ACCELERATING SDG 7 ACHIEVEMENT

POLICY BRIEF 06

SUSTAINABLE ENERGY TECHNOLOGY INNOVATION

7 AFFORDABLE AND CLEAN ENERGY

ACCELERATING SDG 7 ACHIEVEMENT

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POLICY BRIEF #6

SUSTAINABLE ENERGY TECHNOLOGY INNOVATION

Developed by

United Nations Industrial Development Organization (UNIDO), International Renewable Energy Agency (IRENA), International Energy Agency (IEA) and UN Environment

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CTCN

KEY MESSAGES

Status of sustainable energy technology innovation and progress towards achieving SDG 7

- Innovation has played a critical enabling role in progress towards the SDG 7 targets, by reducing costs and enhancing the capabilities of technologies such as solar, wind and energy storage. Significant further innovation is needed, however, in all aspects of the energy system if we are to markedly accelerate the energy transition and achieve the SDG 7 targets.
- Innovation priorities are shifting. Innovation in power generation technologies will further reduce costs and accelerate uptake, but the most pressing innovation needs are now in the end-use sectors of transport, industry and buildings, as well as in the design and operation of the whole energy system.
- Innovation is needed to enable increased electrification of those end-use sectors, accompanied as well by innovations in the systems that will facilitate the integration of high shares of variable renewable power. Emerging technologies such as the digitalization of grid services, local and grid-scale battery storage, smart charging for electric vehicles, wider utilization of mini-grids, and many others, will be key enablers.
- Beyond electrification, additional innovation is needed to develop the technology solutions that can help affordably decarbonize activities such as iron and steel making, cement production, chemicals and petrochemicals production, freight and maritime transport, and aviation.
- Delivering that innovation will require increased and focused action. That action will need to be better coordinated across national governments, international initiatives and the private sector. Public and private sector investment must significantly increase. Improved data collection and analysis is also needed to better target efforts and track progress. Action today is a matter of urgency, as technology innovations can take many years to reach wide-spread deployment.

Priority actions towards 2030

- Increase public-sector investment in research, development and demonstration, as a starting point in line with pledges made by Mission Innovation members at COP21, but going beyond that to deliver further increases in the 2020s.
- Mandate established international platforms to work collaboratively to develop an improved globally shared understanding by key public and private sector investors of the critical sustainable energy innovation needs of developed, emerging and developing markets.
- Enhance existing data collection and information-sharing activities on public and private sector spending for sustainable energy technology innovation.
- Support and encourage established international platforms to strengthen knowledge diffusion and establish more cross-border cooperation on sustainable energy research and innovation.
- Establish many more bilateral and multilateral public/private-funded commercial-scale demonstration projects and "real-world" pilot programmes for innovative sustainable energy technologies and processes.
- Encourage the development of internationally harmonized technical standards and quality-control requirements that will facilitate the cross-border trade of innovative sustainable energy technologies.

Champion a systemic approach to innovation that considers not just technology innovation but also innovations in systems, processes, market design and business models in order to accelerate the diffusion and uptake of innovations.

OVERVIEW

This document provides policymakers with a high-level overview of the status of technology innovation in the context of SDG 7. It briefly summarizes the progress made to date and provides illustrative examples of areas that require increased innovation efforts in power generation, end-use sectors and the systems as whole. It highlights the key policy considerations that should be taken into account when developing actions to accelerate innovation.

Sustainable energy technology innovation and SDG 7

The global energy system is changing, driven by technological innovation and new policy priorities.

The ways in which people access energy (SDG target 7.11)[1] are a part of this change. 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 off-grid and mini-grid systems have been making headway and this trend is expected to increase (IEA, 2017a).

In an even more accelerated fashion, the way in which energy is produced (SDG target 7.2)[2] is transforming as renewables continue to gain ground over power generation from fossil fuels. In the power sector, in 2016, renewables accounted for two-thirds of all global net capacity additions.

Energy efficiency, largely enabled through progress made in energy system optimization and energy management systems standards, (SDG target 7.3)[3] has improved at a fast rate since 2010 (2.2 per cent per year).

However, despite the positive trends observed in recent years, global efforts still fall short of the ambitious targets set out in SDG 7. While SDG 7 confirms the general understanding that sustainable energy solutions should be operationalized for the benefit of humankind and the environment, their use is currently inadequate, and unequal, as only a fraction of countries utilize their sustainable energy resources efficiently. These current insufficient efforts are being further challenged. Rising living standards mean more people will buy appliances, electronic devices and other goods powered by electricity, driving up energy needs, while innovative transportation technologies are also gaining momentum and are projected to increase electricity demand.

Innovation in energy technologies and associated systems and processes is crucial for addressing future pressures and sustaining changes in the sector, and at the same time tackling the environmental and health problems associated with climate change and air pollution (IEA, 2017b).

