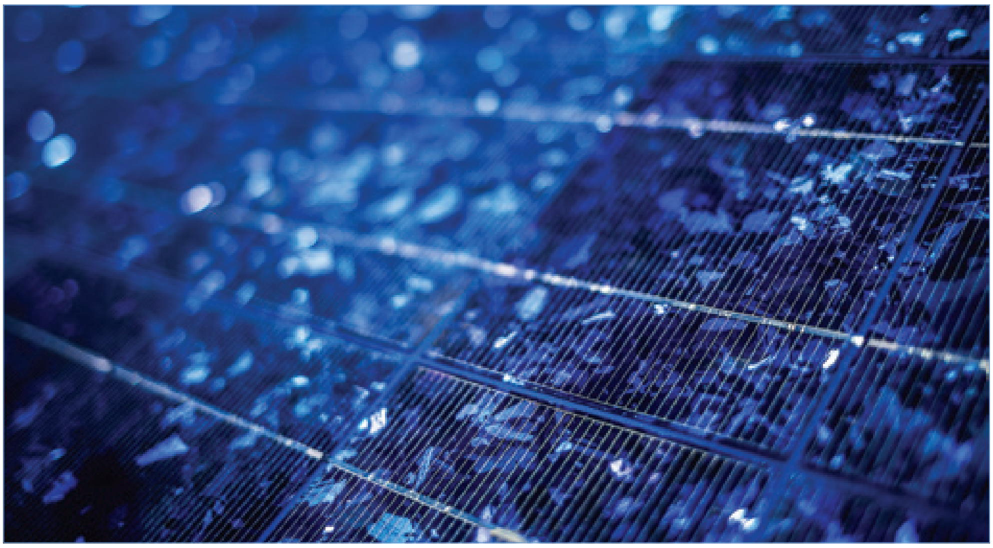
LCTPi
Led by wbcsd

Low Carbon Technology Partnerships initiative

Scaling UP renewables

“The challenge
is significant,
but it is surmountable
The time to act is now”



LCTPi
Led by wbcsd

CEO Statement

With power, comes responsibility.

Power is the engine of development in the modern age. It has enabled the human race to reach new heights, raise living standards across the globe and achieve some of our greatest goals.

It is also a service whose generation and use has traditionally been a primary contributor to climate change.

An urgent and industry-wide transformation is needed in order to decarbonise the electricity sector and help ensure that the rise in global temperatures is limited to under 2°C.

The challenge is significant, but it is surmountable. The very attributes of the power sector that have driven the progress of the human race since the industrial revolution are also the ones that can help to save it. With technologies that have been more recently developed, the sector has one of the biggest opportunities to be a main contributor to a low-carbon, sustainable energy world.

Fifteen leading companies in the renewable energy sector agree on a shared vision to speed up this transition to a low carbon energy system by accelerating the deployment of renewable energy. We understand our responsibility, and we are taking the lead.

The time to act is now.

This is our statement of ambition:
Renewable energy is reliable and increasingly competitive. We believe that 1.5 TW of additional capacity can be deployed before 2025.

In addition to hydropower, currently the largest renewable energy source, wind and solar photovoltaic power are widely deployed, mature technologies that are increasingly competitive with traditional energy sources. At the same time, investor demand for renewable assets is growing.

But there are still barriers that prevent the widespread uptake of renewable energy technologies and its benefits. Effective integration of increasing penetration of renewable energy in the grid and ensuring access to finance for renewable energy projects are the two that we believe are most significant.

Together we are developing solutions to address these barriers by:

- **Facilitating efficient, reliable, effective and commercially viable integration of renewable energy** into grids and electricity markets, by developing evolutionary solutions and recommendations, by proactively engaging with policymakers and regulators and by promoting energy interconnections globally;
- **Facilitating the significant scaling up of green bond finance** through a commitment to robust verification and transparency as well as de-risking our project pipelines;
- **Working with corporate renewable energy buyers to scale renewable energy procurement** and increase direct demand for renewable energy;
- **Promoting sustainable electrification of remote areas** via accelerated deployment of low carbon microgrids.

Business has taken the lead in technological development. In many cases the technologies are also commercially available. In some cases further development is needed, such as for crucial enabling storage and smart grid technology.

New business models and forward-looking regulatory and market structures are the next step towards facilitating the accelerated deployment of renewable energy technologies at the lowest economic, environmental and societal cost.

However, business cannot act alone. Success also depends on urgent action by governments, both at the local and global level. Current market and regulatory conditions cannot drive the global deployment of renewable energy technology at the speed that is required.

There is no “silver bullet” from either technology or policy. Policies need to be tailored to match national contexts and to remove the barriers we have identified, and to put renewable technologies on a level playing field with conventional ones. Critically, governments need to work together across the globe, to address this inherently global challenge.

We believe that public policies should promote:

- A stable and robust carbon pricing system across all sectors of the economy with dedicated use of revenues for renewable energy and other low carbon initiatives;
- A stable and reliable energy policy framework that sends a clear signal to investors while being flexible to evolving technical, economic and social circumstances;
- A level playing field between renewable and conventional technologies, addressing issues such as subsidies to fossil fuels, discriminatory market rules in some markets, systemic bias in financial regulation and unfavourable administrative requirements;
- Development of operational and market frameworks to harness and value the full potential of renewable generation and facilitate the deployment of new business models;
- Planning of and investment in transmission and distribution infrastructure with consideration for the growing penetration of distributed renewable energy;
- Support for innovation and R&D across a wide range of proven and promising technologies.

Ulrich Spiesshofer
CEO, ABB Group

José Manuel Entrecanales
Chairman & CEO, ACCIONA

Richard Lancaster
CEO, CLP Holdings

David Walker
CEO, DNV GL Energy

Jean-Bernard Lévy
Chairman and CEO, EDF

António Mexia
CEO, EDP Group

João Manso Neto
CEO, EDP Renováveis

Gérard Mestrallet
Chairman and CEO, ENGIE

We will continue to innovate and invest in renewable energy and we will continue to work together on the actions listed above.

These efforts will drive down carbon emissions from the energy sector and bring wider benefits to society, the environment and the economy. These benefits range from enhanced energy security, positive socio-economic impacts particularly for local communities, and increased flexibility and resilience of electricity systems.

We emphasise that government action on these recommendations is also necessary to ensure the scalability of our business solutions and, ultimately, to remain under the 2°C threshold.

We look to governments and to other stakeholders to work together to create a policy environment that encourages and supports this massive and essential investment in renewable energy infrastructure.

With power, comes responsibility. The time to act is now.

James A. Hughes
CEO, First Solar

Ignacio S. Galán
Chairman and CEO, Iberdrola

Liu Zhenya
Chairman, State Grid Corporation of China

Jean-Pascal Tricoire
Chairman and CEO, Schneider Electric

Christian Rynning-Tønnesen
President and CEO, Statkraft

Anders Runevad
Group President & CEO, Vestas Wind Systems

Vineet Mittal
Managing Director, Welspun Energy

Contents

LCTPi

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How to get more renewables into the electricity mix

SCALING UP RENEWABLES

Introduction

Considerable acceleration in deployment of renewable energy is needed in order to decarbonize the energy sector and achieve the International Energy Agency 2°C scenario.

In addition to hydropower, currently the largest renewable energy source, wind and solar photovoltaic (PV) are mature technologies that are increasingly competitive with conventional energy sources. Meanwhile, demand for renewable assets from investors is growing. However, challenges remain or, indeed, emerge – particularly in terms of integration of increasing penetrations of renewable energy (RE) into the grid, electricity market design, ensuring bankability of RE projects and scaling finance for RE deployment.

Through the Low Carbon Technology Partnerships Initiative, a group of leading companies in the energy sector are working together on solutions to directly address these key barriers to accelerated deployment of RE and to enable the transition to a low carbon economy to be achieved at the lowest possible financial, environmental and societal cost.

The Low Carbon Technology Partnerships Initiative (LCTPi)

The objective of the LCTPi is to catalyse actions to **accelerate low-carbon technology development** and scale up the deployment of business solutions, to a level and speed that are consistent with the objective of limiting global warming to below 2°C compared to pre-industrial levels.

LCTPi is a **collaborative platform**, gathering together project teams and stakeholders to discuss and agree **concrete actions that are needed to accelerate low-carbon technology innovation and scale up technology and solution diffusion.**

It focuses on solutions that are beyond business as usual. It is a unique opportunity to showcase how business can and is tackling climate change.

The development and implementation of business solutions in the LCTPi focus on:
- **Removing the barriers** that are preventing existing solutions from being deployed;
- **Developing new solutions** to complement existing ones.

The LCTPi is supported by the French Presidency of COP21. It is one of the flagship initiatives of the Lima – Paris Action Agenda for COP21, coordinated by the French Presidency of COP21, the Peruvian Presidency of COP20, the UN Secretary General's office, and the Executive Secretariat of the UNFCCC.

THE SCALING UP RENEWABLES LCTPi

Scaling Up Renewables is one of the nine LCTPi tracks. In this track, sixteen of the world's leading companies worked during 2015 to develop a vision for renewable energy.

The group shares the ambition that:
Renewable energy is reliable and increasingly competitive and we believe that 1.5 TW of additional capacity can be deployed before 2025. We are working to scale up deployment by improving RE integration and removing barriers to finance.

The 1.5 TW figure is based on the International Energy Agency (IEA) 2 degrees scenario (DS) which states that renewable energy capacity must grow from 1.94 TW in 2015 to 3.49 TW in 2025 and 4.53 TW in 2030, as illustrated in Figure 1.

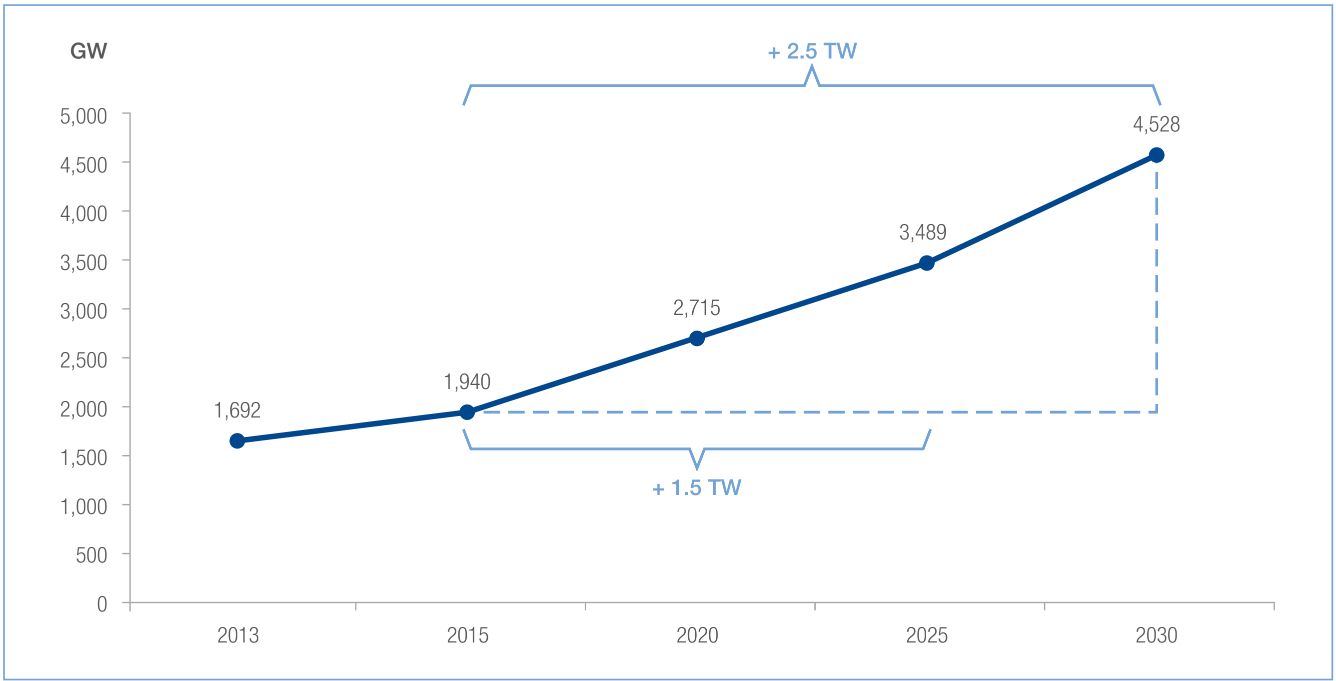

Figure 1. Renewable energy deployment required under IEA 2DS scenario[1)]

This deployment of RE will reduce cumulative global CO_2 emissions by 13 Gt by 2025 and by 35Gt by 2030 compared with the IEA 6DS. Annual CO_2 emissions reductions are 3Gt per annum and 5Gt per annum in 2025 and 2030, respectively.

