for maximum efficiency. For example, trains and track equipment could be managed through a whole-system approach of intelligent maintenance which allows trains and track equipment to monitor each other and cause less damage. Intelligent maintenance would also provide accurate and timely information for condition-based intervention.

Given the potential benefits, countries around the world have focused on demand management programmes – both mandatory and voluntary – covering industrial, transportation, residential and commercial uses (see Box 18 – South Africa residential consumer engagement). Indeed, a quarter of global energy consumption is covered by energy-efficiency regulation worldwide.[88] These include:

- standards and labelling programmes, such as Energy Star, which are the primary tools to improve the efficiency of appliances and other energy-consuming products. By 2014, 81 countries had such programmes

- standards for electric motors used in industrial applications which had been introduced in 44 countries by the end of 2013

[87] UNEP (n.d.), Global Initiative for Resource Efficient Cities: Engine to Sustainability
[88] IEA (2015), Op. cit

- vehicle fuel economy standards covered 70% of the world's light-duty vehicle market as of late 2014.[89]

Emerging and high-growth economies are embedding energy-efficiency programmes as a means to manage their energy consumption growth rate, thereby improving energy security and improving environmental sustainability. For example, Ghana implemented an efficiency programme focused on household refrigerators that involved minimum energy-efficiency standards, consumer education and outreach and rebate programmes (see case study on page 82 – India: Improving energy efficiency and managing demand).

In the industrial sector, governments use a variety of incentives and regulations to stimulate energy efficiency and the marketplace for energy-efficiency technologies and services. Japan's Top Runner programme (see case study on page 83) is often viewed as an exemplary approach to drive the development of improved efficiency for cars, electrical appliances, construction materials, and so on.

A comparatively low return on investment or a long payback period for energy-efficiency technologies can deter the adoption of energy-efficiency programmes or technologies. This is particularly the case in countries that have a focus on low fuel prices as a means to stimulate economic investment. In such instances, mandated energy-efficiency programmes may be necessary. For example, most of the electricity in Kazakhstan is consumed in industry and there is strong potential for energy savings. However, low wholesale price for electricity reduces the value of modernisation investments, and market principles alone are unlikely to achieve the government's targets of 40% improvement energy efficiency by 2030 compared to 2008.

---

[89] REN21 (2015), Renewables 2015 Global Status Report

BOX 18: SOUTH AFRICA RESIDENTIAL CONSUMER ENGAGEMENT

In response to insufficient electricity capacity during peak hours, South Africa's electricity distributor, Eskom, devised various strategies to engage the public in voluntary demand reduction. Consumers can access information on the current and projected status of the grid via Eskom's Power Alert site. For residential consumers, the Power Alert site conveys real-time information on the status of the grid on selected TV programmes. The information is presented as four colour-coded alerts, with graphics instructing viewers how to reduce their consumption. The colour and volume bars indicate the level of strain on the energy supply, while icons of home appliances indicate what to switch off.[90]

FIGURE 14: POWER ALERT – HOW DOES IS WORK?

Source: Eskom (2016), Power Alert – How does is work?

[90] Power alert (n.d.) New Power Alert system on SABC and eTV now also on DStv, www.poweralert.co.za/poweralert5/how-does-it-work.php

INDIA

IMPROVING ENERGY EFFICIENCY AND MANAGING DEMAND

POLICY AND GOAL

The Perform, Achieve, and Trade (PAT) policy created an energy efficiency certificate trading system to improve the cost-effectiveness of efficiency improvements in energy intensive industries. Phase 1 (2011–2015) of the PAT was expected to save about 6.6 mtoe of energy, with a co-benefit reduction of about 25 mtoe.[1]

IMPLEMENTATION

Under the scheme, target companies, or "designated consumers" (DCs) receive Specified Energy Consumption targets to abide by. DCs that perform better than their targets can trade their Energy Savings Certificates to other DCs whose own targets are too challenging or costly to meet.[2] Phase 1 primarily focused on four sectors, power, cement, fertiliser and steel and phase 2 is expected to expand the range of DC sectors and set more stringent savings targets.[3]

ACHIEVEMENT

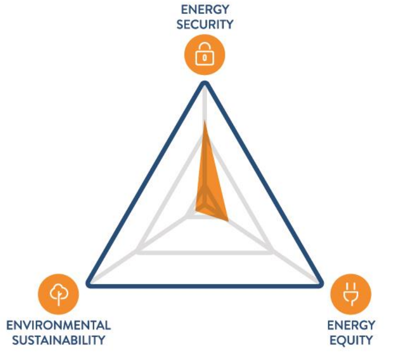
While phase 1 official results have not been released as of the time of writing, a sample of 47 DCs and review of 426 projects offers preliminary observations.[3] In terms of the institutional design of the programme, DC's have expressed that the Monitoring and Verification protocol and process is transparent.[4] On the implementation side, DCs have addressed efficiency predominantly through short-term, low cost measures such as retrofitting – almost 65% of the projects fell into this category. More than 60% of projects implemented were relevant across sectors, suggesting a significant opportunity for cross-sectoral learning.[4] As a country at the low-end of overall Energy Trilemma Index rankings, the PAT programme signals a positive step towards improving India's energy security and sustainability and the application of such policies in similar economies.

CHALLENGES

Few of the efficiency projects involved major technology or process changes. Given the high investment required, long payback times, and lengthy capacity ramp up, DCs have struggled with leadership buy-in for bigger efficiency enhancements. In all sectors, the lack of availability of low-interest loans has also hampered investment in best available technologies.[5]

1. Government of India, Ministry of Power Press Information Bureau, 23 July 2015: Prime Minister to Launch Deendayal Upadhyaya Gram Jyoti Yojana in Patna.
2. Government of India, Planning Commission, Programme Evaluation Organization, 2014: Evaluation on Rajiv Gandhi Grameen Vidyutikaran Yojana.
3. IMFR LEAD, 2015.
4. Shakti Foundation, PAT Pulse: Tracking the Perform-Achieve-Trade Scheme for Energy Efficiency, January 2016.
5. Shakti Foundation, 2016.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
115	117	115	122	107

LESSONS LEARNED

1. The lack of low-interest financing for efficiency improvements may signal the need for alternate financing solutions, such as green bonds.
2. Private sector commitment is crucial for the success of the scheme. To reduce friction in the compliance process, submission processes should be transparent and simple.
3. Programmes should include an incentive and platform to disseminate quick-win, industry agnostic solutions.
4. Initial handholding through sector sub-committees and extensive stakeholder consultation workshops at regular intervals enable transparency and buy-in to the monitoring and verification process.

JAPAN

IMPROVING ENERGY EFFICIENCY AND MANAGING DEMAND

POLICY AND GOAL

Top Runner is a mandatory programme imposed on Japanese manufacturers to meet a standard of energy efficiency in their products by a target year, typically 3–10 years ahead. The goal of the programme is to stimulate continuous energy efficiency improvements in appliances, cars, machinery, and construction materials. The policy improves energy security by reducing energy demand and supports Japan's compliance with international climate change commitments.