Progress in energy technologies

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

Over the past seven years, solar photovoltaic (PV) module prices dropped by over 80 per cent, and the global weighted average levelized cost of electricity (LCOE)[4] fell by 73 per cent to US$ 0.10/kWh in 2017. On-shore wind turbine prices fell by 30–40 per cent between 2010 and 2017, with their LCOE falling by 23 per cent to US$ 0.06/kWh in 2017. Utility-scale solar PV projects commissioned in 2017 had LCOEs as low as US$ 0.05/kWh and on-shore wind was as low as US$ 0.04/kWh (IREANA, 2018), making these technologies competitive with conventional power generation.

Progress is also being made in enabling technologies necessary for a higher uptake of renewable energy into the grid. 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. Lithium-ion batteries, in particular, have undergone major improvements, and are estimated to have doubled in energy density and reduced in cost tenfold in the last 10 to 15 years (Van Norden, 2014).

Trends in energy innovation

Signs are positive that energy technology innovation is accelerating at a historically unprecedented pace. It is driven by a convergence of forces that are reshaping the electric power industry (including climate change, the need for resilient infrastructure, increasing stress on resources, and decentralized supply) and enabled by the interaction of various disciplines, such as data and information networks, which 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.

The rapid progress in energy technology requires more intelligent and integrated energy infrastructure on the distribution end of the energy system to secure the reliability and durability of the grid. Today's grid technology innovations

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1 By 2030, ensure universal access to affordable, reliable and modern energy services.

2 By 2030, increase substantially the share of renewable energy in the global energy mix.

3 By 2030, double the global rate of improvement in energy efficiency.

4 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, which contains cost and performance details of 15,000 utility-scale power generation projects.

are exploring its transformation from a system where electricity flows in one direction to a platform that can 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 traditional utility 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 who can provide services to the larger energy system.

Furthermore, technologies such as sensors, robotics and advanced analytics, which together form advanced interconnected systems capable of quickly analysing large amounts of data, are developing potentially transformative solutions, across various sectors, for improving energy efficiency and managing more variable renewable energy. This development is driven by continuous improvements, and the cost-performance curve of core digital technology building blocks: computing power, data storage, and bandwidth utilization (Hegel et al., 2013).

Tracking investment in energy innovation

Technology innovation is a key driver of change in the energy sector, yet information is scarce on the level of investment in energy research, development and demonstration (RD&D) activities (key enablers of innovation). However, the IEA tracked US$ 19 billion of public spending on all forms of clean energy RD&D worldwide in 2015, including funding by certain state-owned enterprises; RD&D spending on clean energy, and on energy technology generally, has not risen in the past four years. Private sector spending is difficult to accurately track accurately but the data that has been gathered suggests that most private-sector energy R&D is focused on the oil, gas, and thermal power sectors, and most public R&D supports sustainable energy technologies (IEA, 2017c).

Innovation gaps and opportunities

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

Analysis by IRENA shows that energy efficiency and renewable energy have the potential to achieve 90 per cent of the emissions reductions needed by 2050, with renewables having the potential to account for two-thirds of primary energy supply in 2050. To deliver on that potential, however, the annual growth of the renewables share in total final energy consumption needs to rise sevenfold on average until 2050 (IRENA, 2017). Similarly, global energy efficiency, as measured by the world's primary energy intensity, has improved at a faster rate (2.2 per cent per year) since 2010 than in the previous two decades (1.4 per cent per year). Nevertheless, this progress still falls short of the annual rate of 2.7 per cent needed over the period to 2030 to put the world on a sustainable development pathway.

For around one-third of energy-related emissions projected in 2050 (IREANA and IEA, 2017), few economically attractive options for decarbonization exist today. Higher investment in innovation is needed if we are to achieve the cost reductions and performance improvements at the pace required to transition the world's energy systems to low carbon by 2050. A substantial increase in investment in innovation would support accelerated deployment of today's clean energy technologies (further reducing costs and facilitating the integration of clean energy technologies to address local conditions) and finding solutions for those missing sectors, particularly for transport and industry.

Taking such actions is in countries' self-interest. Renewable energy and energy efficiency technologies, stimulated by government-driven efforts, would bring major benefits to countries beyond decarbonizing the energy sector (ibid), by increasing wealth, promoting social inclusion and improving environmental quality and health.

Policymakers need to consider that action to foster innovation today is a matter of urgency, as a full-scale energy transition will take decades due to the different technology steps, the long lifespan of capital stock, and the current role of fossil fuels in all aspects of economies and lifestyles. Their actions should nurture innovation, supporting both RD&D to improve performance and costs, and fresh approaches to the deployment and scale-up of key innovations to fully realize 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 effort.

Innovation needs in the power sector

Relatively established technologies such as hydropower, solar and on-shore wind will continue to improve through further innovation, which will 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 suggests that more than 14 per cent of the CO_2 abatement potential, or 4.5 Gt CO2/yr (ibid), could come from a combination of the following technologies that are not widely deployed yet[5]:

- Concentrating solar power

[5] A more comprehensive overview can be found in IRENA's report "Accelerating the energy transition through innovation" (IRENA, 2017).