Four action plans have been developed to address the key barriers:

- **Facilitating efficient, reliable, effective and commercially viable integration of renewable energy** into grids and electricity markets, by developing evolutionary solutions and recommendations, by proactively engaging with policymakers and regulators and by promoting energy interconnections globally**;**
- **Facilitating the significant scaling up of green bond finance** through a commitment to robust verification and transparency as well as de-risking our project pipelines**;**
- **Working with corporate renewable energy buyers to scale renewable energy procurement** to substitute demand away from fossil fuels and towards RE;
- **Promoting sustainable electrification of remote areas** via accelerated deployment of low carbon microgrids**.**

Further details of these plans can be viewed in Annex 2.

Overview of technologies and competitiveness

RENEWABLES TODAY: HOW COMPETITIVE?

In recent years, modern renewable energy – in particular, wind and solar PV power - have made significant progress towards long-term competitiveness with fossil fuels.

As of 2015, renewable energy accounted for 22.8% of global electricity production. Hydropower is the largest renewable energy source, accounting for 16.6%, followed by wind at 3.1%, biopower at 1.8% and solar PV at 0.9% (see Figure 2). While hydropower continues to dominate the mix, non-conventional renewables (i.e. excluding large hydro) are experiencing much higher growth rates, with an average growth rate of 18% in 2014, compared with 3.6% for hydro[2)]. This report will focus on onshore wind, solar PV and hydropower.

[1)] IEA, 2015, "Medium-term RE Market Report 2014"& ETP 2015. 2020 figure has been estimated with a linear growth rate between 2015 and 2025 IEA estimates

[2)] REN21, 2015, "Renewables 2015 Global Status Report", accessed at www.ren21.net/ren21activities/globalstatusreport.aspx, 4/7/2015.

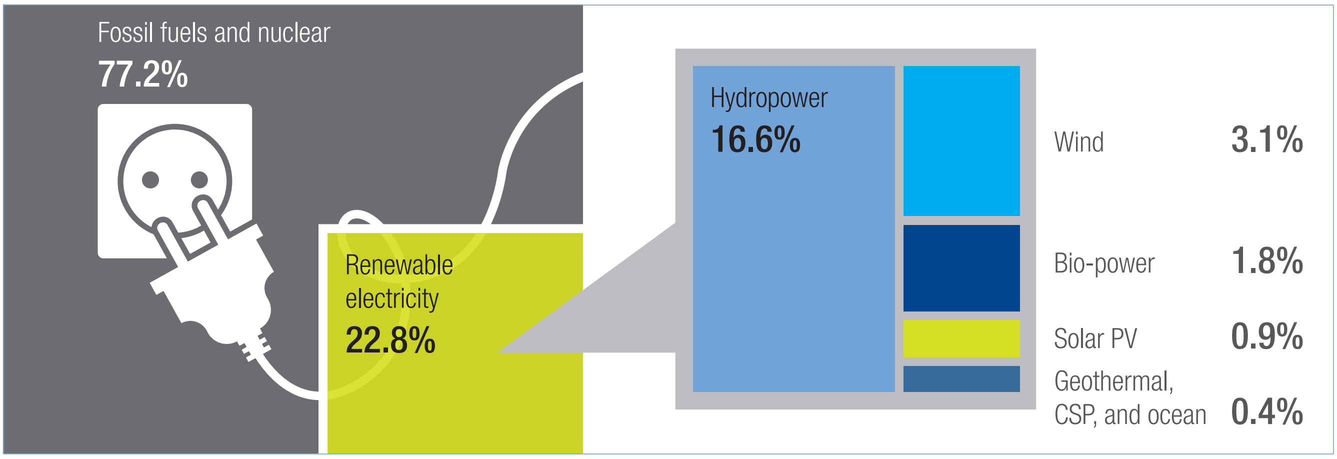

Figure 2. Estimated RE share of electricity production, end-2014[1]

Wind power

Wind power is currently the most widely deployed non-conventional renewable energy source, accounting for approximately 3% of electricity production. The year 2014 saw record installations for wind power, led by China; over 51 GW of new capacity was installed globally to bring the total to 370 GW[2]. Onshore wind power is amongst the lowest cost sources of electricity globally and is already cost competitive with wholesale conventional fossil fuel generation in some markets. Production costs have decreased significantly over the past 10 years and, in combination with technological advances, continue to drive both installed costs and levelized costs lower (the levelized cost of electricity, LCOE, is typically defined as the unit cost of producing electricity over the lifetime of the plant). IRENA reports the LCOE of onshore wind to be between USD 60-90/MWh, with the best projects delivering electricity at USD 50/MWh without any support[3]. Meanwhile, the move towards higher hubs and greater rotor diameters facilitates the development of less windy sites, that were not considered economically viable even a few years ago.

Solar PV power

Like wind power, solar PV power is a mature renewable technology that is experiencing rapid growth in deployment. While currently accounting for less than 1% of global electricity production, solar PV accounted for 30% of all new renewable power capacity in 2013, bringing the global total to 139 GW[4] and 2013 was the first year in which global deployment of solar PV exceeded that of wind. Reductions in module costs have been dramatic in the past six years, falling 80% (see Figure 3 below), and, although the LCOE of solar PV is higher than that of wind – with an estimated LCOE of USD 110-280/MWh on average[5] – recent auctions around the world have revealed considerably lower figures; PPAs for new plants in Germany and Chile are around USD 100/MWh, while winning bids for projects in recent tenders in the Middle East - including Dubai and Jordan - ranged between USD 60-70/MWh[6]. India has seen dramatic cost reductions in recent years, with current average LCOE estimated at USD 130/MWh. Moreover, the flexibility and modularity of solar PV means it holds particular promise as installations can be deployed at a variety of scales and locations and often directly at the point of consumption, potentially avoiding costly network investment. This presents a unique competitive advantage for the technology, and installations at the residential and commercial scale have in many markets achieved or are rapidly approaching retail grid parity; in Australia, for example, high retail electricity prices mean grid parity is a reality in many parts of the country, and one in six households have solar PV installed[7]. This is causing significant disruption to traditional utility business models.

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[1] Adapted from REN21, 2015, "Renewables 2015 Global Status Report", accessed at http://www.ren21.net/ren21activities/globalstatusreport.aspx

[2] GWEC, 2014, "Global Status of Wind Power in 2014" accessed at www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf, accessed 4/5/2014

[3] IRENA, 2014, "Renewable power generation costs in 2014", accessed at www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494, accessed 4/5/2015.

[4] REN21, 2015, "Renewables 2015 Global Status Report", accessed at www.ren21.net/ren21activities/globalstatusreport.aspx, 4/7/2015.

[5] IRENA, 2014, "Renewable power generation costs in 2014", accessed at www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494.

[6] Parkinson, G, 2015, "Jordan solar tender confirms 6c-8c/kWh as new solar benchmark", accessed www.reneweconomy.com.au/2015/jordan-solar-tender-confirms-6c-8ckwh-as-new-solar-benchmark-75006.

[7] Gifford, J, 2015, "Australia leads world in residential solar penetration", accessed www.pv-magazine.com/news/details/beitrag/australia-leads-world-in-residential-solar-penetration_100021291/#axzz3oWLcEaHJ.

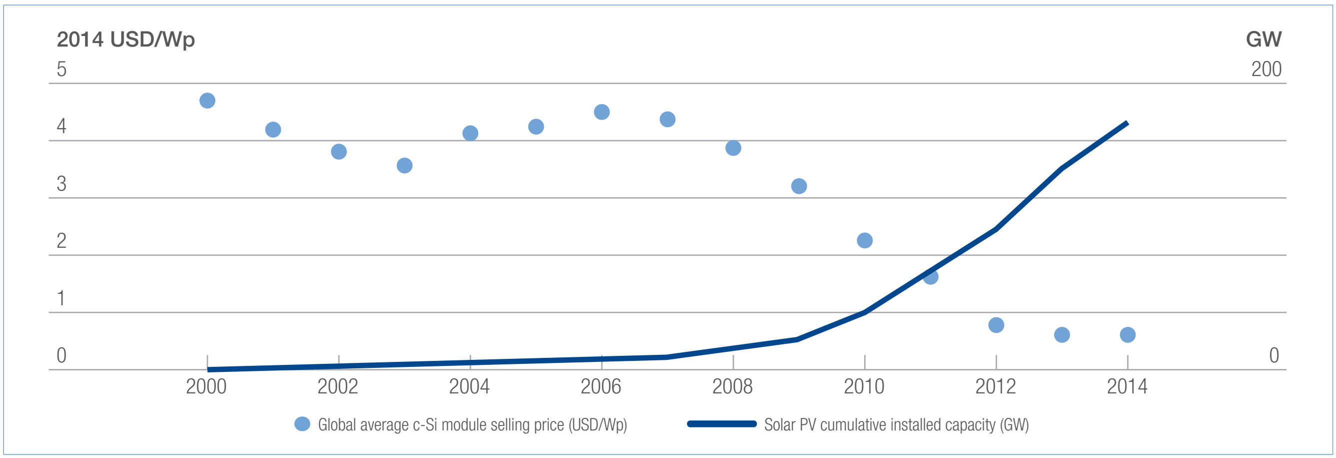

Figure 3. Cumulative global solar PV deployment and solar PV module prices, 2000-2014[1)]

Image courtesy of Acciona

Hydropower

Hydropower is a mature and widely deployed technology and has long dominated the renewable electricity mix. Hydropower has a high energy payback ratio and conversion efficiency as well as a high degree of controllability and flexibility and, with an estimated average LCOE of USD 50/MWh[2)], is fully competitive with wholesale conventional fossil fuel generation. Hydropower from reservoir plants can work with other renewables to smooth fluctuations in output and in some locations presents a potential opportunity in terms of storage via pumped hydro facilities – thereby making hydropower an asset for grid stability. In addition, hydropower facilities can easily be upgraded to incorporate latest technologies, have very low operation and maintenance costs, and in most cases hydropower reservoirs are multi-purpose schemes including irrigation, drinking water, regulation of water flow, navigation, fisheries, recreational activities and flood and drought management. Significant upfront capital expenditure is a barrier for development of new large hydropower plants, particularly due to construction duration. Meanwhile, the sustainability of large scale reservoir hydropower is often called into question given disruption to natural river ecosystems and the social implications of the displacement of rural populations. However, sustainability criteria have been developed by international organizations such as the International Finance Corporation and the International Hydropower Association to better manage these issues.

[1)] Adapted from IRENA, 2014, "Renewable power generation costs in 2014", accessed at www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494

[2)] IRENA, 2014, "Renewable power generation costs in 2014", accessed at www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494, accessed 4/5/2015

Image courtesy of Acciona

RENEWABLES TOMORROW: WHAT POTENTIAL?

In 2014, oil, gas, and coal provided 77% of the world's electricity. But the share of renewable energy in the mix keeps rising and renewables accounted for 59% of global capacity additions in 2014[1].

x3 According to the IEA, renewable electricity generation could nearly triple between 2012-2040, having already overtaken gas as the second-largest source of generation and surpassing coal as the top source after 2035.

USD 12.2 trillion According to Bloomberg New Energy Finance, the world will invest around USD 12.2 trillion in new power generating capacity over the 2015-2040 period. Nearly a third of the cumulative global investment over this period will be spent on solar, followed by another 28% on onshore wind[2].

45% According to 2014 IEA technology roadmaps, wind power could generate 18% of global electricity in 2050. PV systems could generate another 16%. Concentrating solar power (CSP) plants could provide an additional 11%, making a total of 45% of global electricity from wind and solar power.

