HIGH-LEVEL POLITICAL FORUM ON SUSTAINABLE DEVELOPMENT

POLICY BRIEF #6

SUSTAINABLE ENERGY TECHNOLOGY INNOVATION

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This document is a part of a series of Policy Briefs being developed to support SDG7 review at the UN High-Level Political Forum to be held in July 2018. The objective is to inform intergovernmental discussions by providing substantive inputs on SDG7 and its interlinkages with other SDGs prepared through inclusive multi-stakeholder consultation processes. The development of these Policy Briefs is coordinated under the auspices of the Ad Hoc Informal Multi-stakeholder Technical Group of Advisors on SDG7.

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SUSTAINABLE ENERGY TECHNOLOGY INNOVATION AND THE SDG7

The global energy system is changing, driven by technological innovation and new policy priorities. In the power sector, renewables and nuclear capacity additions supply the majority of demand growth. On the demand side, innovative transportation technologies are gaining momentum and are projected to increase electricity demand. Rising living standards mean more people will buy appliances, electronic devices and other goods powered by electricity, also driving up electrical needs. Innovation is crucial to addressing future pressures whilst tackling the environmental problems associated with climate change and air pollution. [1]

The ways in which energy is produced and in which people access energy are also changing. Analysis based on IEA data indicates that from 2006 to 2016 nearly all those who gained access to electricity worldwide did so through new grid connections. Over the past five years however renewables have been gaining ground over power generation from fossil fuels, as have off-grid and mini-grid systems, and this trend is expected to accelerate. [2]

While SDG 7 confirms the general understanding that sustainable energy solutions should be operationalized for the benefits of humankind and the environment, its use is currently inadequate and unequal as only a fraction of countries utilize their sustainable energy resources efficiently. Despite most regions having adequate energy resources, with some regions blessed with all forms of energy potential, many of these suffer severe energy poverty due to inadequate generation capacity, limited electrification, low power consumption, unreliable services and high energy costs. Innovation in energy technologies and the associated systems and processes is needed to sustain changes in the sector and ensure universal access to the benefits in both developed and developing countries.

Progress in Energy Technologies

In recent years there has been impressive progress in the cost of key renewable energy technologies – particularly in solar power and on-shore wind. These cost reductions are primarily driven by economies of scale but have been enabled in part by innovation.

Over the past seven years, solar photovoltaic (PV) module prices dropped by over 80%, and the global weighted average levelized cost of electricity (LCOE) [3] fell by 73% to USD 0.10/kWh in 2017. Onshore wind turbine prices have fallen by 30-40% between 2010 and 2017, with the global weighted average costs of electricity falling by 23% to USD 0.06/kWh in 2017. Utility-scale solar PV projects commissioned in 2017 had LCOEs as low as USD 0.05/kWh and onshore wind as low as USD 0.04/kWh, making them competitive with conventional power generation technologies.

Progress is also being made in enabling technologies for example, recent technological developments and innovations in energy storage systems have led to the emergence of a variety of battery chemistries offering a diversity of performance capabilities and costs. One particular technology that has undergone some major improvements in recent years are lithium-ion batteries which are estimated to have doubled their energy density and reduced their cost tenfold in the last ten to fifteen years. [4]

Progress through Innovation

Signs are positive that energy technology innovation is accelerating at a historically unprecedented pace. Driven by an convergence of forces which are reshaping the electric power industry – from increasing stress on resources, decentralised supply, the need for resilient infrastructure, to climate change – and enabled by the interaction of various disciplines – such as data and information networks – that have traditionally not been linked with energy. As the rate of interlinkages increases and improvements in data and information networks accelerate, we can expect rapid advances in the innovations that exploit the interactions of these technologies.