IMPLEMENTATION

The standard is set by the most energy-efficient product, determined through a study of existing products on the market, and adjusted for forecasted technical improvements. Target dates are set according to the industry's capacity for development and public pressure. While manufacturers compete to set the standard, they can provide a range of models to meet demand since they are evaluated against the weighted average efficiency of their products. To scale the programme, new product categories have been continually added. Compliance is self- reported and enforced through public naming and penalties.[1]

ACHIEVEMENT

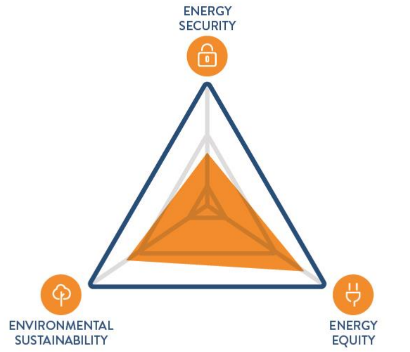
Since the introduction of the programme in 1998, 23 product categories have reached their target improvement[2] and 91% of these have achieved efficiency gains above the ministry's expectations. Overall, the programme has helped reduce energy consumption by 5% in road transport and by 8% in the residential sector. To date, no producers have been publicly named as non-compliant.[3]

CHALLENGES

The programme is designed for a model of incremental innovation in specific product categories, rather than radical technology shifts. Methodologically, it is difficult to determine a rate of technology improvement that is ambitious, yet achievable. There is also uncertainty in how the cost of innovation is translated to end consumers.[4]

1. Japanese Ministry of Economy, Trade, and Industry, 2015: Top Runner Programme: Developing the World's Best Energy Appliance and More.
2. Future Policy, Ecologically Intelligent Design, 2016: Japan's Top Runner Programme.
3. Future Policy, 2016.
4. Kimura Osamu, 2012: The Role of Standards: The Japanese Top Runner Programme for End-use Efficiency.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
13	14	16	23	32

LESSONS LEARNED

1. A public, competitive program can set a clear market direction for product development, reducing the risks for companies investing in energy efficiency.
2. The programme is facilitated by the Japanese market structure, where a small number of domestic producers have the high technical competency and desire to compete for public recognition.
3. Standards are effective for product categories where the rate of technology change is simple to forecast.

FINDINGS AND RECOMMENDATIONS

As highlighted in the 2016 World Energy Issues Monitor, energy efficiency continues to be perceived as the top action priority globally. This highlights that energy leaders believe it is an area that can, and must, be addressed. However, it also reflects the reality that action is falling short of expectations. As highlighted through the case studies and trilemma assessments, potential cost-savings alone are often insufficient to stimulate the production or adoption of energy-efficiency technologies or behaviours. A mixture of regulations, incentives and increasing awareness are typically used to drive improvements.

- **Energy-efficiency standards can stimulate product innovation in favour of higher efficiency:** Mandatory or minimum energy-efficiency standards in buildings, industrial equipment, transportation and residential appliances can accelerate the trend of energy improvement in products. Making energy-efficiency ratings public and highlighting higher efficiency products through labelling and certificate schemes, rewards forward-looking producers, and contributes to the phase-out of low-efficiency products.

- **National energy efficiency institutions and programmes can drive significant energy savings:** Creating national level energy-efficiency bodies is critical in many countries, including fast-growing economies such as India, which are challenged by their size, growth, or disparities in energy access. National bodies may have greater access to capital and human and institutional capacity to support national and state-specific programmes at scale.

- **Feedback mechanisms and decision-making processes that integrate the private sector are critical:** Where the outcome of programmes is difficult to predict, continued outreach and collaboration with the private sector will adjust for policy flaws, ensure more effective monitoring, and increase buy-in for programmes.

- **Industry-targeted energy-savings schemes should be subject to a robust independent evaluation, measurement and verification (EM&V) process:** Energy-savings schemes have often been launched without alignment or capacity to establish a baseline and monitor progress. While industry self-reporting is a low-cost monitoring mechanism, the long-term success of these programmes will depend on having an independent system for measuring and verifying the actual energy savings achieved. In some countries, this expertise will have to be imported until a market is created for these services.

- **Efficiency investments with longer payback periods require additional incentives:** To move beyond the ‘quick win’ of energy-efficiency improvements, industry requires greater information and signals or financing to make the business case for higher cost and longer payback investments. In appropriate cases, regulation will have a role.

5 Decarbonising the energy sector

Decarbonising the energy sector, including increasing the share of nuclear, hydro and renewables in the electricity generation mix and pricing carbon adequately is critical to meeting COP 21 goals.

The environmental sustainability dimension of the Energy Trilemma Index includes a focus on development of energy supply from renewable and other low-carbon sources, including nuclear and hydro. The top ranked countries for environmental sustainability over the review period reflect the role of hydropower in electricity generation in enabling low GHG emissions in energy use. Nearly all the countries in the top 10 over the years have a high percentage (close to 50% or more) of hydro in electricity generation. The exceptions to this are France, which uses nuclear power for three-quarters of its electricity generation, and Denmark, which has developed wind power.

The successful conclusion of COP 21 added increased momentum to the global transition to low-carbon energy. Almost 190 countries demonstrated their commitment to emissions reduction through their intended nationally determined contributions (INDCs), sending a strong signal to the markets and the energy sector (see Box 19). The challenge now is to maintain this momentum in implementation, despite barriers such as market instability and technology risk. Beyond avoiding the damaging impacts of climate change, reducing GHG emissions through renewable use and energy efficiency can increase energy security.

BOX 19: COP 21 – CORE COMMITMENTS AND IMPLICATIONS FOR THE ENERGY SECTOR

The Paris Agreement sets out a goal to put the world on track to hold the increase in the global average temperature to well below 2°C, above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C. While there were no top-down commitments imposed on the energy sector, meeting the goals of the Paris Agreement will require a radical transition to a low (and an eventual net zero) GHG emissions economy. Many countries will look to their energy supply and use as the key agent of change to achieve a peak emissions as soon as possible, and achieve net zero GHG in the second half of this century.

The energy sector (electricity and heat) currently accounts for 41% of the global CO_2 emissions and transport accounts for 23%.[91] To limit global warming to 2°C, energy-sector CO_2 emissions will need to decline at an annual rate of 3.8% compared with a business as usual projected annual increase of 1.9%. Given these figures, many countries will need to make significant changes to their GHG emissions profile by decreasing emissions associated with energy supply or use and transportation.

The agreement provided a strong signal to companies, governments and investors that countries will have to transform their energy mix to adapt to a carbon-constrained future. Actions to promote the environmental sustainability of the energy system have to be weighed against specific national challenges faced in the balancing act with the two other trilemma dimensions: energy security and equity. Securing a sustainable energy supply requires investment in a low-carbon energy future, while avoiding stranded assets (i.e. assets that have been written off, devalued or converted into liabilities unanticipatedly or prematurely) and ensuring affordability.

The long-term challenges of decarbonisation are multifaceted: building in a cost for negative externalities (i.e. a cost that is paid for by a third party), delivering returns on capital-intensive renewable technologies, phasing out the reliance on high-carbon generation, and ensuring supply security, while diversifying resources.[92] In the short-term, these objectives will manifest themselves in policy changes and 'quick win' investment strategies:

- **Governments will create or strengthen policies to decarbonise the power sector through regulation (such as renewable energy standards) and increasing the price of carbon, particularly in the current environment when hydrocarbon prices are low.**

- **The risk of additional emission controls, which could result in stranded assets, will continue to make traditional coal generators less attractive investment options in many countries. For example, in the US, coal plants are retiring early and the UK has set a goal to close coal plant generation by 2025.**

- **As the market diversifies, the cost and speed of deployment of renewables makes certain technologies, such as solar PV, more**

---

[91] IEA (2015), CO_2 Emissions from Fuel Combustion: Highlights 2015
[92] IEA (2016), Repowering Markets: Market design and regulation during the transition to low-carbon power systems; Robinson, D (2015), The Prospects for COP 21 and the Future Role of Natural Gas, The Oxford Institute for Energy Studies; Currie, S (2015), "Disruption of the energy industry", ecogeneration

attractive in the short-term. The cost of utility scale Solar PV projects has plummeted and deployment is significantly faster than wind, hydro and thermal projects.