#1 According to the IEA, solar could be the world's largest source of electricity by 2050, ahead of fossil fuels, wind, hydropower and nuclear.

USD 50/MWh Average LCOE for wind is USD 60-90/MWh though the best wind projects globally consistently deliver energy at a levelized cost of USD 50/MWh.

USD 100 billion The Climate Bonds Initiative estimates the labelled green bond market could reach USD 100 billion by the end of 2015, up from USD 11 billion in 2013 and USD 37 billion in 2014, representing a potentially very significant source of capital for RE projects globally. Corporate issuance is on the rise and appetite for green bonds from institutional investors with mandates to support responsible investments is growing[3].

25.6% The record lab efficiency for mono-crystalline solar PV cells. Recent record efficiencies demonstrate the potential for further efficiency gains in the coming years, allowing more solar power to be harnessed[4].

1.9MW and 4MW The average nameplate capacity of onshore and offshore wind turbines, respectively, installed in 2013. Regional variations are significant with average capacity in Germany for onshore turbines at 2.7 MW, while in China it is 1.5 MW. Wind turbines are getting bigger, stronger and lighter. Taller towers and greater rotor diameters allow turbines to capture lower-speed winds and boost capacity factor.

8 MW The world's largest commercially available wind turbine, the Vestas V-164 offshore turbine, to be deployed in the UK's Burbo Bank Wind Farm.

16.7 million The global renewable energy workforce was 7.7 million in 2014, over 30% of which is in the solar PV sector[5]. A doubling of the share of RE over the coming 15 years will see direct and indirect global employment in renewable energy account for around 16.7 million jobs in 2030, compared to 9.5 million jobs in 2030 under a BAU scenario[6].

[1] REN21, 2015, "Renewables 2015 Global Status Report", accessed at www.ren21.net/ren21activities/globalstatusreport.aspx, 4/7/2015.

[2] Bloomberg New Energy Finance, 2015, "New Energy Outlook 2015", accessed www.about.bnef.com/content/uploads/sites/4/2015/06/BNEF-NEO2015_Executive-summary.pdf.

[3] Climate Bonds Initiative, 2015, "Year 2014 Green Bonds Final report", accessed at www.climatebonds.net/year-2014-green-bonds-final-report-0, accessed 4/5/2015.

[4] Fraunhofer ISE, 2015, "Photovoltaics Report", accessed at www.ise.fraunhofer.de/de/downloads/pdf-files/aktuelles/photovoltaics-report-in-englischer-sprache.pdf.

[5] IRENA, 2015, "Renewable energy and jobs", accessed at www.irena.org/DocumentDownloads/Publications/IRENA_RE_Jobs_Annual_Review_2015.pdf.

[6] IRENA, 2013, "Renewable energy and jobs", accessed at www.irena.org/rejobs.pdf, accessed on 4/5/2015.

Image courtesy of Iberdrola

The benefits of scaling up renewables

Scaling up renewable energy generation will bring economic, social, technical, political and environmental benefits, beyond the fundamental benefit of lower carbon emissions.

LOWER GREENHOUSE GAS EMISSIONS

Emissions of carbon dioxide (CO_2) have increased by 80% since 1970 and 30% since 1990[1)], and the electricity sector is responsible for 56.6% of CO_2 emitted globally[2)]. Scaling up renewables would lower carbon dioxide (and other greenhouse gas) emissions and help mitigate the worst of their impacts.

Importantly, this argument holds firm even if considering the full lifecycle of renewable energy. Lifecycle greenhouse gas emissions associated with renewable energy manufacturing, installation, operation, maintenance and decommissioning are minimal. Specifically, lifecycle assessments conducted by the Intergovernmental Panel on Climate Change (IPCC) indicate that the median values for all renewable energies range from 4 to 46g CO_2eq/kWh, while those for fossil fuels range from 469 to 1,001g CO_2eq/kWh (excluding land use change emissions)[3)]. A typical wind turbine will "pay back" the energy involved in manufacturing and construction within 3-6 months of operation[4)].

ENERGY SECURITY AND INDEPENDENCE

Reliance on fossil fuels often compromises energy independence and energy security and results in a need for costly energy imports, as fossil fuels are often concentrated geographically, are subject to fluctuating price action on global commodity markets and are increasingly difficult and costly to extract. In contrast, renewable energy resources are generally more distributed across nations, can be produced locally for local consumption and local benefit and do not suffer the same exposure to fluctuating global commodity prices. As such, renewables can be localised to reconcile climate awareness with energy security; indeed, a key driver of most countries' commitment to increase the deployment of renewable energy is to reduce dependence on fossil fuel imports and reduce exposure to fluctuating global commodity prices.

[1)] IPCC, 2007, "Greenhouse gas emission trends", accessed www.ipcc.ch/publications_and_data/ar4/wg3/en/spmsspm-b.html

[2)] IPCC, 2007, "Contribution of Working Group III to the Fourth Assessment Report of the IPCC: Technical summary", accessed www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf

[3)] IPCC, 2012, "Renewable energy sources and climate change mitigation", accessed www.ipcc.ch/pdf/special-reports/srren/SRREN_FD_SPM_final.pdf

[4)] Kubiszweski, I, et al, 2010, "Meta-analysis of net energy return for wind power systems", accessed at www.sciencedirect.com/science/article/pii/S096014810900055X.

ENERGY: AT THE HEART OF ECONOMIC AND INTERNATIONAL AFFAIRS

In 2012, the European Union (EU) energy trade deficit amounted to 3.1% of GDP, with the EU dependent on imports for approximately half its energy needs. Tensions with Russia over gas pipelines in recent years demonstrate that energy is at the heart of relations between nations. Moreover, EU economies have experienced energy price increases and supply disruptions associated with fossil fuel use (in particular, oil and natural gas), with adverse consequences for consumers and industries[1)].

Meanwhile, the renewable energy industry contributes 1% of the EU's GDP and in 2010, RE generation avoided €10.2bn in imported fuel costs. Wind energy alone avoided €2.2bn of this. Crucially, fuel costs avoided due to RE production are currently estimated to be equivalent to the costs of RE support mechanisms[2)].

In Chile, consumption has been rising steadily in the past 25 years, though power generation levels have decreased as droughts have significantly affected production from the dominant supply source, hydropower. With limited indigenous sources of conventional energy, imports of natural gas and diesel increased substantially, resulting in high costs and shortages (notably in 2004 as shortages of gas in Argentina led to a halt in exports to Chile). As a result of these dynamics, Chile is reliant on imports for over 70% of its primary energy and experiences one of the highest electricity prices in the region for end consumers[3)]. Accordingly, the National Energy Strategy 2012-2030, announced in 2012, indicates a strong commitment to renewable energy. Crucially, the combination of economic and technical factors means that these sources can often compete on an unsubsidised basis with conventional sources, as recent auctions revealed; wind and solar power took[4)] 20% of total capacity as unsubsidised wind and solar projects offered lower bids than conventional generators[5)].

Thailand is dependent on imports for over half of its energy needs, and both energy consumption and energy dependence are growing significantly; in 2012 for example, energy imports grew at a rate of 16.7% from the previous year. Reliance on imports of fossil fuels – oil, coal, and to a lesser extent natural gas – and resulting energy security issues have been highlighted as key drivers of the government's Alternative Energy Development Plan[6)] . With renewable energy highlighted as the "best" way to reduce fossil fuel dependency, the Thai Government developed the Alternative Energy Development Plan in 2011, which sets a target of renewables supplying 25% of total energy consumption with renewable sources by 2021[7)].

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1) European Commission, 2014, "Member State's Energy Dependence: An Indicator-Based Assessment", accessed www.ec.europa.eu/economy_finance/publications/occasional_paper/2014/pdf/ocp196_summary_en.pdf

2) EWEA, 2012, "Summary of the Impact assessment for a 2030 climate and energy policy framework", accessed www.ewea.org/fileadmin/files/our-activities/policy-issues/legal_framework/EWEA_Climate_and_Energy_Package.pdf

3) Comision Nacional de Energia (CNE), 2012, "National Energy Strategy: 2012-2030", accessed at www.cne.cl/

4) Vorrath, S, 2015, "Renewables clean up at Chile auction, including 24 hour solar", accessed www.reneweconomy.com.au/2015/renewables-clean-up-at-chile-energy-auction-including-24-hour-solar-10549

5) Azzopardi, T, 2014, "Renewables takes 20% in Chilean power auction", Wind Power Monthly, December 2014, accessed www.windpowermonthly.com/article/1326945/renewables-takes-20-chilean-power-auction

6) DEDE, 2012, "Department of Alternative Energy Development and Efficiency Annual Report 2012", accessed www.weben.dede.go.th/webmax/sites/default/files/Annual%20Report%202012%20EN.pdf

7) DLA Piper, 2014, "Renewable energy in the Asia Pacific", accessed www.dlapiper.com/~/media/Files/Insights/Publications/2014/10/Renewable_energy_in_the_Asia_Pacific.pdf

Image courtesy of Welspun Energy

POSITIVE IMPLICATIONS FOR LOCAL ENVIRONMENTS, WILDLIFE AND HUMAN HEALTH

Through the impact of climate change, the burning of fossil fuels adversely affects human health, environment and wildlife due to higher average temperatures, ocean acidification and other ecosystem impacts. In contrast, renewable energy operation has very limited impacts on air and water quality, generates little operational waste and offers significant public health benefits compared with fossil fuels. Moreover, impacts of wind and solar PV on local environments and biodiversity are comparably limited.

Wind and solar PV energy, for example, require little or no water to operate and generate little operational waste. Crucially, wind and solar PV energy do not compete with agricultural, drinking or other important water needs in an increasingly water-scarce world. The area occupied by a wind farm can be simultaneously used as productive agricultural land, while smaller scale solar PV can be deployed on existing structures for little or no land use impact. Even utility scale solar PV installations do not require the extent of manipulation of the natural environment - for example, mountain top removal, hydraulic fracking or chemical contamination - as is often required for oil, gas and coal.

Through established and monitored processes, the development of modern renewable energy occurs at high standards to minimize the impact of development, construction and operation on surrounding environments. For example, wind farm siting and turbine micro-siting are undertaken with consideration of impacts on bird migratory routes and environmentally sensitive flora.

The health impacts of fossil fuels – and, in particular, coal generation – are widely documented[1)]. Such health and safety issues also become economic impacts as public health systems support affected people. Unlike fossil fuel generation (in particular, coal generation), renewable energy development and generation does not impact health of surrounding populations and installation and operation of RE facilities is not a particularly hazardous occupation.

[1)] Epstein et al, 2011, "Full cost accounting for the life cycle of coal", Ecological Economics Reviews, accessed www.chgeharvard.org/sites/default/files/epstein_full%20cost%20of%20coal.pdf

Image courtesy of ABB

SOCIO-ECONOMIC BENEFITS

Renewable energy brings various socio-economic benefits, including increased job opportunities and local economic development.

The manufacturing, development, production and operation of renewable energy power plants and associated equipment creates jobs – IRENA estimates that 7.7 million people worldwide are employed in the RE sector, directly and indirectly, in 2015, with considerable potential for additional growth; a doubling of the share of RE over the coming 15 years will see direct and indirect global employment in RE account for around 16.7 million jobs in 2030. Of note, due to its decentralized nature, RE creates jobs at a local level – particularly important when considering rural employment in the context of remote and off-grid installations. Jobs per installed MW exceed those of conventional fossil generation by up to three times[1)], and are highest per MW for solar PV, which accounts for the majority of RE employment globally.

Of note, emerging economies are expected to account for 90% of global energy demand growth by 2035[2)]. Socio-economic benefits are already being experienced in fast growing developing countries, with China, Brazil and India continuing to host some of the most substantial RE employment numbers, while Indonesia and Bangladesh have shown strong recent increases in RE deployment as well as jobs. The increased deployment of solar home systems in Bangladesh has directly contributed an estimated 115,000 jobs by 2014[3)].