Technologies such as sensors, robotics, and advanced analytics, which together form advanced interconnected systems capable of quickly analysing large amounts of data, are developing potential transformative solutions, across various sectors, for improving energy efficiency. This development is driven by exponential improvements and the cost-performance curve of core digital technology building blocks – computing power, data storage, and bandwidth utilization.[5]

The variety of factors driving the progress in energy technology requires a more intelligent and integrated energy infrastructure on the distribution end of the energy system to secure the reliability and durability of the grid. Out of these reasons today's grid technology innovations are exploring its transformation from a one-way system, to a platform that can

[1] IEA (2017), Energy Technology Perspectives

[2] IEA (2017, World Energy Outlook

[3] LCOE numbers in this section exclude the impact of any local or federal financial support policies, are for the year of commissioning and are based on IRENAs Renewable Cost Database that contains cost and performance details of 15 000 utility-scale power generation projects.

[4] Van Norden (2014), Available online at: http://www.nature.com/news/the-rechargeable-revolution-a-better-battery-1.14815#batt2;
http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/1007/Li-Ion_Battery_costs_-_MP_Final.pdf?sequence=1

[5] Hegel et al. (2013), Available online at: https://www2.deloitte.com/content/dam/Deloitte/es/Documents/sector-publico/Deloitte_ES_Sector-Publico_From-exponential-technologies-to-exponential-innovation.pdf

detect, accept and control decentralized consumption and production assets so that power and information can flow as needed in multiple directions. These innovations are expected to allow consumers to play an increasingly influential role in the future of energy systems by giving them the opportunity to also act as producers of energy and provide services to the larger energy system. IoT technologies are playing, and will continue to play, a key role in this process.

Investment in Energy Innovation

Technology innovation is a key driver of change in the energy sector, yet information on the level of investment in research and development (R&D) activities related to energy technology is scarce. The IEA tracked USD 65 billion of spending on all forms of energy R&D worldwide in 2015, based on a bottom-up approach of collating information on spending by public and private sector bodies. Spending on neither energy technology generally nor clean energy R&D specifically has risen in the past four years. Private sector spending is difficult to accurately track but the data gathered suggests that most private-sector energy R&D is focused on the oil, gas, and thermal power sectors, and most public R&D supporting sustainable energy technologies. [6]

Key Challenges (or Gaps and Opportunities)

Whilst encouraging progress has been made in some key technologies, the pace of change is not sufficient.

Analysis by IRENA shows that energy efficiency and renewable energy have the potential to achieve 90% of the emissions reductions needed by 2050 with renewables having the potential to account for two-thirds of primary energy supply in 2050, growing from 16% today. To deliver on that potential however the growth of the renewables share in total final energy consumption needs to rise seven-fold, from 0.17% per year between 2010 and 2015 to 1.2% per year on average until 2050[7].

For around one-third of energy-related emissions in 2050[8], no economically viable options for decarbonisation exist today.

The world is under investing in innovation if we are to achieve the cost reductions and performance improvements at the pace needed to transition the world's energy systems to low carbon by 2050.

Higher investment in innovation is needed to support accelerated deployment of today's clean energy technologies – by further reducing costs, improving the utility and adapting technologies to local conditions – and to find such solutions for those missing sectors – particularly for transport and industry.

Doing so is in countries self-interest. Renewable energy and energy efficiency technologies, stimulated by government-driven efforts, would bring major benefits beyond decarbonising the energy sector (OECD/IEA and IRENA, 2017); increasing wealth, promoting social inclusion and improving environmental quality and health.

Action today is a matter of urgency, as a full-scale energy transition takes decades due to the different technology development steps, the long lifespan of the existing capital stock and the current role of fossil fuels in all aspects of economies and lifestyles.

Policy-makers need to act now to nurture innovation, supporting both RD&D to improve performance and cost and the innovative approaches to the deployment and scale-up of key innovations to fully realise their potential. While it is the private sector that ultimately must bring innovations to market, governments have a critical role to play in facilitating that.