- **In developing economies, COP 21 will further facilitate the participation of the private sector in renewable energy projects.**

- **There will be a greater focus on the energy efficiency of energy supply, including the O&G sector, power generation and transmission and distribution system.**

- **There will be continued focus on carbon mitigation strategies such as carbon capture and storage, especially as coal is predicted to remain a key fuel source in growing energy markets such as China and India.**

- **Countries will focus on decreasing emissions from the transportation sector by decreasing fossil fuel use for transport, setting performance emission standards, and supporting the adoption of biofuels and electric vehicles.**

In addition, developed countries will be held responsible for: mobilising financial assistance of US$100bn per year by 2020 (including private finance); and defining a new target for increased funding by 2025 for mitigation and adaptation support for developing nations. A broad framework to expand the development and deployment is emerging: the Technology Mechanism of the Convention will not be the only mechanism, but rather other channels for innovation could deliver significant results. For example, the Mission Innovation group and the supporting Breakthrough Energy Coalition have set goals to advance the development and large-scale market deployment of disruptive technologies in the energy sector.

Policies to stimulate the decarbonisation of the energy sector – primarily the electricity generation sector, fall broadly into three core approaches

- Targeted support for low-carbon technologies incentivises the development of new sustainable technologies. Support for renewables can reduce the competitive advantage of cheaper emission-intensive energy generation and consumption.

- A focus on carbon mitigation technologies such as CCS can help countries maintain the energy security offered by existing fossil fuelled energy assets.

- Carbon pricing (including carbon taxes and emission trading schemes) is a key incentive for emission reduction, by reflecting the true cost of high-emission technologies and processes. Regulations limiting GHG-intensive activities also apply an implicit cost on emissions. Facilitating long-term agreements can thereby help to reduce uncertainty for decision makers.

There are challenges, however, with decarbonising the energy sector, including technology issues and concerns about the costs. It is therefore important to unbundle electricity bills from taxes and levies. For example, in the US, the proposed Clean Power Plan to reduce CO_2 emissions from existing power plants is being highlighted and has been criticised because of its potential costs to utilities and consumers. These cost impacts can diminish civil support for the energy transition, creating political and regulatory risks for the energy sector and its investors.

Low-carbon energy generation technologies

Most countries have commitments to increase their renewable energy generation to improve energy security and decrease GHG emissions. For example, Korea (Republic) – one of the top energy importers in the world – relies on fuel imports for about 97% of its primary energy consumption. The nation sets targets for new and renewable energy to supply 11% of the country's total primary energy supply and a 15% reduction in energy demand by 2035.

The types of policy instruments used to support low-carbon technologies vary across market maturity, sectors, and countries' institutional contexts. Policy instruments include: 'demand pull' measures to create or strengthen the demand for low-carbon technologies, for example, feed-in-tariffs and renewable portfolio standards; and 'supply push' instruments, such as RD&D financing and tax incentives that can be leveraged to reduce barriers in producing the technology, and correct market failures. Within the scope of this report, we focus on demand-side measures to transition to low-carbon technologies.

Feed-in policies now exist on every continent, and more than 98 states, provinces and countries have feed-in policies.[93] Feed-in tariffs typically make use of long-term agreements and pricing tied to the costs of production for renewable energy producers and the policy allows for variety in design and implementation – although the common features of feed-in tariffs include a price per kilowatt hour that is determined administratively (rather than through market competition) and is available on a standard offer basis. By offering a set price for electricity by renewables, the feed-in tariff minimises key investor risks when compared to other policy types, thereby lowering the cost of capital required to finance projects.

---

[93] REN 21 (2015), The First Decade: 2004 – 2014, 10 years of yenewable rnergy progress; For a detailed discussion of the effectiveness of feed-in tariffs, please see: World Energy Council/ Oliver Wyman (2014), World Energy Trilemma: Time to get real – the myths and realities of financing energy systems

TURKEY

DECARBONISING THE ENERGY SECTOR

POLICY AND GOAL

The Law on Utilisation of Renewable Energy Resources (2005) provides a legal and regulatory framework to expand the use of renewables in electricity generation with the target of generating 30% of total installed energy capacity from renewables by 2023.

IMPLEMENTATION

Feed-in tariffs (FITs) are the main renewable energy support mechanism introduced in the 2005 law. Under the law, renewable energy producers sold electricity to generators at an average wholesale price determined by the Energy Market Regulatory Authority. Given the unsatisfactory results, the government amended the law in 2010 to adjust the price, period, and traders of the FIT scheme, awarding differential rates based on the renewable source. The amendment also added a premium to the tariff if power plants used domestically manufactured components.

ACHIEVEMENT

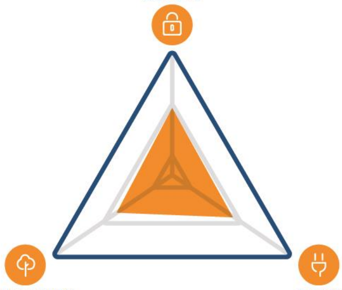
Turkey has doubled its installed renewable energy capacity to 25 GW between 2005 and 2010.[1] However, GHG emissions have not decreased in line with renewable growth. Since 2005, Turkey's emission intensity has fluctuated as it increasingly leverages its domestic coal supply. Total annual emissions have risen due to growing electricity demand being primarily met by fossil fuels.[2]

CHALLENGES

In general, the FIT has been lower than the average electricity prices in the spot market, which has attracted less investment since 2005 than policy makers were seeking. Compared to other countries where FIT guarantee periods are between 15 and 25 years, Turkey's 10 years is less attractive.[3] Critics have challenged that the country still provides legal and financial incentives to coal, while limiting licenses for solar and wind projects.[4] The country's leadership sees coal as the primary driver of economic growth and plans to double coal capacity from 2015 levels by 2019.[5]

1. Energy-in-Demand International, September 25, 2015: Progress being made in promoting renewables in Turkey.
2. MPDI, Energies 9, 31, Burcin Atilgan and Adisa Azapagic, 2016: Assessing the Environmental Sustainability of Electricity Generation in Turkey on a Life Cycle Basis.
3. Renewable and Sustainable Energy Reviews no. 48, Izzet Ari and Ramazan Sari, 2015: The role of feed-in tariffs in emission mitigation: Turkish case.
4. Scientific American, Lisa Friedman, October 9, 2015: Can Coal-Powered Turkey Get Serious about Climate Change?
5. Scientific American, 2015.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
82	87	75	73	76

LESSONS LEARNED

1. Investment in coal should factor in the social and environmental externalities to compare the true cost against renewables.
2. The FIT scheme should be continuously evaluated against other country experiences to maintain competitiveness. Static FIT rates below wholesale electricity prices and shorter guarantee periods may reduce the attractiveness of investment in Turkish renewable projects.
3. While attaching a premium for locally manufactured components can stimulate local technology development, the incentive may increase the cost and time to investment by complicating the due diligence process.

In Turkey, feed-in tariffs have been used successfully to diversify the country's energy mix (see case study on Turkey). With substantial potential for renewable energy resources, Turkey ranks 7th in the world with regard to geothermal resources and has set a target of producing 30% of its electricity from renewables by 2023.[94] Unlike other feed-in tariff schemes, the country also adds a premium for domestically produced components. However, the emission reduction benefit from increased renewable use has been counterbalanced by heavy investment in coal to fuel the country's economic growth. Turkey's energy strategy is multidimensional due to its extreme reliance on imported energy – while it expands its energy portfolio with renewables and nuclear, it is also diversifying the sources of its existing supply to increase energy security. Observers caution that the country has not fully come to terms with the consequences of increased emissions from coal power plants – a question Germany is also dealing with, albeit on a different scale.