In addition to creating new jobs, increasing use of renewable energy offers other important economic and social development benefits. Wind and solar PV can be comparably rapidly deployed – for example, a 50MW wind farm can be built in 6 months – a particular advantage in markets with fast growing demand. The added benefit of modularity (particularly for solar PV) allows for flexibility to meet specific local needs and deliver local benefits. RE provides decentralized energy facilities, within local communities, and therefore contributes to local economic diversification and development not only through direct community support (for example, funds set up to channel lease revenues to local schools), local job generation and skills and training but also, for example, through income to landowners hosting wind turbines – often a crucial income diversification and hedge against changing weather conditions and during years of low agricultural output. Wind turbines only occupy 5-15% of total wind farm land area and the remaining land can continue to be used for productive agricultural purposes. Meanwhile, estimates from the US suggest the return on land may be boosted by 30-100%[4)].

RE is also crucial in facilitating energy access for remote communities. The IEA estimates that 1.3 billion people, 20% of the world's population, are currently without access to electricity[5)]. Many of these people live in rural and remote areas and RE microgrids are a critical opportunity to provide electricity to remote areas in a clean, affordable and sustainable manner (see box below).

1) www.nrel.gov/docs/legosti/fy97/20505.pdf

2) IEA, 2013, "World energy outlook 2013 factsheet: How will global energy markets evolve to 2035?", accessed www.iea.org/media/files/WEO2013_factsheets.pdf

3) IRENA, 2015, "Renewable energy and jobs", accessed at www.irena.org/DocumentDownloads/Publications/IRENA_RE_Jobs_Annual_Review_2015.pdf.

4) www.nrel.gov/docs/legosti/fy97/20505.pdf

5) IEA World Energy Outlook 2014

LOW CARBON MICROGRIDS: FACILITATING SUSTAINABLE ENERGY ACCESS

The success of addressing climate change caused by greenhouse gas emissions and achieving a 2°C pathway will also depend on the solutions deployed to bring modern energy services to remote areas, mainly in developing countries. The majority of existing, remote electricity supply is based on diesel and continuing business-as-usual for remote electrification will cause a significant increase in greenhouse gas emissions. As such, low-carbon alternatives must be developed.

The required technology for low-carbon microgrids exists and many demand profiles can be economically served with those technology options today. Nevertheless, there remain significant barriers to implementation. Chief among these are:

- Regulatory environments are often not laid out to be supportive of the development of microgrids. That hinders the ability for individual developers to capture the value of constructing and operating microgrids. Microgrids fall in a grey area when it comes to regulatory frameworks; and many governments do not have the capacity to design microgrid-friendly policies and identify where microgrids can help their country to provide access to electricity and reduce dependency on fossil fuels. Better collaboration between all stakeholders is necessary to work with governments on a beneficial regulatory setting.
- Renewable energy is in many cases the most economical solution for remote village electrification, with the LCOE of RE microrgids lower than those dependent on diesel fuel[1]. However, microgrid systems with a high share of renewables are more capital intensive (particularly if, for example, battery storage is included) and this higher upfront investment requirement can be a barrier to deployment, even if LCOE is lower.
- New strategies for financing beyond traditional project finance or equity finance are needed to unlock new sources of capital and reduce transaction costs for low carbon microgrid development. Aggregation of projects and other risk diversification strategies will be critical, and green bonds present a promising avenue towards increased institutional investment.
- Challenges exist around the degree of local technical knowledge and skills to support microgrid construction, operations, management and maintenance. Technical experts should collaborate with NGOs and local communities to provide education and information effectively.
- Setting acceptable retail tariff levels while ensuring profitability is a challenge for independent microgrid operators. Tariff setting is usually constrained by regulation and social acceptance.
- Like all energy infrastructure, political risks are a threat particularly in emerging markets. This is especially problematic in the case of village microgrids which have longer payback periods.

Low-carbon microgrids offer a promising opportunity for enhancing clean, affordable and sustainable energy access. The IEA estimates that achieving their Energy for All Case would require an increase in global electricity generation of around 840TWh by 2030 of which around 300TWh would be supplied via microgrid solutions[2]. Development and deployment of microgrids is already underway globally, though a scale up in deployment is now needed. While most of the technology is already available, further development is needed in some areas, such as storage technology, to bring down costs and improve performance. Innovative business models are also necessary to ensure the bankability, sustainability and scalability of microgrids.

[1] IEA Africa Energy Outlook 2014

[2] IEA, World Energy Outlook 2011, Energy for All

FLEXIBILITY AND RESILIENCE

RE can be deployed in both centralized and decentralized configurations and in both cases offers substantial benefits in terms of flexibility and enhancing the resilience of electricity grids. Generally speaking, renewable generation has the ability to improve system reliability via reducing peak loads, providing ancillary services (such as frequency and voltage support) and improving power quality. Heavy grid infrastructures can be avoided with increased distributed generation and localization of energy production, with the ability to generate electricity at or near the load. In addition, resilience to major disruptions arising from, for example, natural disasters, is typically higher in decentralized systems with embedded generation; distributed generation can be used to maintain operations when the grid is down during weather-related outages and regional blackouts[3]. Particularly when combined with grid modernization and smart grid technology, resilience can be substantially improved.

[3] www.ferc.gov/legal/fed-sta/exp-study.pdf

Scaling finance and improving bankability

Accelerated deployment of renewable energy is needed in order to decarbonize the energy sector and business as usual investment will not deliver the transformation required. Demand for renewable assets from investors is growing, however, challenges remain – particularly in terms of ensuring bankability of RE projects to unlock a greater pool of capital at the lowest possible cost.

Financing challenges associated with renewable energy range from technical and physical to political, regulatory, legal and macroeconomic. Many of the challenges faced by RE are faced by infrastructure and energy projects more broadly, however RE – and in particular, wind and solar PV - also face additional challenges, as will be discussed further below. Risks vary throughout the project lifecycle and are highest in development and construction phase, though noteworthy operational risks include merchant risk and the potential for poorly managed retroactive policy changes.

Generally speaking, key risks to renewable energy projects include the following[1]:

- Policy and regulation: Policy environments and incentives, regulatory conditions and planning and permitting procedures are major considerations for RE development. There may be a lack of policy stability and transparency or a lack of clarity on which institutions have authority over renewable policy and how policies and regulations are to be interpreted. Moreover, market structures often favor conventional generation, externalities such as carbon emissions are generally not priced in and disproportionate fossil fuel subsidies in many markets continue to distort market incentives.
- Operational and physical risks: While solar PV and wind technologies are mature and reliable, factors such as adverse weather conditions affecting construction and maintenance schedules, unreliable grid infrastructure or high levels of curtailment can impact the revenue stream.
- Revenue/sales risks: These risks include counterparty risks (creditworthiness of offtaker and ability to meet payment schedules), merchant risk, generation profile risk (arising from the inability to manage output depending on price) and lower than expected energy output resulting in lower than expected income.
- Sponsor risks: In particular, this refers to financial strength, equity availability and ability of sponsor to deliver the project (for example, organizational structure, expertise and track record, management and internal procedures, etc.).
- Construction risks: This primarily refers to the ability of contractors to deliver the project on time and budget and to the required standard (meeting all local regulatory and compliance requirements), insurances, contracting risk, etc.
- Macroeconomic risks**:** Currency, commodity price and interest rate fluctuations, wage growth and general economic conditions.
- Business culture and legal issues**:** A lack of transparency regarding general business and legal issues such as land ownership, which can be particularly challenging for RE, are problematic in a number of markets.
- Familiarity and local capacity**:** There may be a lack of understanding of the risk profile of renewables projects and lack of local public capacity in managing RE projects and targets.

[1] SE4All Finance Working Group, 1 June 2014.

DE-RISKING RE PROJECTS: CORPORATE PPAs

Offtake risk is a key issue for renewable energy projects and addressing a lack of creditworthy offtakers and credit risk associated with weak utilities is important in unlocking additional and lower cost capital for RE. Meanwhile, growing cost competitiveness, strained public finances and increasing corporate interest to directly procure RE combine to present both a need and an opportunity for alternative offtake approaches.

Encouraging corporate procurement via PPAs directly addresses offtake risk for RE projects and increases the demand for RE. Millions of megawatt hours are needed to meet existing corporate renewable energy goals, however businesses face a variety of challenges in accessing cost-effective solutions on favourable terms. In particular, the following issues were raised[1]:

- The need for greater choice in options for RE procurement: both in terms of suppliers and products.
- The importance of transparency in costs: many companies are willing to enter into direct and long term supply agreements however wish to harness the benefit of increasing cost competitiveness in RE.
- Challenges associated with regulatory restrictions: e.g. some states in the US and India prohibit non-utilities from signing PPAs.
- Increased access to longer-term, fixed price energy: a key perceived benefit of RE procurement is the ability to lock in an energy price and avoid fuel price volatility. Crucially, there is a need for options in terms of contract tenor. However, economic uncertainty in some markets may cause companies to be reluctant to sign long term agreements.
- The ability to procure RE close to company facilities: buyers have indicated a preference to procure renewable energy from projects near operations or on the relevant regional grid to ensure benefit to local economies and communities as well as enhance the resilience and security of the local grid.
- The need to generally increase access to PPAs and leases: in particular, simplify contractual and administrative procedures as these are widely perceived to be complex and time consuming.

Nevertheless, there is momentum gathering in recent years with a number of large corporates (such as IKEA and Nestle) committing to procure 100% renewable energy and initiatives such as RE100 well underway, and the number of companies making commitments is growing. The Corporate Buyers' Principles work led by the World Resources Institute show strong interest from companies in procuring RE directly via PPAs and the development of a suite of new products to aid corporate renewable energy purchasing led by the Rocky Mountain Institute is further evidence of rising interest in the sector.

[1] WRI, 2015, "Corporate Renewable Energy Buyers' Principles: Increasing access to Renewable Energy", May 2015

Recent trends in renewable energy finance

Renewable energy is no longer a niche market but is attracting interest from mainstream investors such as pension and insurance funds. In addition to challenges facing infrastructure projects more broadly, renewable energy projects face distinct financing challenges stemming from its unique features and the increasing number of investors that are relatively new to the sector.

The proposed headline RE commitment of 1.5 TW by 2025 requires approximately USD 3.5 trillion in investment between now and 2025[2]. Business as usual investment will not deliver the required volume and cost of capital needed. There is a need to attract private sector finance to raise the volume of capital required and to reduce dependence on strained public finances.

To this end, institutional investors present a huge potential source of funding, with assets under management in excess of USD 90 trillion[3]. While there is significant investor demand for RE assets, investment from such funds has been limited to date and lack of suitable investment vehicles has been cited as an issue.

Mobilising the required capital at a favorable cost will therefore require both de-risking of projects and broadening the range of investment vehicles available. Indeed, a growing range of financing mechanisms are evident; in addition to traditional project finance there has been strong interest in newer approaches such as green bonds, yield cos and asset backed securities. These new approaches have the potential to access funds from a wider pool of investors and reduce the cost of capital significantly, with

[2] IEA, 2015, "World Energy Outlook Special Report: Energy and Climate Change", accessed www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf

[3] CBI, 2015, "Scaling green bond markets for sustainable development", accessed www.climatebonds.net/resources/publications/scaling-green-bond-markets-sustainable-development

substantial potential to reduce the LCOE in turn; since renewable energy projects are typically capital intensive, a higher degree of upfront investment is required and the LCOE is therefore highly sensitive to the cost of capital, as indicated in Figure 4.

However, generally speaking, a number of key challenges in the financing of RE projects remain. Some challenges are common across infrastructure projects more broadly; for example, capital adequacy requirements under Basel III following the 2008-2009 economic crisis have made it more difficult to obtain bank loans with the long maturities required by infrastructure projects. Mini-perm markets – in which refinancing is required at regular intervals - provide a potential alternative, however this introduces refinancing risk. Non-traditional lenders such as debt infrastructure funds have emerged to fill some of the void in the infrastructure debt financing market and have moved from a relative niche to a growing trend: fund managers are increasingly launching vehicles focused solely on debt investments[1].