- 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 US$ 5.71 trillion, from 2015-2050.

Innovation needs in the end-use sectors

The electrification of end-use sectors (heating and cooling, transport) could offer win-win situations for reducing emissions while also supporting the integration of higher shares of variable renewable energy in power systems. Beyond electrification, carbon capture and storage (CCS), advanced biofuels, and fuel switching are some of the innovative emission reduction solutions for sectors such as iron and steel making, cement production, chemical and petrochemical production, maritime transport, aviation, freight and 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 quickly commercialized. For example only 1 per cent of global demand can directly respond to shortages or excess supply. IEA estimates that about 20 per cent of electricity consumption worldwide will be available for demand response in 2040 (IEA, 2017a).

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

- High-performance low-cost batteries for electric vehicles
- Advanced biofuels, 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
- CCS for cement clinker production, iron making, waste incineration and biomass processes.

Wider system innovations

With the rapid cost decreases for solar PV and wind, the issue of system integration of variable renewables is an increasingly pressing priority. Innovations in energy storage and demand response will play important roles in the energy transition, providing flexibility to energy systems, improving the management and increasing the potential to accommodate further distributed generation.

Key technologies that require further innovation to better enable the energy system to accommodate higher shares of renewables include:

- Short- and long-term energy storage solutions
- 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
- Digitalization of power systems (smart grids)
- Market models that provide real time price signals to encourage demand response
- Standardized off-grid solutions for rural areas and remote locations.

In addition to innovation in technologies, improvements are needed in the energy system to support and accelerate wider adoption and scale-up of clean energy. Above all, innovations are needed in enabling infrastructure, business models, market designs and system operation.

Figure 6.1

innovation for the Energy Sector Transformation

Source: IRENA (2018) Opportunities of the Energy Transition (available at: http://www.mofa.go.jp/files/000340293.pdf).

How to fill the gap in sustainable energy technology 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:

Better data on public and private sector spending on sustainable energy technology innovation is vital. Relevant data is needed to enable decision makers to better identify gaps and opportunities to enhance the efficiency of resource allocation. Measurement of progress in clean energy innovation needs to go beyond the flow of money and also focus on performance indicators.

Cost reduction is the priority. The main goal of the innovation efforts in low-carbon technologies should be 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. Mobilizing the innovation capacity of the private sector is of prime importance. While traditionally public supported research provides a source of knowledge and discovery, the private sector is playing an increasingly prominent role in this regard and is crucial for bringing new technologies into the market. Businesses, entrepreneurs and investors are best suited to identify, evaluate and support the most promising ideas for commercialization and turn innovations into products and companies.

Innovation requires a multidisciplinary portfolio 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 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 technology progress and transition pathways evolve. Continuous monitoring and adjustments will be needed.

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 commercialization stages. Innovations in business models, market designs, enabling infrastructure and systems operation, are equally crucial to achieve the energy transformation.

Innovation challenges span borders. In addition to efforts at the national level, international collaboration can be an essential enabler of accelerated progress. In particular, governments working together to increase cross-border and public-private collaboration can use a range of mechanisms, including technology collaboration programmes, mission innovation, innovation accelerators, and regional centres.

Policy incentives are lacking in key sectors. The sectors with the least progress in innovation for decarbonization 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 prioritizing options that can stimulate private sector innovation in these sectors.

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 owing to their global nature. For those sectors, global agreements for the deployment of innovative technology solutions are indispensable.

Sustained innovation for electricity networks and system integration technologies could enable accelerated growth of renewable power. Technology advancements, notably in PV and wind energy technologies, offer scope for reducing production costs. However, policies should address infrastructure challenges and market design issues to improve system integration of renewables.

Energy efficiency must go hand in hand with decarbonized generation. Significant opportunities exist in renovating and refurbishing existing capital stock. Furthermore, optimization of energy systems in industry can result in substantial and cost-effective energy savings, and energy management systems standards can deliver systematic and sustained energy performance improvements, driving behavioural change in organizations across different sectors. Building on these opportunities, the deployment of connected devices, automated controls, advanced monitoring systems and analytics is offering new and improved possibilities for energy efficiency within individual facilities and across energy systems. However, such activities should not happen in isolation. Policies and regulation should leverage beneficial synergies by promoting the dissemination of digital technologies and supporting energy efficiency improvements and the adoption of sound energy management practices.

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 (UNIDO 2017).

The needs of both developing and emerging economies need

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

The interlinkages between SDG 7 with other goals need to be exploited. SDG 7 is closely interlinked with other goals such as poverty eradication, food security, urbanization, water, education, health, gender, environment, climate change and economic growth. Innovation is a key enabler of most if not all the SDGs. While Goal 9 includes a specific focus on innovation (build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), clean energy technology innovation can play an essential role in achieving other goals if the interlinkages between them are appropriately utilized.

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