Innovation Needs in the Power sector (emerging technologies)

Technologies such as Solar and On-shore Wind will continue to improve, through further innovation, to reduce costs, improve performance and adapt systems to more applications. In addition, however technologies that are not widely deployed today will have to play an important role in the transformation of the power sector. Increased innovation is needed to ensure these technologies achieve their full potential.

IRENA's analysis indicates that more than 14% of the CO2 abatement potential, or 4.5 Gt CO2/yr, [ref] could come from a combination of the following technologies[9]:

- Concentrating solar power
- Ocean energy
- Offshore Wind
- Geothermal energy
- Enabling electrification – Batteries and Electric vehicles
- Heat and cold storage

The additional investment needs for these technologies are estimated at USD 5.71 trillion, from 2015-2050.

Innovation Needs in the End-use sector (Heating & Cooling, Transport)

The electrification of end-use sectors could offer a win-win situation in reducing emissions while also supporting the integration of higher shares of VRE in power systems. Beyond electrification, there are currently no economically viable emission reduction solutions available for sectors such as iron and steel making, cement production, chemicals and petrochemicals production, maritime transport, aviation,

[6] IEA (2017), World Energy Investment

[7] IRENA (2017), Accelerating the energy transition through innovation

[8] Ibid.

[9] For a more comprehensive overview please see IRENA's report "Accelerating the energy transition through innovation" (IRENA, 2017)

freight, or the replacement of non-sustainable traditional biomass.

Industry and buildings are the most challenging sectors, followed by some transport modes. These sectors require new technology solutions to be developed and then to be commercialised quickly. For example only 1% of global demand can directly respond to shortages or excess supply. IEA estimates that about 20% of electricity consumption worldwide will be available for demand response in 2040.[10]

Addressing the needs of the end-use sector will require innovation in a suite of emerging technology solutions that offer significant impacts requires additional innovation efforts. Examples include:

- high-performance low-cost batteries for electric vehicles
- advanced biofuels and biochemicals and biomaterials
- new cement types that reduce cement clinker needs
- new marine shipping solutions
- solar thermal and other renewable solutions in the urban environment
- renewables-based clean cooking solutions that meet consumer needs;
- digitalized demand response systems;
- CO2 capture and storage for cement clinker production, iron making, waste incineration and biomass processes

Wider System Innovations

Alongside innovation in technologies, innovation is needed in the energy system to support and accelerate the wider spread adoption and scale-up of clean energy. In particular innovations are needed in: enabling infrastructure, business models, market designs and system operation.

A holistic approach to energy technology innovation is required. In particular, with the rapid cost decrease of solar PV and wind, the issue of system integration of variable renewables is increasingly a pressing priority and one that will influence technology competition across energy markets. Energy storage and demand response will play important roles in the transition, providing flexibility to energy systems, improving the management and increasing the potential to accommodate further distributed generation.

Key technologies that will enable a high share of variable renewable power in electricity systems include:

- seasonal storage
- super grids that take advantage of the benefits of geographical distribution of renewables
- power-to-X approaches that offer efficient uses for electricity supply surpluses
- digitalisation of power systems (smart grids)
- market models that provide real time price signals to encourage demand response
- standardised off-grid solutions for rural areas and remote locations

How to fill the gap in sustainable energy technology and innovation?

Addressing these innovation needs at the pace required to deliver the SDGs requires collective action from national governments, international initiatives and the private sector. Key considerations include:

Cost reduction is an overriding priority: The main goal of the innovation efforts in low-carbon technologies is to ensure cost competitiveness without the need for subsidies. In that way, innovation will contribute to maintaining an accelerated scaling up of low-carbon technology, irrespective of fossil fuel price volatility and independent of climate policy agreements.

The active engagement of the private sector is critical: Mobilising the innovation capacity of the private sector is of prime importance.

Innovation requires a portfolio approach: Innovation is an uncertain process and so innovation policy frameworks need to ensure that effort is balanced between potentially competing approaches. Flexibility in innovation policy design is also important: the portfolio of low-carbon technologies may change as the technology progress and transition pathways evolve. Continuous monitoring and adjustments will be needed.