Limited public financing, ongoing weak economic growth and policy uncertainty are also challenges common across infrastructure project development. However, the public and private sectors can work together to scale finance to address some of these challenges. 'Smart' use of limited public finance is crucial: as highlighted in the OECD Green Investment Report, there is "significant potential to close the green investment gap by mobilizing private finance through the smart use of limited public finance". Indeed, targeted government spending has been known to promote private sector investment volumes 5 times the initial public spend[3]. There is a need to work with governments to develop the most effective and efficient mechanisms and for public and private sector to collaborate from the outset to maximize successful outcomes sooner.

Not only must typical constraints to infrastructure finance be overcome, but significant investment must also be redirected from conventional to renewable generation, particularly from institutional investors. The key challenge for the industry is in de-risking projects and developing and deploying relatively simple and liquid instruments that meet the risk-return profiles of a broader range of investors. With policy stability being a key risk to renewable energy in much of the world – and particularly in emerging markets – this report will now explore in further detail the importance of a clear policy framework.

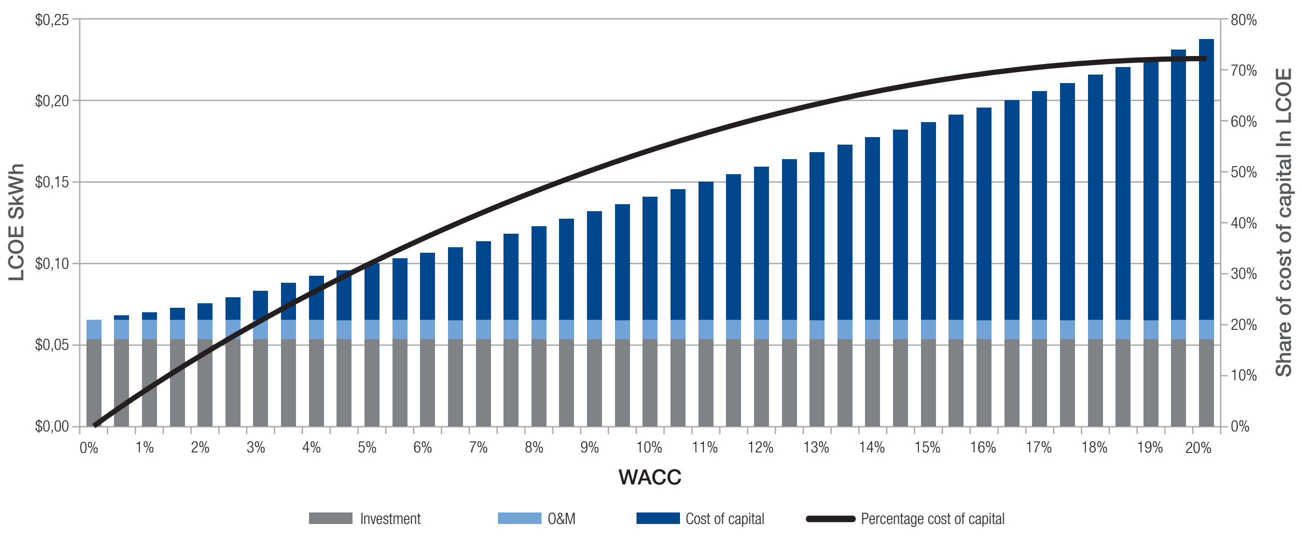

Figure 4. Effect of cost of capital on LCOE for solar PV[2]

[1] Bishop, P, 2013, "The Rise of Infrastructure Debt: New Opportunities and Investor Interest", www.preqin.com/docs/newsletters/INF/Preqin_Infrastructure_Spotlight_February_2013.pdf.

[2] IEA, 2015, "Wind and solar roadmaps", presentation the LCTPI, Geneva, February 2015

[3] OECD, 2013, "The Green Investment Report", www3.weforum.org/docs/WEF_GreenInvestment_Report_2013.pdf

NEW FINANCING INSTRUMENTS

Green bonds

Green bonds - relatively simple fixed income instruments used exclusively to fund 'green' projects, including renewable energy infrastructure - present an especially promising opportunity.

Green bonds allow access to funding sources outside the commercial lending market and have the potential to significantly increase the pool of capital available. Institutional investors with social and environmental mandates seeking particular risk-return profiles generally have strong demand for these bonds due to relative ease of investment and direct access to renewable energy projects. Green bonds may be issued on the basis of investment in a portfolio of green infrastructure projects or for individual projects.

Issuance of green bonds has grown dramatically in recent years. Globally, in 2014, USD 36 billion of labelled green bonds were issued, compared with USD 11 billion in 2013, and the Climate Bonds Initiative (CBI) estimates the market could reach USD 100 billion in 2015[1]. While these sums represent a small fraction of the USD 100 trillion global bond market, the trends are promising.

Indeed, institutional interest in renewable energy assets is rising. A survey in 2013 found over 30% of large institutional investors are planning to increase investment in such assets; while some funds might be invested directly into acquiring projects, much will probably target bonds for governance And liquidity reasons[2]. In particular, institutions wishing to divest from hydrocarbon stocks and bonds will be looking to trade into comparable renewable-energy securities.

Geographical reach of green bonds is also growing. While most bonds to date have been issued by European or US entities, in 2015 India's Yes Bank issued its first green bond, Chinese turbine manufacturer Goldwind undertook the first labelled issuance in China and Australian bank NAB issued the first certified climate bond from a bank.

Yield Cos

Yield cos are dividend-orientated companies that bundle a number of renewable energy assets into a single fund and trade shares in the fund on an exchange. Projects under development are generally kept in a separate entity, and the yield co is not subject to corporate taxation. Cash flows from the operating projects are distributed as dividends.

[1] CBI, 2015, "2014 Green Bonds Final Report", accessed at www.climatebonds.net/year-2014-green-bonds-final-report-0

[2] EY, 2013, "Pension and insurance fund attitudes towards renewable energy investments", www.ey.com/Publication/vwLUAssets/EY_-_Cleantech_institutional_investor_survey/$FILE/EY-Institutional-investor-survey-results.pdf

The yield co proposition works on the basis that investors are willing to accept lower returns for projects that are de-risked – in this case, operational projects with stable cash flows - and this lower cost funding can then be reinvested to fund new projects, with higher risk profiles that would otherwise carry higher cost of finance. As an indication, the recent yield co IPOs offered yields between 3-7%; this cost of capital is significantly lower than could be expected for a plant financed under more traditional financing arrangements[3].

Such vehicles allow investors direct exposure to wind and solar PV projects and considerable flexibility exists in that utility-scale and smaller distributed generation may be bundled into a single portfolio. This way, yield cos may provide an investment opportunity of a sufficiently large scale for investors with large appetite for exposure to renewable energy assets.

Asset Backed Securities

Securitisation refers to the process of converting a pool of illiquid assets into tradable securities. In the case of solar PV systems, for example, a portfolio of residential and commercial scale rooftop systems can be pooled and asset-backed securities issued based on the portfolio of underlying cash flows. Pooling assets in this way reduces credit risk as the rated bonds are linked to the combined pool (rather than to the credit risk of a single investment), which in turn enables access to lower cost of debt.

Like green bonds and yield cos, such structures allow a wider group of investors to gain exposure to the solar PV market – notably, institutional investors such as pension funds (who may purchase higher-rated tranches) and insurance companies who seek longer term, steady returns.

SolarCity's securitisation of its PV portfolio in late 2013 represents the first such deal in the solar PV space, raising USD 54 million at a cost of 4.8%[4] in the first of a number of similar transactions. Again, capital raised in this way can be recycled into newer projects, considerably reducing the cost of capital and, in turn, the cost of energy. Moreover, the emergence of such financing structures indicates that renewable energy is becoming an acceptable asset class in its own right.

[3] Martin, K, 2013, "Yield Cos Compared", www.chadbourne.com/files/Publication/23563110-8a1e-40f0-88ba-b6d868e8cb56/Presentation/PublicationAttachment/2198b0b7-d98f-4208-8d23-b7b15a92450b/YieldCosCompared_Dec13.PDF, Chadbourne & Parke, LLP

[4] www.greentechmedia.com/articles/read/SolarCitys-New-201M-Securitized-Solar-Portfolio-Keeps-the-Capital-Flowing

Image courtesy of ABB

Facilitating the scale-up of renewable energy finance

In summary, the challenge in scaling finance for accelerated RE deployment lies in encouraging a shift in investor appetite, de-risking projects and developing and deploying relatively simple and liquid financial instruments.

Whilethe private sector will drive much of the project development and financial commitment, policymakers have a critical role to play in ensuring legal and regulatory frameworks are conducive to RE growth.

A number of actions can be taken by policy makers to contribute to project de-risking, and to facilitate the growth of new business models and financing approaches. Key recommendations are as follows:

- Develop stable and transparent energy and renewables policy: These policies must have clear targets and roadmaps to substantially reduce policy risk, as discussed further below.
- Develop mechanisms to address macroeconomic risks: For example, creating a government-backed fund to manage currency risk, as currently proposed in India.
- Work with development institutions: To prioritize and scale funding for renewable energy infrastructure and develop credit enhancement mechanisms where needed.
- Review regulation to remove systemic bias: Ensure that regulation of pension funds and insurance companies does not systemically disincentivize investment in clean energy infrastructure. Legal ownership structures, laws governing the disclosure of risks by publicly quoted companies, and the use of ratings agencies which focus on near-term quantifiable risks, are examples of areas which may need to be addressed.[1)]
- Ensure "smart" use of public funds: Targeted use of public funds (e.g. via green banks with clear remits, strategic green bond issuance and guarantees /credit enhancement) can work to scale private sector investment.
- Consider additional incentives for RE finance in early stages of markets: For instance, China has proposed tax relief for income from green bonds.
- Strengthen local bond markets: As mentioned above, green bonds represent a particularly promising opportunity for RE investment. However, weak local bonds markets have been cited as a barrier in markets such as India. Strengthening local bond markets is critical in facilitate the required scale up in green bond investment.

The private sector also has a critical role to play – both the RE industry and the investment community. Independent verification of green bonds must be encouraged to ensure transparency. Standardization and aggregation of projects are needed to achieve scale and reduce costs, while best practice in project development (such as environmental standards, construction processes and equipment selection) is necessary to ensure the bankability of underlying assets. Stakeholder engagement, communication and knowledge sharing is crucial in facilitating wider uptake of new approaches.

[1)] BNEF (2013). Clean energy – white paper. Financial regulation – biased against clean energy and green infrastructure?

Image courtesy of EDP

The importance of a clear policy framework

A clear policy framework brings confidence to investors, clarity to the market and incentives to energy producers to become more efficient. It promotes sounder and more transparent political decision making and brings a range of wider benefits to society as a whole.

Creating clear national and international policy frameworks is essential to consolidate recent growth in renewable energies and to scale finance for the transition to a low carbon economy. Broadly speaking, key challenges regarding policy frameworks for RE are as follows:

- Creating stable and reliable regulation.
- Internalizing the cost of externalities and levelling the playing field.
- Balancing Local Content Requirements (LCRs).

Each of these will be discussed in turn.

CREATING STABLE AND RELIABLE REGULATION

Creating stable and reliable regulation is crucial in unlocking capital and accelerating the deployment of renewable energy. Political instability and uncertainty with respect to RE policy has had significant impacts in a number of markets, including Spain, Italy and Australia.

While RE is already competitive in some markets – for example, in some mature markets in Europe, or in markets where techno-economic factors mean that wind and solar PV are cheaper than conventional thermal generation, such as Chile[1] – in many countries renewable energy requires early policy and regulatory support as markets are inherently biased to incumbent conventional generators. The accelerated deployment of RE typically involves the entry of new players to the power sector and increasing renewable penetration generally requires changes in the regulatory framework of the energy market.

To this end, there are two immediate challenges for policy makers:

- To demonstrate a real and trustworthy commitment by setting up realistic but ambitious long-term national emission reductions targets and, particularly in less mature markets, renewable energy targets.
- To establish a solid, predictable and reliable policy environment. An environment that:
  - Attracts private investment through developing mechanisms to provide some revenue certainty for renewable projects;
  - Equips policy makers to adapt regulation to meet the changing nature of renewable energy costs and technology;
  - Assures transparency and equality for all stakeholders and players in the market and maintains investor confidence;
  - Builds public acceptance through continuous communication on the benefits of renewables to broader society.