Renewable energy auctions ('tendering') are emerging as a popular way to reach a competitive price for renewable energy and replace FIT schemes in early adopter countries such as Germany. Auctions promise a number of benefits including, cost-effectiveness of energy deployment, transparent processes, and relative ease in raising capital in riskier developing countries. By 2015, more than 60 countries, the majority developing economies such as Brazil, China, Morocco, and South Africa, had planned or conducted renewable energy targets.[95] Germany is also reforming its Renewable Energy Act in 2016 in favour of an auction system that will enable easier renewable management in relation to grid expansion, and improve planning security in the power sector for Germany as well as its neighbours.[96] For FITs and renewable portfolio standards, there is no 'one-size-fits-all' formula. The design of the auction should be crafted according to the country's characteristics and goals.[97]

Renewable portfolio standards are another policy instrument to stimulate renewable investment, where the regulator mandates targets for renewable generation in electricity. Utilities can meet the target by buying renewable energy from independent providers, or by developing renewable generation in house. Successful implementation of renewable portfolio standards are accompanied by a

---

[94] Flanders State of the Art (2015), Renewable Energy in Turkey
[95] IRENA (2015), Auctions Emerge as Key Instrument to Promote Renewable Energy, 25 August, 2015
[96] Appunn, K (2016), "EEG reform 2016 – switching to auctions for renewables", Clean Energy Wire, (15 February, 2016)
[97] IRENA (2016), Auctions Emerge as Key Instrument to Promote Renewable Energy, 25 August, 2015

renewable energy certificate market, where utilities can trade renewable energy credits to meet their portfolio obligations and minimise the cost of compliance.[98] These approaches encourage utilities to meet their renewable goals cost-effectively as they must use renewable sources at market prices.[99] However, if the target does not differentiate the type of energy, this will result in the lowest-cost technology being favoured. Programmes vary widely in their structure, targets and enforcement mechanisms, depending on the country's resource base and energy goals.

Carbon mitigation technologies

Given the dominant role that fossil fuels continue to play, particularly in developing countries, a portfolio of carbon mitigation solutions is needed to confront rising emissions. Alongside renewable energy generation and energy efficiency, CCS is a critical component of the technology portfolio.

CCS is a set of technologies to capture and transport CO_2 from key sources to a storage site where it is permanently trapped in porous geological formations deep below the surface of the earth.[100] CCS is attractive for the industrial sector, where cement, iron, steel, chemical and refining plants together contribute to 20% of global emissions, and where currently there is no other technology which would enable the transition to low (or zero) carbon operation.[101] According to the World Energy Council's energy scenarios, CCS can play an important role after 2030 in cost-effective CO_2 mitigation.[102] This is supported by the IEA's Energy Technology Perspectives 2012 2°C Scenario (2DS), where CCS contributes one-sixth of total CO_2 emission reductions required in 2050, and 14% of the cumulative emissions reductions through 2050 against a business-as-usual Scenario (6DS).[103]

While the urgency for CCS is growing, the challenge remains to deploy the technology cost-effectively (see Box 20). It is estimated that the cost of a new average-sized, coal-fired power plant that captures up to 90% of its CO_2 emissions is US$1bn over 10 years.[104] Under the World Energy Council's energy scenarios, the cost of avoiding CO_2 in coal and gas power plants equipped with CCS, ranges

---

[98] EIA (2016), Most States Have Renewable Portfolio Standards, 3 February, 2012
[99] Johnson, E and Oliver, M (2015), "Panel Paper: Feed-in tariffs versus renewable portfolio standards: an estimation of policy risk in the electricity sector", Association for Public Policy Analysis and Management (APPAM) (13 November, 2015)
[100] Forbes, S and Almendra, F (2011), CCS Demonstration in Developing Countries: Priorities for a Financing Mechanism for Carbon Dioxide Capture and Storage, WRI
[101] Ellington, F (2013), Why We Need CCS to Secure Future Renewables, Business Green
[102] World Energy Council (2013), World Energy Scenarios: Composing energy futures to 2050
[103] IEA (2013), Technology Roadmap: Carbon Capture and Storage 2013
[104] Forbes, S and Almendra, F (2011), Op. cit

from around \$40–80/tCO_2 in 2020 reducing to \$30–60/tCO_2 in 2050.[105] The technology is still in its early days, and findings from large-scale CCS projects launched to date, such as the Saskatchewan's Boundary Dam 3 (2014) and Australia's Gorgon liquefied natural gas (LNG) project (2016), will help drive costs down for later technology adopters. Despite design issues affecting the efficiency of carbon capture from the Saskatchewan Boundary Dam, CCS is still viewed as an essential solution.[106] Australia's experience demonstrates the substantial role a government must take to implement a CCS project, including advocating for the technology, supporting cost digressions, and taking responsibility for long-term liability should any gas escape.[107]

BOX 20: DECARBONISATION TO REDUCE WATER-STRESS

Available resources are an important element of picking decarbonisation policies. Some of the technologies highlighted as part of the low-carbon transition, such as biofuels or CCS, require nearly double the water needs of a coal power plant and could put additional pressure on the energy-water nexus.[108] Currently, thermal power and hydropower generation together contribute 98% of the world's electricity generation and these rely on water for cooling and efficient functioning respectively. A recent study revealed that climate change impacts on water resources could lead to reductions in electricity production capacity for more than 60% of the power plants worldwide from 2040–2069.[109] Water stress impacts are already being felt. For example, Zimbabwe depends mostly on hydroelectric power from Kariba Dam, and the 2014–2015 drought, coupled with a 2016 El Niño-induced drought, resulted in power output decreasing by half. Similar difficulties are seen in Zambia which generates 90% of its electricity from hydroelectric power plants. By January 2016, generation reduced by three-quarters at one plant due to water levels.[110] Brazil has likewise faced hydro-generation production cuts due to drought. In December 2014, the biggest dams in Brazil were only at 16.1% capacity.

[105] World Energy Council (2013), Op. cit
[106] Austen, I (2016), "Technology to make clean energy from coal is stumbling in practice", The New York Times (29 March, 2016)
[107] Paton, J (2016), "Carbon capture and storage to be tested by oil companies in Australia", The Globe and Mail (20 April, 2016)
[108] World Energy Council (2016), The Road To Resilience – Managing the risks of the energy-water-food nexus,
[109] Michelle T.H. et al (2016), "Power-generation system vulnerability and adaptation to changes in climate and water resources", Nature Climate Change
[110] Mambondiyani, A (2016), "Zimbabwe: Drought cripples hydropower", Rural Reporters (18 February, 2016)

Current and emerging water stress risks are particularly acute in areas with some of the highest current and future energy demands, including China, India, Southwestern US, the Middle East and Sub-Saharan Africa. Looking forward, it is estimated that the total electricity demand for desalination in the Middle East is expected to triple over the period 2007–2030 as the region races to meet rising water and energy demands.[111]

For developing countries that rely on fossil fuels to power their growth, CCS promises a strategy to mitigate carbon emissions, without stalling progress towards their development goals. In Kazakhstan, where the fuel mix currently consists of 80% coal, CCS will be deployed as an interim low-carbon measure. As one energy executive stressed, “For the transition period, we must use this opportunity for safe, stable supply in the domestic market. CCS can give us the possibility to survive the transition before starting with the renewables.” This strategy can allow time for renewables to be developed towards the country’s 2050 goal of 50% renewables mix, and the gradual phase-out of fossil fuels.

In the absence of a market for CCS created by regulation or higher carbon prices, or permanent funding for prototypes, few CCS demonstration projects have been launched in Africa, Asia or Latin America. Accelerating CCS demonstration efforts in non-OECD countries is critical to keep up with emission-reduction targets.[112] Projects in developing countries can also serve as an innovation ground to improve policymaking, technology and implementation, at a potential lower cost than possible in developed countries.[113]

Carbon pricing

Countries are implementing policies to internalise the costs and impacts of GHG emissions and to increase the adoption of technologies that decrease emissions from fossil fuels (such as CCS), or to stimulate efficiencies in fossil fuel generation. The carbon pricing toolbox includes carbon taxes, carbon trade markets and emission standards. Carbon pricing is being increasingly recognised by governments and the private sector as an effective market-based mechanism to meet global emission reduction targets. As one energy executive noted, “This market based instrument has the advantage that it does not discriminate certain

[111] IEA-ETSAP and IRENA (2012), Water Desalination Using Renewable Energy Technology: Brief no.112, March 2012
[112] See also, IEA CCS Roadmap with proposed 50 CCS projects in developing countries in the next 10 to 20 years, www.wri.org/publication/ccs-demonstration-developing-countries
[113] Forbes, S and Almendra, F (2011), Op. cit

generation technologies and furthermore it implements a platform for technology neutral innovation.The CO_2 emission reduction is being achieved at the lowest possible costs."