Innovation requires a multi-disciplinary approach: The most attractive new solutions may be found at the interface of different areas, such as between the energy sector and ICT.

Innovation is broader than technology R&D. Innovation covers the complete technology lifecycle. Increased R&D investments are important, but in isolation will not bring the needed results. Efforts should also cover the demonstration, deployment (technology learning) and commercialisation stages. Innovations in business models, market designs, enabling infrastructure and systems operation, are equally crucial to achieve the energy transformation.

[10] IEA (2017), World Energy Outlook

Innovation challenges span borders: Much of activity needs to take place at a national level but international collaboration can also be an enabler of accelerated progress. In particular governments working together to increase cross-border and public-private collaboration.

Policy incentives are lacking in key sectors: The sectors with the least progress in innovation for decarbonisation are those where proper policy incentives and long-term perspectives are lacking. This includes heavy industry as well as freight transportation and aviation. Governments should consider prioritise options that can stimulate private sector innovation.

Some industries require global, sector-specific agreements: The aviation, shipping, iron and steel, cement, chemical and petrochemical sectors cannot be transformed through national policies alone due to their global nature. For those sectors, global agreements for the deployment of technology solutions are indispensable.

Energy Efficiency must go hand-in-hand with decarbonised generation: Significant opportunities exist in the domain of renovating and refurbishing existing capital stock. Furthermore, the deployment of connected devices is growing providing new opportunities for energy saving through more accurate control of consumption. However, such activities should not happen in isolation, the introduction of policies that mandate energy efficiency improvements have to increase beyond current levels.

Manoeuvring the innovation race: The vast and increasing speed of digitalized technology development could lead to a first-mover advantage for pioneering countries or companies. This would give the few top runners large economic influence and – if regulations are weak – the power to lever out social and environmental standards. Countries could therefore not only be increasingly challenged to provide suitable framework conditions for innovation, but also to protect existing standards and to expand them to newly developing digital branches.[11]