[1] Azzopardi, T, 2014, "Renewables takes 20% in Chilean power auction", Wind Power Monthly, December 2014, accessed www.windpowermonthly.com/article/1326945/renewables-takes-20-chilean-power-auction

Recommendations for policymakers and regulators

The development of a regulatory framework should be built around five core principles: transparency, stability, predictability, affordability and social acceptance. With these principles in mind, key recommended actions for policymakers and regulators are as follows:

- Set emissions reduction targets: Set binding long term emission reduction targets at the highest level of political decision-making, commit to a decarbonization path and make firm commitments to international frameworks on medium to long-term targets.
- Consider renewable energy targets: These targets are a key part of promoting industry growth in some markets – particularly in emerging or less mature markets. Such targets are a way to stimulate investment in the near term as the removal of barriers will take longer to resolve (e.g. electricity market design, grid upgrade requirements, etc.). Targets must also be assessed by interim metrics, to help stay on track, maintain momentum and make adjustments as the industry matures and develops.
- Streamline procedures: Simplify and streamline administrative procedures for development and construction of RE projects and promote capacity and knowledge building within responsible agencies.
- Deploy effective and efficient market mechanisms: An effective regulatory framework should include market mechanisms to encourage efficiency – mechanisms that are designed and developed on a clear, transparent and objective basis. Market mechanisms and remuneration schemes must provide high visibility to ensure the associated benefits can be accounted for in investment decisions. This will also reduce the cost of energy delivered, as the risk (and, in turn, the cost of capital) is reduced.
- Promote stakeholder consultation: Establishing a stable regulatory framework requires a comprehensive stakeholder-engagement process.
- Carefully manage policy changes: Temporary or transitional periods are needed to ensure a soft transition between different incentive mechanisms, increasing certainty for stakeholders in committed investments. While mechanisms must be adaptive to changing circumstances, retroactive policy changes should be avoided and any necessary policy changes should be carefully managed in a process that is characterized by industry and stakeholder engagement.

INTERNALIZING EXTERNALITIES AND LEVELLING THE PLAYING FIELD

Governments urgently need to make the cost of electricity from fossil fuels reflect associated environmental impacts and allow renewable energy to compete on a level playing field. There are policy instruments and interventions already available to address market failures.

As discussed above, electricity generation from fossil fuels creates negative impacts on society and the environment, the cost of which is not borne by the polluters themselves but rather by society as a whole. Such impacts are known as negative externalities. The key externality related to the current global electricity system is CO_2 emissions, with associated climate change impacts.

An indirect financial benefit to fossil fuel producers arises if producers are not required to pay for CO_2 emissions. This indirect benefit adds on to the existing direct fossil fuel subsidies that governments support globally; these reached USD 550 billion in 2014, four times more than those for renewable energy (USD 120 billion)[1)]. Within this, fossil fuel subsidies specifically for electricity generation, natural gas and coal amount to USD 268 billion. However, these figures do not account for indirect (or implicit) subsidies; indirect subsidies include provision of land and services (such as water) below market rates and under-pricing of social and environmental externalities[2)]. If such externalities are accounted for as subsidies, the IMF estimates that the total, global post-tax energy subsidy bill exceeds USD 5 trillion, the vast majority of which is accounted for by fossil fuels.

These factors contribute to a pricing distortion and constitute a market failure in the electricity sector. It sends misleading signals to investors that renewable electricity it is not an optimal cost-driven investment choice.

These market failures can be addressed via regulation, or implementation of market mechanisms to internalize environmental externalities on the polluter-pays principle. For example, considering CO_2 emissions, cap and trade permits, such as carbon emission trading schemes, or taxation mechanisms, such as carbon pricing, can be implemented. However, a clear and stable pricing structure is required for this to be effective.

Fundamentally, if implemented, such actions will send a signal to investors that renewable electricity is indeed an optimal, cost-driven investment choice.

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1) IEA, 2014, "World Electricity Outlook".

2) IMF, 2014, "The Impact of Fossil-Fuel Subsidies on Renewable Electricity Generation", accessed www.iisd.org/sites/default/files/publications/impact-fossil-fuel-subsidies-renewable-electricity-generation.pdf

PROMISING FOUNDATIONS

Efforts to establish carbon pricing systems are making headway. System design is improving, and implementation is underway. This momentum needs to continue, with new systems learning from the successes and failures of earlier experiences.

Carbon trading schemes have been created on supranational, national or subnational level in Europe, New Zealand, US and China, which announced a national ETS for 2017. Carbon taxes are also being implemented in a number of regions - for example in British Columbia, France, Mexico and shortly South Africa. In all, about 40 national and over 20 sub-national jurisdictions are putting a price on carbon. Challenges have been experienced in some systems – notably in Europe during the Global Financial Crisis – and provide important lessons for systems going forward.

Meanwhile, a growing number of leaders – at national, local and corporate level – are advocating for carbon pricing and are working together under Carbon Pricing Leadership Coalition to expand the use of effective carbon pricing policies that can maintain competitiveness, create jobs, encourage innovation, and deliver meaningful emissions reductions [1)].

Financial institutions are also incorporating carbon pricing or carbon considerations into investment decisions. For example, the European Bank for Reconstruction and Development incorporates a “shadow” price for carbon – by which the cost of carbon emissions is incorporated into financial analysis [2)].

[1)] Carbon Pricing Leadership Coalition, 2015, “Who we are”, accessed at www.carbonpricingleadership.org/who-we-are

[2)] European Bank for Development and Reconstruction, 2013, “ Energy Sector Strategy”, accessed www.ebrd.com/downloads/policies/sector/energy-strategy-comment.pdf.

In addition to a general failure to internalize externalities, regulatory environments and market design often favor traditional, conventional generation over modern renewable energy.

Failure to evolve and refine market rules will pose a serious long-term risk for renewable development and this lack of fair and competitive market also leads to sub-optimal decision making and inefficient resource allocation. Examples of such biases include:

- Discriminatory market rules: While market rules in countries (such as Denmark, Spain and Germany) are undergoing a continuous development process and are more and more open to renewables – facilitating growing shares of renewables in the generation mix - market rules in most countries still limit the participation of renewables, particularly in grid support services.
- Technical regulations: Technical requirements are often still based on traditional technologies and therefore create artificial barriers to entry to the market.
- General administrative regulations: Administrative regulations and permitting requirements are often structured based on conventional generation technologies and impede new technologies. For example land and urban regulations, access to public funds and taxation rules.

While quantification and internalization of all externalities is not a realistic outcome in the near term, the key externality of CO_2 emissions can be readily addressed; as discussed above, pricing mechanisms have already been established and indeed implemented.

Much of the solution also lies in identifying and removing any existing regulation that hinders renewable energy deployment, so that it can occur in the most efficient and cost effective way.

Recommendations for policymakers and regulators

Fundamentally, regulation and policy must create a more balanced playing field in order to scale RE deployment and facilitate efficient resource allocation. Achieving a level playing field for renewables requires coordination across many fields of public policy making, though it is noted that energy regulators have a crucial role to play. Key recommendations for policymakers and regulators in terms of internalizing externalities and levelling the playing field are outlined below.

- Implement carbon pricing mechanisms: Such as a direct tax on carbon emissions, or a cap-and-trade system. Mechanisms for implementing a price on carbon must give a clear price signal to be effective in directing investment and must be built around rules and targets that give predictability. Specific recommendations for carbon pricing include:
  - Carbon pricing should be robust (meaningful enough to redirect investment to low carbon solutions) and stable (encouraging approaches that create certainty and predictability).
  - Carbon pricing must apply across all economic sectors, and not only be borne by electricity consumers.
  - Price stabilization mechanisms should be adopted for carbon trading schemes. Price caps and price floors are the most straightforward approach, and allow for a clear price signal to the market.
  - Use of revenues must be complementary and sustainable. Options to consider include incentives or tax breaks for RE related development and using revenues for further RE investment or R&D. For example, revenue from Australia’s carbon tax was used to finance the Clean Energy Finance Corporation, a green bank.

- Remove subsidies for fossil fuels: As fossil fuels receive a disproportionate amount of energy subsidies, subsidies should be removed to create a less distorted and more socially, environmentally and economically sustainable system. Measures should be implemented to ensure the poorest in society are not disadvantaged.
- Support technologies not yet commercial: With 'smart' use of public funding and collaboration with the private sector. This includes promoting and supporting organizations in research and development of new renewable electricity technologies through Public-Private Partnerships.
- Set the objective: Make levelling the playing field a primary objective for energy policy and ensure that no new regulation is put in place without an analysis of its impact on such an objective.
- Audit regulation: An in-depth audit of existing regulation in the energy sector will identify all rules that may have a discriminatory impact on renewable technologies. Such an audit should be open to participation from all stakeholders, and results should be published and periodically updated.
- Modify rules: Modify market rules and economic support mechanisms for all technologies in order to correct discriminations.

BALANCING LOCAL CONTENT REQUIREMENTS

Investors have cited problems with Local Content Requirements (LCRs) in some of the most active countries developing renewable energies, including Brazil, India, South Africa and Canada.

LCRs foster domestic economic growth, local employment and local industry. But without a fair and balanced framework that benefits national economies **and** renewable investors, LCRs can put the deployment of renewables at risk: LCRs can distort competition by limiting the number of players in the market and also risk increasing the cost of goods and services. This may hamper the ability of renewable technologies to compete with conventional technologies and may increase the final retail price of electricity and undermine national competitiveness. Eventually LCRs may significantly impede the process of promoting renewables – if the benefits of new technologies are outweighed by higher net costs from LCRs.

However, this is not always the case. Relatively strong (but not extreme) local content requirements in South Africa did not prevent cost reductions of wind and solar power; the tariff of wind power fell by over 50% and that of PV by over 75% between Bid Window One and Four[1)].

Recommendations for policymakers and regulators

In countries where LCRs are in place, policymakers must facilitate local value creation while minimizing market distortions and additional costs for electricity consumers. With this in mind, key recommendations for policymakers are as follows:

- Consider market size and stability versus level of LCR: Local and regional market size and stability are important pre-requisites for investors looking to develop projects or manufacturing sites. A larger and more stable market will have greater chance of attracting investors despite the additional costs associated with LCRs.
- Ensure an appropriate share of local content: The share of local content required for an investment must be set appropriately: too high and LCRs will demotivate project developers to invest, as local components might be difficult or expensive to source. Consideration of locally available production and skill capacities is crucial, in terms of avoiding bottlenecks and project delivery risk and expense.
- Run a cost-benefit analysis: Undertake static and dynamic cost/benefit analyses to inform any implementation of or adjustment to LCRs.
- Stakeholder consultation: work with local and international businesses – in particular, with project developers and component producers - to design and develop an LCR scheme will produce the best outcome for all. This will help governments determine appropriate LCRs in a collaborative and transparent way.
- Incentives to learn: Governments must continually incentivize innovation and learning-by-doing. This will enable local businesses to develop the necessary technological capabilities required to build capacity and improve efficiency and quality – and ultimately become internationally competitive.
- Transparency and certainty: An LCR framework must be totally transparent, with clear disclosure, verified information and a level playing field between local and foreign investors as well as technologies. There must be certainty around how the scheme will evolve or change over time.
- Maximize social impact: LCRs must focus on economic factors that will have maximum social impact, such as a positive impact on the labor force.
- Monitoring tools: Establish transparent monitoring tools to assess effectiveness and results of LCR compliance, and to guarantee all processes remain fair and equal. Regular public evaluations of the impact of LCR should also be undertaken.

[1)] IPP Procurement Program, 2015, "Renewable Energy IPP Procurement Programme Bid Window 4 Preferred Bidders' Announcement", accessed www.ipprenewables.co.za/#page/2183

Integrating renewable energy into grids and electricity markets

Efficient and cost effective integration of RE into grids and electricity markets are needed to deploy larger volumes of renewables.

While wind and solar PV power are mature technologies, due to their inherent variability and their dispersed nature, increasing RE penetration poses various challenges on the existing electricity system and does not typically fit well with traditional electricity market structures and related regulations. As a result, regulation and market design remain barriers for the large-scale integration of RE in many markets.