According to the World Bank, since 2012, the number of carbon pricing instruments implemented (or scheduled for implementation) has almost doubled, from 20 to 38. The share of emissions covered by carbon pricing has increased threefold over the last decade. By 2015, carbon pricing was in place in 40 national jurisdictions and 20 cities, states and regions, and a number of policies are due to be enacted by 2020, including in Chile and South Africa. The Canadian province of Ontario is building an emission trading scheme modelled after neighbouring Quebec, while Quebec and California expanded their cap-and-trade programmes in the past year by including transport fuel. In 2015, the combined value of carbon pricing instruments was estimated at just under US$50bn globally. However, 85% of emissions are priced below what economic models estimated is needed to reach the 2°C climate goal.[114]

Private companies, including more than 400 leading international companies in all sectors, are also using carbon pricing internally as a risk management strategy to test the impact of potential mandatory emission pricing, and locate opportunities for operational and energy efficiencies.[115] Leading up to COP 21, chief executives from 79 major firms, representing over US$2.1trn in revenues in 2014, called on climate leaders to include carbon pricing as a mitigation mechanism in the climate agreement.[116] This was also a key priority for energy leader's surveyed in the World Energy Council's 2015 Trilemma Report. A coalition of 11 European energy companies, called the Magritte Group that produce more than 50% of the electricity in Europe, also lent their support to a carbon price leading up to the COP 21 negotiations.[117]

With increasing consensus on the need for carbon pricing, new countries, such as Korea (Republic), are embarking on creating carbon markets, while others are adapting their existing markets, like the European Union Emission Trading System (EU-ETS), in response to the lessons learned. EU-ETS, the largest international carbon-pricing instrument, has faced issues with excess emission allowances that

[114] World Bank Group (2015), State and Trends of Carbon Pricing; See also, CDP (2015), Putting a Price on Risk: Carbon pricing in the corporate world
[115] Ibid.
[116] World Economic Forum (2015), Open Letter from CEOs to World Leaders Urging Climate Action, 23 November, 2015
[117] Engie (2015), "CEOs say carbon pricing is the best way to implement historic Paris deal", Politico (16 December, 2015)

have driven the price of carbon too low to incentivise significant mitigation efforts.[118] An energy executive stresses that a key finding from carbon markets is that “The fidelity of the price signal is critical and the clearer it is, the better… as it will result in a better allocation of resources and clearer signals for consumers.”

A reform of the programme will go into effect in 2019 to improve the cost-effectiveness of emissions reduction and make the system more resilient to macroeconomic dynamics.[119] Korea (Republic) is a new player in carbon trading that has also faced challenges in administering its programme, though in this case there are not enough emissions being traded due to a lack of liquidity and the price of emissions has been volatile in its first year (see case study on Korea, Republic). The Korea (Republic) case provides cautionary lessons for other emerging economies – and China in particular, as it prepares to launch its emission trading scheme in 2017.

The chief concern in both contexts has been the impact of carbon pricing on the competitiveness of domestic industrial sectors. However, the World Bank highlights that the risk is generally limited to emission and trade intensive industries, and can be abated through policy components, including free allocations, exemptions, rebates and financial assistance. With the COP 21 agreement extending climate commitments to all countries, and the use of carbon pricing in many countries’ NDCs, the risk of carbon leakage is also declining.[120] However, the mechanics for international linking of carbon markets and out of COP 21 have yet to be developed.

As noted above, regulations limiting GHG-intensive activities also apply an implicit cost on emissions. Regulations limiting GHG emissions in the transport sector are a prime example of this.

Approximately 25% of all GHG emissions in Europe and the US, and 10% in China, are made up of road transport emissions. The decarbonisation of transportation will therefore play an important role in reaching the climate targets set out in the COP 21 agreements.

---

[118] Carbon Market Watch (2014), What's Needed to Fix the EU's Carbon Market: Recommendations for the market stability reserve and future ETS reform proposals
[119] World Bank Group (2015),Op. cit
[120] Ibid.

KOREA

DECARBONISING THE ENERGY SECTOR

POLICY AND GOAL

The Act on Allocation and Trading of GHG Emissions (2012) created a mandatory emission trading scheme for the country's largest GHG emitters. The policy initially set a target of reducing GHG emissions by 30% below the business as usual scenario by 2020, as well as a 37% reduction by 2030 per Korea's INDC submission to the UNFCCC. In February 2016, South Korea abandoned its 2020 target but remains committed to the 2030 goals.[1]

IMPLEMENTATION

The first phase (2015–2017) is targeting 525 companies representing around 68% of national GHG emissions. Allocations are free for all sectors, and then will be given through a mix of free allowances and auctions in phases 2 and 3. In terms of compliance, emissions must be reported annually and verified by a third party. The penalty for non-compliance is up to three times the average market price of allowances of the given compliance year.[2]

ACHIEVEMENT

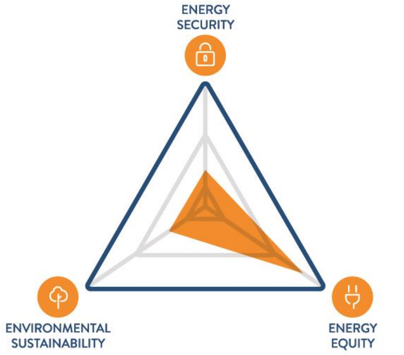
Since the launch of the scheme, illiquidity has been a regular feature in the market. 321,000 Korean Allowance Units (KAUs) were traded on the Korea Exchange (KRX) in the first 12 months of the scheme, out of around 545 million allowances given out for free. Offset trading has fared slightly better, with 920,000 Korean Carbon Units (KCUs) being exchanged in the first 12 months.[3]

CHALLENGES

Since the Korean market has historically been tightly managed by the government, the private sector is relatively inexperienced with commodity trading. Similarly, the Ministry of Environment and regulators are less experienced in using market-based mechanisms to resolve environmental issues.[4] Amid industry resistance to the programme and uncertainty around policy changes, companies have been reluctant to sell their allowances in the market and prices have continued to rise to levels which threaten to place significant financial burden on participating companies in the form of compliance or penalty costs.[5]

1. Carbon Pulse, February 2016: South Korea abandons 2020 GHG target, puts ETS in new hands and lifts early action credit cap.
2. International Carbon Action Partnership, March 2016: Korea Emissions Trading Scheme.
3. Carbon Pulse, January 2016: Analysis: Korea ETS poised for revamp after torturous first year.
4. Carbon Pulse, January 2016.
5. Carbon Pulse, January 2016: Analysis: Korea ETS poised for revamp after torturous first year.
6. IETA and KPMG, Sungwoo Kim and Hyoungchan Kim, 2015: Building a Korean ETS for the Future.
7. IETA and KPMG, 2015.

TRILEMMA BALANCE



INDEX RANK AND BALANCE SCORE

2011	2012	2013	2014	2015
55	54	64	55	54

LESSONS LEARNED

1. An ambitious cap on emissions can create resistance from industry.
2. Prior to launching an aggressive system, the government could ease the impact on targeted industries by offering government assistance, such as increased R&D funding, to help companies reach their carbon obligations.[6]
3. Illiquidity undermines the system – specific measures should be in place to kick-start trading when the number of market participants is low and a few companies hold the majority of allowances.[7]

Indeed, the EU, US and China – the world largest automobile markets – have set fuel economy improvement targets of approximately 30% for cars from 2014 to 2020. If the majority of these fuel economy improvements are met through electric vehicles, an estimated 7.6 million additional electric vehicles will be needed by 2020 in the EU, US and China alone.