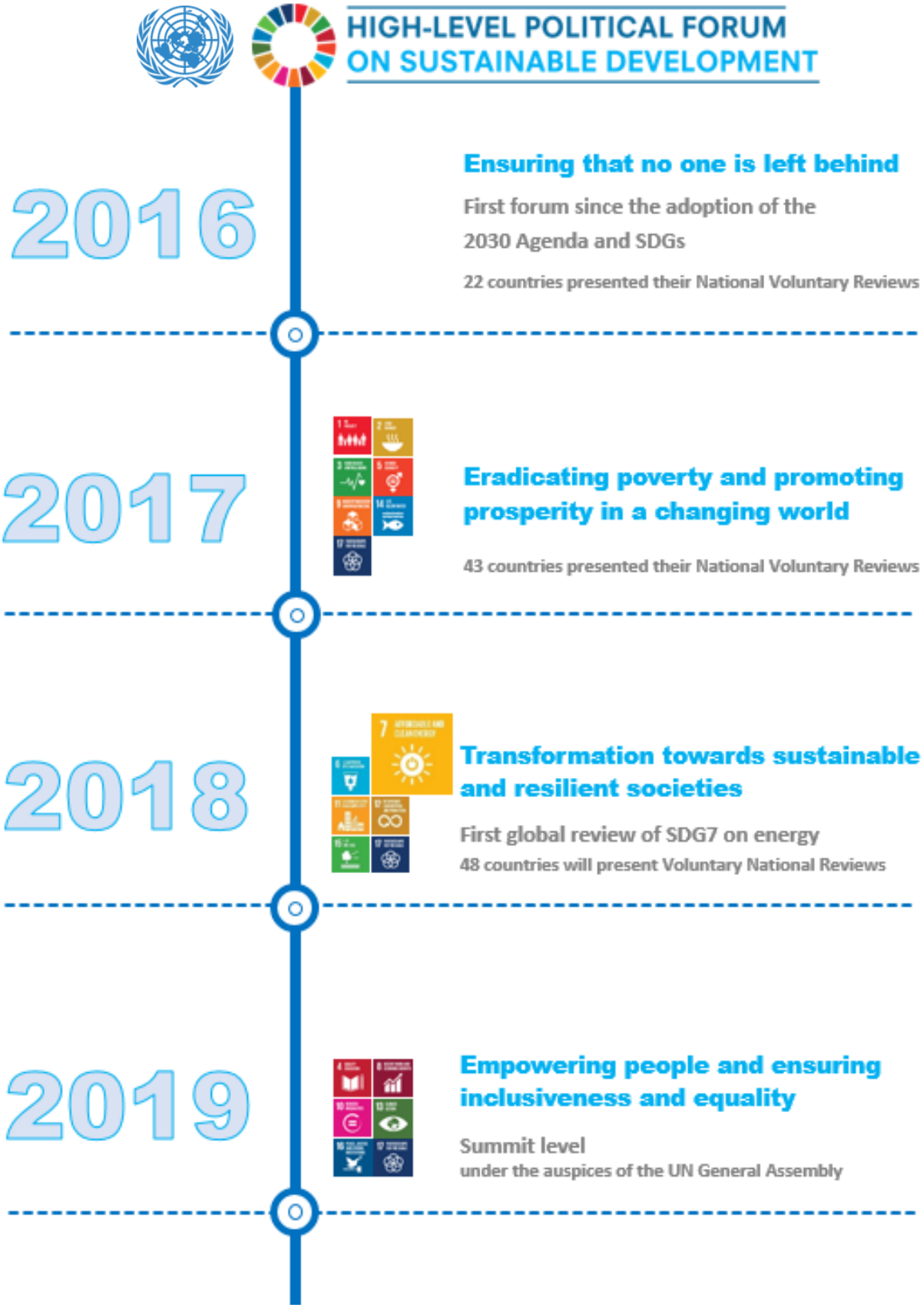
The needs of both developing and emerging economies need to be considered: Historically, innovation for low-carbon technology has been driven by industrialised economies. However, a large amount of future growth in energy consumption will come from developing and emerging economies, which have different economic, technology and geographical context. Energy services and technology performance needs are often very different in these developing economies, compared to developed ones. Therefore, a more significant effort is needed to find innovative solutions for developing countries. Obvious examples include clean cooking solutions and decentralised off-grid technologies for providing electricity access.

Policy recommendations

To address gaps in our current capabilities policy makers should:

- Champion a systemic approach to innovation that considers not just technology innovation but also innovations in systems, in processes, in market design and in business models in order to accelerate the diffusion and uptake of innovations.
- Develop an improved globally-shared understanding amongst key public and private sector investors of the critical innovation needs and what is needed to address them;
- Establish more bilateral and multi-laterally public-private funded commercial-scale demonstration projects and 'real-world' pilot programmes for innovative technologies and processes.
- Encourage the development of internationally harmonised technical standards and quality control requirements that will facilitate the cross-border trade of innovative technologies;
- Utilise existing international programmes, such as IRENA, IEA, UNIDO, UN Environment and their Technology Collaboration Programmes, Mission Innovation, Innovation Accelerators, and Regional Centers to define a joint renewables technology innovation agenda, which identifies the critical innovation needs of developed, emerging and developing markets and develops collaborative strategies to address them.
- Increase public sector investment in Research, Development and Demonstration, in line with pledges made by Mission Innovation members at COP21.
- Support and encourage established platforms to strengthen knowledge diffusion and establish more cross-border co-operation on innovation.
- Home grown innovations in developing countries that address local needs and challenges should be encouraged and accelerated through existing financial mechanisms while creating enabling environments through appropriate policy solutions.

[11] UNIDO (2017), Accelerating clean energy through industry 4.0



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