However, the majority of the challenges are not technical in nature but rather regulatory or market-driven. From a technical point of view, progress has been made on improving the capability of wind and PV generators to provide various system services (full voltage and a certain amount of power regulation), while forecasting is more precise on increasingly fine timescales and technology for remote monitoring and control has vastly improved. The deployment of smart grid technologies at distribution level is generating opportunities for distributed energy to participate in the provision and trade of electricity services through market mechanisms.

Fundamentally, there is a paradigm shift required, to change the view of variable renewable generation from being a “problem” which must be made to conform to the existing market and grid operation rules, to becoming a power system supporter. That is, there is a need to transform the power grid to work for renewables, rather than simply ask renewables to adapt to the grid.

Image courtesy of DNV GL

In the most mature markets, considerable progress has been made, for example, in Germany, Ireland, Italy, France, Belgium and Spain, where valuable features of RE technology – such as full electronic control of reactive and active power – are now being specifically harnessed by grid operators and rewarded by electricity markets. However, further progress is needed; for example, when curtailment is required, this should occur in a progressive manner, rather than in the form of "on – off" curtailment.

THE 50.2 HZ ISSUE

In Europe, distributed generation was traditionally considered as negative load and so installations were required to switch off automatically and instantly as soon as the frequency exceeded a particular level. In Germany, this level was set to 50.2 Hz. This does not represent a technical limit but rather connection rules set by the regulators at a time when RE penetration was much lower.

In instances where there is considerable output from distributed, renewable generation – for example, high wind speed periods or peak solar output across Germany's almost 40 GW of installed PV in summer – and generation exceeds load, frequency will increase beyond this specified limit and cause mass switch-off of all distributed generation in that control zone. This results in a power surge and, in one instance in 2006, and almost resulted in a major system blackout across Europe.

Given that the cause of this is a regulatory rather than technical issue, with a proper definition of the disconnection rules such issues can be avoided. In fact wind and solar PV are capable of providing support to system operators in the case of such events. National grid codes can and have been revised (for example, in Germany, Italy, Belgium and Spain) to integrate new frequency requirements. Moreover, the 50.2 Hz issue demonstrated the ability of new technologies containing advanced communications and software to avoid costly retrofit programmes [1].

[1] EPIA, 2012, "Connecting the sun", accessed at www.epia.org/fileadmin/user_upload/Publications/Connecting_the_Sun_Full_Report_converted.pdf

Technical and commercial challenges with renewable integration into the grid

Current electricity transmission systems are typically designed around large generation plants delivering electricity on a centralised basis – not around distributed renewables.

Transmission and distribution systems have historically been built to accommodate large centralized generators. Renewables display a number of features which differ from conventional generation; they have variable generation patterns and (in the case of solar PV) do not exhibit some of the intrinsic network stabilizing properties like synchronous inertia. At low penetrations, the impact of these differences is negligible, with the exception of local technical issues in deployment hotspots. This is no longer the case as penetrations of wind and solar PV increase, displacing conventional generation on the power system.

Of note is that DSOs face particular challenges in the transition to a renewables-based electricity system: fundamentally, these operators must now not only manage load, but generation. Renewable energy plants are significantly more dispersed than conventional alternatives; they are often connected at the distribution level, as consumers both generate electricity through microgeneration technologies and consume power through the distribution network. These changes bring both technical challenges (two-way power flows and power quality impacts) and business model implications (with new pricing schemes potentially required) for DSOs.

Some of the impacts are beneficial. For example, a distributed solar PV installation might bring the advantage of reduced electrical losses due to proximity to load. Wind and solar PV can be deployed quickly and flexibly in terms of configuration, scale and location, and improved energy assessment and forecasting techniques mean that the accuracy of short term and long term energy prediction has vastly improved. However, in general, as penetrations increase, challenges to existing power system design and operation emerge. The relevance and magnitude of these effects varies by power system, depending on characteristics such as level of concentration of RE, general robustness of grid and strength of interconnections.

Broadly speaking, there are three grid related challenges that must be overcome to scale up renewables. Firstly, there is often a planning gap. Renewable energy plants can be developed much faster than conventional alternatives: a solar PV plant, for example, can be built in months, compared to years for conventional alternatives. The speed in developing renewables, however, is not matched by the construction of transmission grids, which have long planning and permitting cycles that can reach up to 10 years. This 'planning gap' between renewables and transmission grids can cause delays in RE deployment and grid access or problems associated with excessive curtailment.

Secondly, there may be a location gap. Renewable energy plants can be either centralized around one location or distributed across a wide area. Typically, however, they are significantly more dispersed and flexible in terms of location compared to conventional energy sources. While this flexibility is often an advantage of RE generation, in some cases, challenges arise due geographically difficult or dispersed locations, and the nature of legacy distribution grid infrastructure built to accommodate a centralized generation system.

Thirdly, there may be a flexibility gap. The variability of wind and solar power generation requires greater flexibility in the grid system than is currently available. More complex and advanced control mechanisms are required to maintain the balance between supply and demand, while also managing power flow fluctuations. Sufficient investment provision must be made for this by TSOs, DSOs and regulators.

From an integration point of view, the technical difficulties faced by renewable energies include:

- Supply uncertainty: Wind and other variable renewable generators exhibit changing dynamics, non-linearities and uncertainties – a set of challenges that require advanced forecasting and control strategies.
- Voltage rise and reverse power flows in distribution networks: Voltage rise is one of the key impacts of distributed generation, and is common on weak or long grids in times of low consumption and high RE generation. Distributed generation may cause reverse flows, in systems that have been designed for one-way power flow; reverse flows are more common as penetration of distributed RE increases and can cause component overload (if the flows are greater than the capacity of the transformer or the lines[1)]).
- Below-full operation: Finally, variable renewables such as wind and solar generators may operate below full available power to provide grid support services like balancing. This has economic consequences since renewable generators have higher opportunity costs than conventional generators (who can save on fuel costs by not providing power). To this end, storage may be a viable solution for RE facilities, given that, for instance, control power usually is required only for a short period of time.

CURTAILMENT IN CHINA

Without proper grid code and connection requirements, RE projects may be subjected to excessive constraints in output, which ultimately undermine the development of RE projects in the long run. In China, in 2013, over 20 TWh of wind energy was restricted due to grid integration issues, which was roughly equal to the annual output of 8 GW of wind capacity in China. In some provinces, curtailment rates exceed 15-20% of annual production.

Similar problems are now experienced by solar PV facilities; in the first half of 2015, the north-west provinces of Gansu and Xinjiang saw curtailment levels of approximately 30% and 20% of generation, respectively[2)].

This heavy grid curtailment has been a significant problem and indicates the importance of proper planning for effective RE deployment and electricity sector management. Of note, State Grid Corporation of China is actively addressing curtailment issues by accelerating cross-regional power grid construction; in particular Ultra High Voltage, large capacity and high efficiency long-distance transmission technology.

One such connection is the Hami South-Zhengzhou ±800kV UHV project, the so-called "electrical silk road", in operation since January 2014. The project crosses 6 provinces from western to eastern China; at approximately 2,000km it is the longest UHV transmission project in the world and has a transmission capacity of up to 8GW. Crucially, the link enables ongoing development of wind and solar PV power in North-West China in connecting this renewable resource rich area with load centres in eastern China.

2) Lacey, S, 2015, "Another Reason We Can't Fully Trust China's Solar Installation Numbers", accessed www.greentechmedia.com/articles/read/another-reason-we-cant-trust-chinas-solar-installation-numbers.

1) EPIA, 2012, "Connecting the sun", accessed www.epia.org/fileadmin/user_upload/Publications/Connecting_the_Sun_Full_Report_converted.pdf

The importance of smarter integration of renewables

Smarter integration of renewables could lower costs for generators, lower electricity prices for consumers and lower overall carbon emissions. Moreover, it will remove grid bottlenecks and enable renewables to be deployed more rapidly.

In a number of European countries, a sizable proportion of demand can now be covered by variable renewables. In 2013, in Spain, for example, more than 20% of total annual domestic electricity demand was fulfilled by wind alone, with the maximum daily demand covered by wind power reaching over 65%[1]. Similar annual figures were reported in Denmark, Portugal, Germany and Italy. The integration of these increasing penetrations of wind and solar PV is most efficient and cost effective with smarter integration – across technical, regulatory and market aspects.

The following features are deemed key when considering smarter integration of variable renewable energy. Each will be discussed in more detail in the following sections.

- **Making renewables – and the grid – more flexible and predictable:** One of the impacts of improved technology and control that is already evident is the vast improvement in forecasting methods. For wind and solar PV, for example, forecast reliability has improved significantly, making supply from renewable sources much more reliable from a control point of view[2]. In addition, advanced controls can save cost in allowing for the remote management of technical problems and enhancing operational management in power systems. In Spain, for example, remote control centers are now mandatory, and Acciona and Iberdrola both manage multi-GW portfolios through remote control centers.
- **Adapting market rules:** Adapting market rules will ensure that optimal and cost effective approaches are adopted. Most rules defining the procurement of system services are not designed for RE participation. Crucially, improved system stability and adequacy enables renewables to fully participate in ancillary services markets, providing more and better options for valuing flexibility.
- **Developing the transmission system:** Developing the transmission system will mean that more renewable energy plants can be connected to the system more quickly. A transmission system that facilitates electricity exchange between countries via HVDC or UHVDC will connect resource-rich areas with load centers and bring more competitive wholesale and retail markets. Additionally, a more interconnected system brings the potential for more reliable and secure operations[3].

Image courtesy of Acciona

[1] Red Electrica de Espana, 2014, "The Spanish Electricity System", accessed www.ree.es/en

[2] www.technologyreview.com/featuredstory/526541/smart-wind-and-solar-power/

[3] Though note that because the AC system is 'stiff-connected', this enables cascading failures, therefore protection measures have to be taken to prevent (contain) spreading (cascading) of failures/outages.

Image courtesy of Welspun Energy

- **Transforming the distribution system:** A smart distribution system will enable more renewable plants to be connected more quickly. It will also ensure that key technical performance metrics are not compromised, thereby increasing reliability. Additionally, it will enable consumers to generate their own energy cost effectively, and maximize the use of the existing network. In fact, analysis suggests that demand response is particularly good value, as it can deliver major savings at limited or negative cost[1]. Crucially, the value of smart grids increases markedly in low emission scenarios, as renewables penetrations increase[2].

Solutions and recommendations

MAKING RENEWABLES – AND THE GRID - MORE FLEXIBLE AND PREDICTABLE

Opportunities to improve renewables technology and control - making renewables more a flexible and predictable market participant - include better forecasting, centralized control centers and a host of other solutions, now and for the future.

Meanwhile, a variety of technologies can be implemented to make the grid itself more flexible, thereby enabling the power grid to work for renewables, rather than simply asking renewables to adapt to the grid.

Nowadays, technical improvements allow operation of renewable generation systems similarly to modern thermal power plants. While there are additional upfront investment costs for enhanced provision, these are relatively low and, if appropriate cost recovery or market mechanisms are in place, their deployment will be commercially feasible in most cases.

These active power control services have the potential to allow wind and solar PV energy to assist the power system both under disturbances and during normal conditions. With the right market mechanisms and regulations, RE can be an asset to the system. Renewable-based generators with advanced control capabilities can provide full grid support services to help maintain power system security and reliability. For example, through the use of inertial response and primary and secondary frequency response, renewable generation can provide assistance in balancing the generation and load on the system. Moreover, if adequate controls are developed, and incentives provided for this, dispersed renewables may considerably improve the resilience of the electrical system in case of severe disruptions; if islanded capabilities are developed, dispersed renewables may continue to deliver a minimum of electricity during the period when the main system is out of order.

Recommendations for policymakers and regulators

Key recommendations for policymakers and regulators in facilitating renewable energy to be a more flexible and predictable market participant are as follows:

- Level the playing field: Renewable power plants should be granted equal access to participate in electricity markets and regulators should take into account the unique features of renewable power generation.

[1] DNV GL, Imperial College and NERA Economic Consulting (2014) *Integration of renewable energy in Europe.* www.ec.europa.eu/energy/sites/ener/files/documents/201406_report_renewables_integration_europe.pdf

[2] USEF (April 2014) An introduction to the Universal Smart Energy Framework.