The key policy strategy adopted by the Chinese government has been the use of subsidies for both producers and buyers. Through the use of subsidies, in 2015 China's electric vehicle industry had more than four times the sales figures for 2014, with 330,000 sold. However, this did not reach the target of 500,000 EV for 2015.

However, the use of subsidies as a policy strategy is being phased out and will be replaced by a government focus on the manufacturing of battery-related technologies, an industry where China has a natural advantage, due to its abundance of rare earth metals such as lanthanum, a key ingredient in hybrid technologies.

Decision makers have the opportunity to encourage alignment between electric vehicles manufacturers and utility companies. Utilities are increasingly recognising electric vehicles as one of their largest growth opportunities, especially in more mature EU and US markets. The additional electricity required to fuel the estimated 7.6 million additional electric vehicles needed to achieve the fuel economy targets would correspond to approximately half of the electricity consumed in Switzerland in 2011. This also underlines the importance of decarbonising the electricity sector.

There could be an opportunity for utilities to act as a catalyst to overcome the barriers for consumers to adopt electric vehicle technologies, including providing finance to address high vehicle prices and range anxiety, and provide access to charging infrastructure.

FINDINGS AND RECOMMENDATIONS

Decarbonising the economy demands a broad policy package, including a price on carbon and incentives to ensure low carbon and carbon mitigating technologies are financed and deployed. With the long-term goal of net zero carbon emissions, policymakers must avoid decisions that would lock in high-emission trajectories and infrastructure investments that will be obsolete in a low carbon economy. The case studies discussed offer some evolving lessons for countries implementing decarbonisation measures while balancing growth priorities and public support.

- **Renewable energy investment policies need to be dynamic:** Policies must be designed at the outset to enable adaption in relation to the market, technological developments, and lessons from other countries' experiments.

- **The process to amend policies needs to be transparent and phased:** Nascent renewable and carbon markets respond sharply to policy uncertainty. Policymakers should develop clear channels to communicate policy changes and ensure predictable implementation.

- **The government has a strong role in educating and incentivising the private sector to embrace green goals:** As Korea's early experience with emission trading schemes demonstrates, the private sector (particularly in developing countries) may require additional engagement and education to embrace green policies. This can take many forms – from monetary support for green RD&D to 'soft' levers such as capacity building with international organisations (see Box 5 on page 30 – UAE vision 2021 to diversify the energy mix), or reputational incentives to be 'branded' green/energy efficient (see case study on page 83 – Japan: Top Runner programme).

- **Carbon markets allow emissions to be reduced in the most cost-efficient way.** Tools to keep supply and demand of allowances in balance are needed to cope with possible external shocks (such as financial crisis). Such tools should be based as much as possible on automatic mechanisms to avoid government intervention.

Conclusions

The energy sector has ambitious goals and significant challenges to meet its commitments under the COP 21 agreement and the Sustainable Development Goals, while continuing to balance the energy trilemma to provide secure, affordable and environmentally sustainable energy. The five years of energy trilemma assessments, and many countries' initiatives to drive changes in their energy systems, provide a range of policies which yield learning to support country-level and global goals. There are examples of policy initiatives focused on all dimensions of the energy trilemma, from nearly every country in the world – spanning different country contexts, GDP groups, geographic regions and energy resources. Policymakers and the energy sector can learn and benchmark from these efforts as countries look to transform their energy sectors and put in place the policy frameworks to support ongoing change.

Through case studies and interviews, this 2016 World Energy Trilemma report has identified five key areas to stimulate development in energy systems and balance the energy trilemma. Common lessons can be found across the five areas to support energy policy development. The review also reinforced three interconnected policy areas to create an attractive foundation for private sector investments in all aspects of the global energy sector as identified in 2012:

- a coherent and predictable energy policy
- stable regulatory and legal frameworks for long-term investment
- public and private initiatives that enable RD&D and innovation.

ENERGY POLICYMAKING POST COP 21: LESSONS FOR POLICYMAKERS AND THE ENERGY SECTOR

Provide clarity to the market

Throughout the energy trilemma research, one message has been clear around the globe: the level of policy and regulatory risk around energy investments must be minimised. Clarity in energy policy and regulations is key to reducing the cost of capital and attracting investments. As one energy executive noted, "The clearer the goal is, the better allocation of resources."

As they update energy policies to meet COP 21 commitments, policymakers will need to provide more detail on the instruments they will use to attain these goals and to generate public and industry support. Broad consensus on the approaches to be used in the medium- and long-term is crucial to create a stable business environment to support energy investments.

Push change in critical areas using a staged approach

The policy review also highlighted the importance of mechanisms that keep policies up-to-date. In a period of continued volatility in energy markets and technological developments, policymakers must find the balance between consistency, transparency and stability while not locking-into costly or unsustainable approaches. For example, a renewable-energy promotion system based on ‘produce and forget’, with long-term guaranteed margins for investors, is not a sustainable solution in the long term. It is only appropriate at the very starting point. As one policymaker advised, “Take a more staged approach, especially when it is related to new technologies, and their cost could come down.”

While acknowledging the benefits of moving forward in stages, energy leaders also noted the need for a strong push to make changes. As one energy leader noted, “Do a plan and go ahead… political leadership matters and sometimes you need to make critical pressure to ensure things move forward.”

Take a change management approach in communicating policies and setting expectations

The evolution of the global energy system, including expanded access, new regulatory frameworks, new technologies, and new players in the energy system, to name a few, is gathering pace. There will be some more and some less successful policies; some areas of RD&D will lead to breakthrough and others will not; cost savings may be achieved in the short-term but, in some cases, may not materialise. However, long-term agreements are essential to reduce the cost of capital, ensure investors' confidence and therefore support the transition to decarbonisation. Politics will have an impact on policies. In this context, (as one policymaker suggested), “You need a clear communication plan and a risk-tolerant public willing to accept failures here and there for the overall good.”

Stimulate a broader industry engagement

Robust and strong dialogue between policymakers and industry is crucial to ensuring the development of a regulatory framework to support a resilient 21st century energy system. The energy system is undergoing many changes and governments are pilot testing or evolving regulatory frameworks to support the increased use of renewables, the development of the smart grid or the expanding use of electric vehicles. Dialogue on what works, and insights on technology developments, will help ensure up-to-date policies.

As well as the investment community, it is also important to discuss the expanding range of companies that are involved in the energy sector. For example, information technology companies are heavily invested in developing energy storage solutions. Corporations are also driving growth in renewables as an increasing range of companies – including retail, IT, manufacturing and hospitality – across all sectors, are entering into power purchase agreements for renewable energy through large- and utility-scale, off-site, renewable energy procurement. In 2015 corporations – rather than utilities – accounted for the majority of wind energy deals in the US.[121] This power purchase agreement approach is also being used in many developing countries where companies could face scheduled load shedding, electricity price hikes, forced load curtailment, or no access to the state grid. Research indicates that, for many companies, the shift to renewable energy is driven by cost as well as environmental considerations.[122]

Look beyond the energy sector to meet climate and energy goals

Decarbonising the economy and meeting COP 21 goals will require huge changes in the energy sector, but the climate goals will not be achieved solely through these changes. Decarbonisation of the broader economy will be necessary and will require changes in energy demand across all economic sectors – transportation, manufacturing, agriculture and commercial and residential buildings.

The necessary changes to the energy sector and energy demand must be aligned to the broader national economic agenda. For example, are energy sector policies aligned to the country's industrial growth or transportation policies at city, regional and national levels? And are planned developments in the energy sector aligned with job stimulation plans?

Support strategies to finance the equitable transition to a low-carbon energy system and an expanded energy system

The financial community and high rates of investment in the energy sector are critical to achieving energy goals. As noted in the 2014 World Energy Trilemma report: Time to get real – the myths and realities of financing energy systems, the financial sector has the view that the necessary level of capital to meet energy needs exists, but questions whether the energy sector will be able to attract and absorb capital on the necessary scale.

To reduce their risk, institutional investors, who are a large segment of potential infrastructure investors, are increasingly assessing investments against long-term trends, including climate risks and the risks of stranded assets.[123] Indeed over 500 institutions with assets totalling more than US$3trn have divested from fossil fuel

---

[121] Labrador D, "First-time buyers are dominating corporate renewable purchasing", RMI (17 February, 2016); American Wind Energy Association (2015), US Wind Industry Fourth Quarter 2015 Market Report
[122] Baker & McKenzie (2015), The rise of corporate PPAs: A new driver for renewables
[123] Mercer (2015), Investing in a Time of Climate Change

portfolios over the past couple of years.[124] The challenge for the energy sector is to ensure that high volumes of investments remain in the sector, that there are clear mechanisms to support investments, and that divestiture from fossil fuels (which will provide the backbone of global energy supply through 2050) does not jeopardise energy security.

The financial community and entrepreneurs can also bring forward innovative mechanisms to pay for expanding energy access, as the examples of cell-phone-enabled systems have demonstrated.

Increase communications with the public

In a period of rising social media use, more and more segments of the population and communities are voicing their perspectives on the development and siting of energy infrastructure and the focus of energy policies. The experience of one energy executive sums it up for many globally, “I think we underestimated some of the community involvement, and everyone involved in infrastructure has had the same experience.”

Leadership to build social acceptance for changes to energy supply and demand is more critical than ever before. In a period of transition and rising energy literacy from the public, communication with the wider society is increasingly important in energy planning. “Explaining the value equation to the general public is a challenge – you need to do it earlier and explore options and alternatives and make sure people get a good grasp of that.”

Meet the need for more research and development to support private sector innovation

Research, development and deployment, along with innovation, are critical to achieving current and future energy goals. Government-funded RD&D can help accelerate and attract private investment in key areas and remains critical in the area of carbon mitigation.

Private sector innovation has been key to reducing costs in energy technology development and often in financing the adoption of energy technology – particularly in energy efficiency, (such as building efficiency or residential energy efficiency). Alongside energy storage, private sector innovation will also support needed reductions in energy demand.

---

[124] Henn J and Dubois C (2015), “Divestment commitments pass the $3.4 trillion mark at COP21”, 350.org (2 December, 2015)

APPENDIX: EXPERT INTERVIEWS

The World Energy Council and Oliver Wyman, a subsidiary of Marsh & McLennan Companies, would like to thank the following global energy leaders and their teams for taking the time to talk to us during the preparation of this report and for taking an active role in driving forward this critically important dialogue regarding our global energy future. Your perspectives and insights have been very helpful and enriched the process greatly.

- Robert Pritchard, Executive Director, Energy Policy Institute of Australia
- Ricardo Gorini, Head of the Energy Economic Department, Energy Research Office (EPE), Brazil
- Roberto Schaeffer, Professor, Energy Economics, Federal University of Rio de Janeiro, Brazil
- Alexandre Szlko, Professor, Energy Planning Programme, Federal University of Rio de Janeiro, Brazil
- Colin Andersen, Chair, Energy Council of Canada
- Jeff Labonté, Director General, Energy Safety and Security, Government of Canada
- Corissa Petro, Professional, International Section, Ministry of Energy, Chile
- Satu Helynen, Vice President, Operations, Smart Industry and Energy Systems, VTT Technical Research Centre of Finland
- Pentti Puhakka, Proeject Leader, Energy conservation and Energy efficiency, Energy Department, the Ministry of Employment and the Economy, Finland
- Rolf-Martin Schmitz, Chief Operating Officer, RWE, Germany
- Martin Schöpe, Head of Division, General Iissues of International and External Energy Policy of the Ministry of Economics and Energy, Government of Germany
- Carlo Pignoloni, Head of Italy and Europe Area, Enel Green Power, Italy
- Masakazu Toyoda, President and CEO, Institute of Energy Economics Japan (IEEJ), Japan
- Almasadam Satkaliyev, Chairman, Samruk-Energy JSC, Kazakhstan

- Joo Young Joon, Director, Ministry of Trade, Industry and Energy Korea (Republic)
- Francisco Xavier Salazar Diez Chair, World Energy Council Mexican Committee, Former Chairman, Energy Regulatory Commission of Mexico
- Abubakar Sambo, Former Director General, Energy Commission, Nigeria
- Paddy Padmaathan, President and CEO, ACWA Power, Saudi Arabia
- Brian Statham, Chair, South African Member Committee
- Suhail Al Mazrouei, Minister of Energy, Government of the UAE,
- Peter Mather, Country Head of UK and Vice President of Europe, BP, United Kingdom
- Tony Cocker, Chief Executive Officer, E.ON, United Kingdom
- David Turk, Deputy Assistant for International Climate and Technology, US Department of Energy, United States
- Olga Otegui, National Energy Director of the Ministry of Industry, Energy and Mining, Government of Uruguay

ACKNOWLEDGEMENTS

The project team would like to thank the individuals who informed the project's approach, supplied information, provided ideas and reviewed drafts. Their support and insight has provided an invaluable contribution to the development and quality of the report.

WORLD ENERGY COUNCIL STUDY GROUP – PRINCIPAL CONTRIBUTORS

Joan MacNaughton (Executive Chair); Philip Lowe (Vice Chair); Hajime Murata (Honorary Chair)

(Note: organised by countries' alphabetical order)

Maria Eugenia Posleman, Argentina; Ernesto Badaraco, Argentina; Horacio Fernandez, Argentina; Philipp Irschik, Austria; Simonetta Naletto, Belgium; Boris Gorenstin, Brazil; Maria Claudia Grillo, Brazil; Lauro Valdir de Souza, Brazil; Pietro Erber, Brazil; David Collie, Canada; Andrew Pietrewicz, Canada; Dan Boucher, Canada; Jim Crone, Canada; Steve Dorey, Canada; Peter Edwards, China; Gabriel Vizcaino, Colombia; Daniel Diaz Toro, Colombia; Daniel Romero, Colombia; Linda Chimborazo, Ecuador; Ahmed Sami, Egypt; Tawfik F. Azer, Egypt; Mihkel Härm, Estonia; Jourma Routti, Finland; Pirjo Jantunen, Finland; Alain Bucaille, France; Francois Dassa, France; Jean-Michel Trochet, France; Jean-Eudes Moncomble, France; Christian Hoffmann, Germany; Jochen Lorz, Germany; Katharina Klein, Germany; Ulrike Doering, Germany; Stefan Saatmann, Germany; Kwaku Jnr. Kunadu, Ghana; John W. M. Cheng, Hong Kong, China; Joseph Law, Hong Kong, China; Karuna Kalra, India; Pradeep Chaturvedi, India; Rupa Devi Singh, India; Mohsen Mazloum Farsibaf, Iran; Mehdi Sadeghi, Iran; Jan Okko Ziegler, Italy; Sunil Parwani, India; Luca Bragoli, Italy; Mariano Morazzo, Italy; Daniela Di Rosa, Italy; Giuseppe Montesano, Italy; Marco Piredda, Italy; Carlo Stagnaro, Italy; Valeria Palmisano, Italy; Hajime Murata, Japan; Samal Bex, Kazakhstan; Michel-Ange Medlej, Lebanon; Gintaras Adzgauskas, Lithuania; José María Valenzuela, Mexico; Sanae Boujrada, Morocco; Maxwell Muyambo, Namibia; Jenny Lackey, New Zealand; Andrew Millar, New Zealand; John Carnegie, New Zealand; Mahaman Laouan Gaya, Niger; Roseline Kela, Nigeria; Abbas Musa, Nigeria; Michal Smyk, Poland; Dariusz Gulczynski, Poland; Nuno Ribeiro da Silva, Portugal; Anton Vladescu, Romania; Luminita Durau, Romania; Mothana Alodhaib, Saudi Arabia; Yousef Alshammari, Saudi Arabia; Noura Mansouri, Saudi Arabia; Miodrag Mesarovic, Serbia; Charles Mahony, South Africa; Nombeko Mbava, South Africa; Raúl Alejandro Livas Elizondo, Spain; Paul Westin, Sweden; Wolfgang Kweitel, Switzerland; Chawalit Pantaros, Thailand; Cansu Karaca, Turkey; Aylin Çiğdem Köne, Turkey; Ghasaq Yousif Shaheen, United Arab Emirates; Simone Bares, United Kingdom; Susan Lower, United Kingdom; Ashutosh Shastri, United Kingdom; Michael Putra, United Kingdom; Serhat Akmeşe, United States; Cecilia San Roman, Uruguay, Wisdom T Farirai, Zimbabwe