- Grid code requirements: System studies taking into account expected renewable penetration should inform the principal basis for Grid Codes when formulating the requirements and capabilities for renewable generation. This will avoid costly retrofits and/or extra burdens for new generators. Standards and grid codes should be developed and continuously updated to reflect technology improvements and advances in control systems.
- Define the role of DSOs and TSOs: Cooperation between DSOs and TSOs and clear definition of boundaries in roles and responsibilities is required. Guidelines should be specifically developed on how the distribution system can contribute to grid reliability and stability.
- Cost-benefit analysis: System operators should deliver mandatory cost-benefit analyses when Grid Codes or national grid connection requirements are created.
- Standardization of backbone infrastructure: The exchange of data (including forecasts) and associated communication interfaces between generating facilities and the relevant system operators should be standardized. Common methodologies for assessing system flexibility, system adequacy and the needs of grid support services with large amounts of renewable power plants should be developed.
- Facilitate deployment of new business models: Enable participation of new entrants through innovative business models such as demand response or aggregation of distributed resources (both generation, and demand) to enhance flexibility and dispatchability of RE.
- Strengthen regional interconnections: Better connections between neighboring market zones facilitates the widespread adoption of renewables and increases the reliability of supply. This will be discussed further in the context of transmission system recommendations.

The private sector also has a crucial role to play. In particular, there is a need for increased R&D funds to be focused on addressing challenges associated with grid integration. This could include improved forecast methods, transnational grid studies, development of capacity to provide ancillary services, energy storage and demand side management. Expanding grid-supporting capabilities of power electronic interfaces connecting new energy sources to the grid (solar inverters, wind converters, battery energy storage converters) is also crucial. Additionally, there is a need for continued improvement in forecasting and security; improved forecasts and online dynamic security methods used in power system operation will allow greater advanced control capabilities for renewable power plants. With better forecasting capabilities and wide-area information, renewables can ultimately be more fully utilized.

Adapting market rules

Market rules can be designed and adapted to harness the full potential of wind and solar PV technologies.

With the exception of providing energy on demand, wind (and to some extent solar PV) can do anything a network operator requires - and often faster or more accurately than conventional generation. Although the potential flexibility of wind and solar is significant – with a high potential to address technical challenges to system operation - in most markets project developers and operators are not given a reason to use it. The key is to structure markets and regulation so that the full benefit of wind and solar PV generation can be harnessed.

It is also necessary to provide stronger market signals to ensure that the flexibility provided by conventional generators – and increasingly provided by battery, pumped hydro and other forms of storage – is appropriately valued.

Of note, "Virtual Power Plants", which aggregate a number of distributed generation facilities into a single operating entity, can achieve the required scale and flexibility to participate in the wholesale and ancillary services market and reduce the variability of supply.

AGGREGATION OF DISTRIBUTED RE FACILITIES

"Next Kraftwerke" is an aggregation of individual RE power plants operating in Germany since 2012. It aggregates the output of over 2,000 distributed resources (biogas, solar, wind, hydro, demand response) representing over 1 GW across multiple DSOs and now expanding into Belgium and Austria. Plant optimisation software allows for dynamic optimisation and allows the VPP to increase or reduce output either immediately or within minutes of a command being issued.

California's Independent System Operator has led the way towards enabling aggregation of smaller systems in recently approving rules to allow companies to purchase electricity from a number of commercial and residential systems and bundle it for sale on wholesale electricity markets. The consolidation of output may span PV systems, batteries and potentially EVs[1]. While the economics of aggregation of smaller systems will take some time to optimise, it is clear that regulatory changes can allow the development and deployment of new business and operational models and facilitate integration of distributed renewable energy resources into the grid.

[1] Bloomberg News, 2015, "California Approves Distributed Energy Resource Providers To Aggregate Renewable Energy Generation", accessed www.renewableenergyworld.com/articles/2015/07/california-approves-distributed-energy-resource-providers-to-aggregate-renewable-energy-generation.html.

Recommendations for policymakers and regulators

- Widen the range of ancillary services in the electricity market: Adequate market frameworks and technical requirements are needed to harness the full benefits available. This could include a liquid market platform for grid support services in liberalized markets. A market-based approach is considered preferable as it avoids distortions associated with capacity schemes.
- Amend grid codes: Grid codes must be amended or revised to enable participation of RE in grid support services. In particular, recommendations on frequency and voltage support should be implemented.
- Support or develop an implementation roadmap: Describing the capabilities and grid support services needed with increasing wind and solar PV penetration.
- Cost-benefit analysis on pricing: Cost-benefit analyses should be undertaken in the absence of liberalized and liquid market platforms. Appropriate price ranges for the provision of support services should be assigned to ensure prices capture benefits both in terms of the value of the service and the cost savings to system operations. A clear framework for how to carry out the cost-benefit analyses should be established.
- Engage stakeholders: Regular consultation on the appropriate regulatory regime or market platform for grid support services should be undertaken, covering governance, financial arrangements, power system studies and other technical capabilities.

Developing the transmission system

Solutions for the transmission system must focus on future adaptability, and not just build on the rules of the past.

When assessing potential solutions at the transmission level, there are two main schools of thought about how to address future transmission needs in less mature markets with lower penetration of renewables.

One, a ‘supergrid’ or ‘megagrid.’ This solution would replace or overlay existing transmission networks with High (or Ultra High) Voltage Direct Current (HVDC). It would provide greater future flexibility, but the concept remains expensive and faces a number of technical challenges.

Two, a hybrid grid. This would transform the existing grid into a hybrid transmission grid, combining newer Alternating Current (AC) technologies and materials with existing AC transmission networks. The goal is to increase flexibility and capacity. It also bridges gaps by using HVDC links between existing transmission grids and HVDC corridors to transport power over long distances. Currently, this approach is cheaper than the ‘supergrid’ alternative. The growing need to integrate large power generation plants with numerous small and dispersed plants requires a combination of AC and DC technology, overhead lines, underground cables, and both slow (mechanical) and fast (power electronics) controls. These demands will result in an increasingly complex transmission system that will need to be both flexible and reliable.

Image courtesy of State Grid Corporation of China

RECOMMENDATIONS FOR POLICYMAKERS, REGULATORS AND OPERATORS

- Set out the policy plan for the next decade/s: Given the long lead times for transmission system build-out, a policy timeline of at least a decade is required to address planning issues. A legal framework needs to be put in place - in particular in countries which have unbundled grids - to define the needed grid developments. An example for such a framework is the recently introduced European Ten Year Network Development Plan process in combination with the National Grid Development plans of the EU member states, introduced in 2009.
- Speed-up legislation and provide clearer roadmaps to address the planning gap: Consultation and due process are important during transmission planning, but the process must be accelerated to reduce the long lead-times of new transmission projects where possible. Improved energy roadmaps that provide clearer geographic guidance on likely future generation and load centers would also aid transmission system planning.
- Create a meshed regional network: Develop high and ultra-high voltage transmission networks that cross national borders to address location and flexibility gaps across wide regions. Wide geographic dispersion of RE generation can overcome variability issues; interconnections across borders or regions can have smoothing effects while connecting resource rich areas with load centers. For example, the Agora Energiewende analysis of onshore wind aggregation across the European continent revealed considerable potential for smoothing wind generation, with the single largest hourly fluctuation at 10% of installed capacity. Meanwhile, hourly output changes exceeding 5% of installed capacity occur for only 23 hours in a year.
- Improve harmonization and co-operation: International forums such as the European network of transmission system operators for electricity (ENTSO-E) should be supported to improve harmonization of Grid Codes. Cooperation between TSOs and DSOs is again necessary.

Image courtesy of ABB

Transforming the distribution system

There are already several potential technical and market-based solutions available at the distribution level. But they must be adopted quickly to avoid distribution becoming a roadblock, and the role of DSOs is increasingly important as these operators are managing an increasing proportion of RE in the distribution grid.

Of note is that, despite the challenges highlighted above, distribution grids can take up significant amounts of distributed, variable generation with little or no grid adjustments. Nevertheless, as penetration of distributed RE increases, challenges to the system arise. The solution will comprise a combination of technical upgrades, 'smart' technology measures and regulatory and market changes. Recommendations are detailed below.

RECOMMENDATIONS FOR POLICYMAKERS, REGULATORS AND OPERATORS

The consequences of changes to the distribution system must be fair for all. Below are recommendations for policymakers, regulators and operators looking at distribution systems.

- Smarter technologies: Deploy 'smarter' technologies (including smart meters and smart grid managing systems, storage, advanced communication, smart inverters and intelligent distribution transformers) to enable more active network management, improve monitoring, maximise the use of existing network assets and facilitate increased hosting capacity and reduced costs. New specifications for equipment – particularly inverters – can be used to future-proof distribution grids.
- Better planning: Without long-term grid planning for integration of small systems, bottlenecks and other issues are more likely. As with transmission grids, long term planning and forward-looking approaches (such as prognosis exercises of future installed generation) are needed to develop cost effective strategies to manage distribution systems.
- Smarter regulation: Break down regulatory barriers to enable new agents to enter the market and allow aggregation of multiple distributed RE plants to facilitate increased participation in markets and grid support services. Regulators must establish the clear and efficient incentives so that participants can make the most of new possibilities.
- Provide innovation funding for pre-commercial technologies: Newer distribution technologies, such as batteries and smart grid systems, require ongoing R&D to facilitate and accelerate commercial deployment.
- Promote cooperation with TSOs: Regulation must promote, not discourage, cooperation and information-sharing between TSOs and DSOs.
- Move away from 'fit and forget': The move from distribution network operator to distribution system operator should be promoted. This is part of a new energy paradigm that moves away from 'fit and forget' to a more active network management approach. It focuses on changing from centralized generation to distributed generation, and from networks to systems.

Summary and conclusions

Considerable acceleration in deployment of renewable energy is needed in order to decarbonise the energy sector and achieve the IEA 2°C scenario. Business as usual investment will not deliver the volume of capital required at a favourable cost, and technical challenges must be overcome. The private and public sector must work together to scale renewable energy deployment and overcome key barriers associated with access to finance and renewable energy integration.

The Renewable Energy LCTPi brings together sixteen of the world's leading energy companies to develop and deploy business solutions to address these challenges. However, success also depends on urgent action by governments: current market and regulatory conditions cannot drive the global deployment of renewable energy technology at the speed that is required.

In summary, public policies should promote:

- A stable and robust carbon pricing system across all sectors of the economy with dedicated use of revenues for renewable energy and other low carbon initiatives;
- A stable and reliable energy policy framework that sends a clear signal to investors while being flexible to evolving technical, economic and social circumstances and avoiding retroactive changes where possible;
- A level playing field between renewable and conventional technologies, addressing issues such as uneven subsidies to fossil fuels, discriminatory market rules in some markets, systemic bias in financial regulation and unfavorable administrative requirements;
- Development of operational and market frameworks to harness and value the full potential of renewable generation and facilitate the deployment of new business models;
- Planning of and investment in transmission and distribution infrastructure with consideration for the changing nature of the electricity system and the growing penetration of distributed renewable energy;
- Support for innovation and R&D across a wide range of proven and promising technologies.

While the private sector can and will continue to invest in renewable energy deployment and solutions to address barriers, government action on these recommendations is also necessary to ensure the scalability of our business solutions and, ultimately, to remain under the 2°C threshold.

Fundamentally, there is a need to create a policy environment that encourages and supports this massive and essential investment in renewable energy infrastructure.

The time to act is now.

Annex 1: List of acronyms

2DS	Two degrees scenario
6DS	Six degrees scenario
BAU	Business as usual
CBI	Climate Bonds Initiative
CO_2	Carbon dioxide
COP	Conference of the Parties
eq	equivalent
EU	European Union
GDP	Gross Domestic Product
Gt	Gigatonne
GW	Gigawatt
GWh	Gigawatt hour
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt hour
LCOE	Levelized cost of electricity
LCR	Local content requirement
MW	Megawatt
MWh	Megawatt hour
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
RE	Renewable energy
TW	Terawatt
TWh	Terawatt hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollars
WBCSD	World Business Council for Sustainable Development

Annex 2: Renewable Energy LCTPi Action Plans

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