Stuart Neil (Senior Director, External Affairs and Communications, World Energy Council); Alessandra DeZottis (World Eneryg Council)

FUTURE ENERGY LEADER'S CLIMATE CHANGE TASK FORCE

Peter Edwards, China; Pirjo Jantunen, Finland; Samal Bex, Kazachstan; Michel-Ange Medlej, Lebanon; Andrew Millar, New Zealand; Abbas Musa, Nigeria; José María Valenzuela, Mexico; Cansu Karaca, Turkey; Susan Lower, United Kingdom; Wisdom T Farirai, Zimbabwe

WORLD ENERGY COUNCIL STUDIES COMMITTEE

Brian Statham, South Africa (Chair); William D'haeseleer, Belgium; Claudia Cronenbold, Bolivia; Eduardo Correia, Brazil; Jing Ding, China; Bin Wei, China; Qinhua Xu, China; Yaxiong Zhang, China; Li Zhu, China; Jean-Paul Bouttes, France; Rauno Rintamaa, Finland; Jeanne Ng, Hong Kong; B P Rao, India; Atsushi Noda, Japan; Nastaran Rahimi, Iran; Alessandro Costa, Italy; Carlo Papa, Italy; Hardiv Situmeang, Indonesia; Arturo Vaca, Mexico; Jan Antonczyk, Poland; Ioan Dan Gheorghiu, Romania; Ayed Qahtani, Saudi Arabia; Maria Sunér Fleming, Sweden

OLIVER WYMAN / MARSH & MCLENNAN COMPANIES PRINCIPAL CONTRIBUTORS

Francois Austin (Global Leader, Energy Practice, Oliver Wyman); James Basden (Partner, Oliver Wyman); Richard Druce (Associate Director, NERA); Andrew George (Energy and Power Chairman, Marsh); Bernhard Hartmann (Partner, Oliver Wyman); Wolfram Heidrich (Partner, Oliver Wyman); Wing Yi Kan (Associate, Oliver Wyman); Louisa Li (Principal, Oliver Wyman), Arun Mani (Partner, Oliver Wyman); Rodolfo Macarrein (Partner, Oliver Wyman); Sandro Melis (Partner, Oliver Wyman); Ana Patricia Giraldo Moreno (Managing Director, Marsh); Bob Orr (Partner, Oliver Wyman); Robert Peterson (Partner, Oliver Wyman); Jane Ren (Senior Director, Oliver Wyman); Saji Sam (Partner, Oliver Wyman); Veit Schwinkendorf, (Partner, Oliver Wyman); Richard Smith-Bingham (Director, Global Risk Center, Marsh & McLennan Companies); Michael Wagner (Partner, Oliver Wyman); Alex Wells, (Consultant, Oliver Wyman); Kate Wildman (Manager, Oliver Wyman); Alex Wittenberg (Executive Director, Global Risk Center, Marsh & McLennan Companies)

PROJECT TEAM

Christoph Frei (Secretary General, World Energy Council); Joan MacNaughton (Executive Chair, World Energy Council); Brian Statham (Chair, Studies Committee, World Energy Council); Sandra Winkler (Director Policies, World Energy Council); Upinder Aujla (Principal, Oliver Wyman); Thorsten Querfurt (Partner, Oliver Wyman)

AUTHORS / PROJECT MANAGEMENT

Roxana Gharegozlou (Senior Consultant, Oliver Wyman); Lucy Nottingham (Director, Global Risk Center, Marsh & McLennan Companies); Andrea Buser (Manager Trilemma & Issues Monitor, World Energy Council); Diletta Giuliani (Senior Manager, Trilemma, World Energy Council)

OFFICERS OF THE WORLD ENERGY COUNCIL

MARIE- JOSÉ NADEAU
Chair

YOUNGHOON DAVID KIM
Co-chair

MATAR AL NEYADI
Vice Chair – Special Responsibility
Gulf States/Middle East

NUER BAIKELI
Vice Chair – Asia

KLAUS-DIETER BARBKNECHT
Vice Chair – Finance

LEONHARD BIRNBAUM
Vice Chair – Europe

OLEG BUDARGIN
Vice Chair – Responsibility for
Regional Development

JOSÉ DA COSTA CARVALHO NETO
Chair – Programme Committee

JEAN-MARIE DAUGER
Chair – Communications & Strategy Committee

HASAN MURAT MERCAN
Vice Chair – 2016 Congress, Istanbul

BONANG MOHALE
Vice Chair – Africa

SHIGERU MURAKI
Vice Chair – Asia Pacific/South Asia

O.H. (DEAN) OSKVIG
Vice Chair – North America

BRIAN A. STATHAM
Chair – Studies Committee

JOSÉ ANTONIO VARGAS LLERAS
Vice Chair – Latin America/Caribbean

CHRISTOPH FREI
Secretary General

PATRONS OF THE WORLD ENERGY COUNCIL

World Energy Trilemma 2016, published by the World Energy Council 2016 in partnership with OLIVER WYMAN

World Energy Council, Company Limited by Guarantee No. 4184478
Registered in England and Wales
VAT Reg. No. GB 123 3802 4
Registered Office 62–64 Cornhill, London EC3V 3NH
www.worldenergy.org

ISBN: 978 0 946121496

WORLD ENERGY COUNCIL

Algeria
Argentina
Armenia
Austria
Bahrain
Belgium
Bolivia
Botswana
Brazil
Bulgaria
Cameroon
Canada
Chad
Chile
China
Colombia
Congo (Dem. Rep.)
Côte d'Ivoire
Croatia
Cyprus
Czech Republic
Denmark
Ecuador
Egypt (Arab Rep.)
Estonia
Ethiopia
Finland
France
Gabon
Germany
Ghana
Greece
Hong Kong, China
Iceland
India
Indonesia
Iran (Islamic Rep.)
Iraq
Ireland
Israel
Italy
Japan
Jordan
Kazakhstan
Kenya
Korea (Rep.)
Kuwait
Latvia
Lebanon
Libya
Lithuania
Luxembourg
Mexico
Monaco
Morocco
Namibia
Nepal
Netherlands
New Zealand
Niger
Nigeria
Pakistan
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Saudi Arabia
Senegal
Serbia
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Swaziland
Sweden
Switzerland
Syria (Arab Rep.)
Tanzania
Thailand
Trinidad & Tobago
Tunisia
Turkey
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Zimbabwe

62–64 Cornhill
London EC3V 3NH
United Kingdom
T +44 (0) 20 7734 5996
F +44 (0) 20 7734 5926
E info@worldenergy.org

www.worldenergy.org | @WECouncil