HIGH-LEVEL POLITICAL FORUM ON SUSTAINABLE DEVELOPMENT

POLICY BRIEF #3

SDG 7.2: SUBSTANTIALLY INCREASE THE SHARE OF RENEWABLE ENERGY IN THE GLOBAL ENERGY MIX

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KEY MESSAGES

Status of renewable energy and progress towards achieving SDG 7.2

- Sustainable Development Goal 7 aims to "ensure access to affordable, reliable, sustainable and modern energy for all". Sustainable and modern energy takes many forms, but a key focus is on increasing the contribution of renewable energy in the global energy supply. Many initiatives aim to substantially increase the share of renewable energy in global energy supply (SDG 7.2), with the primary indictor typically being the share of renewable energy in total final energy consumption (TFEC).
- The share of renewable energy in TFEC grew modestly from 2012 to 2015, from 17.9% to 19.3% (REN21, 2017; IEA, Wold Bank, 2017). Most of this increase was from renewable electricity from water, solar and wind power. Solar and wind power still make up a relatively minor share of energy consumption, however their growth has gathered significant pace in recent years.
- The results of the 2017 Global Tracking Framework (GTF) report indicate that the world is not on track to achieve the SDG 7 renewable energy indicator 7.2.1 (IEA, World Bank, 2017) and business-as-usual projections suggest limited growth acceleration till 2030 (IEA, 2017) – therefore significant additional efforts are needed.
- Renewables have accounted for more than half of all global power capacity additions over the past five years, and the share of renewable energy in power generation has been growing by 0.7% percentage points per year to around one-quarter of total global power generation in 2017 (IRENA, 2017j).
- While renewable power generation has witnessed significant progress recently, electricity only makes up 20% of TFEC. The challenge is to increase the share of renewable energy in the heat and transport sectors, which together account for 80 per cent of global energy consumption.
- By 2030, the share of renewable energy in TFEC must be sustainably increased. For example climate policy may require up to a seven-fold increase of the growth rate of the renewable energy share between now and 2030, and beyond. Of the 19% renewables share seen in 2015, around half was traditional use of bioenergy, which must be phased out and replaced with modern energy by 2030. Therefore, any increase in the overall share of renewables must factor in significant decreases in traditional forms of bioenergy, meaning the increase in modern renewables deployment would be even higher. Such acceleration is technical and economically feasible but it requires concerted action (IRENA 2017d).

View to the future and role of renewables in setting the world on a pathway to achieving the Paris Agreement

- Currently, about 80% of TFEC comes from fossil fuels, with just under 20% derived from renewables (IRENA, 2018a). Growth rates in the share of renewables in TFEC from 2010-2015 average around 0.2 percentage points absolute increase per year. To reach a 36% renewable share by 2030, the growth in share must increase to on average 1.4 percentage points per year – a seven-fold acceleration. Aligning the transition with the 1.5C climate goal would require increasing the rate of renewables deployment during the 2018 – 2030 period even further.
- Renewable energy represented about 25% of global electricity generation in 2017, with the rest generated by fossil fuels and nuclear. Around 60% of all electricity in 2030 could be generated by renewable energy according to 'REmap', the global energy roadmap of the International Renewable Energy Agency (IRENA) (IRENA, 2016b).
- Action on energy use for heating and transport, however, is lagging, with no increase in renewable energy shares seen in recent years. Energy system integration through electrification of end uses can strongly contribute to increasing the shares of renewables in heating and transport, while simultaneously unlocking energy flexibility resources from these demand side sectors, thereby facilitating higher shares of renewables integration in the power sector. Properly exploiting these synergies can prove to be fundamental for articulating a climate consistent transition.
- Energy efficiency has a fundamental role to play in order to articulate a climate consistent transition within the available time frame and optimizing the use of resources. Reaching a specific target in renewables shares is strongly facilitated by deploying energy efficiency, since this reduces the amount of absolute renewable energy capacity deployment. The right balance between energy efficiency and energy flexibility has to be pursued when articulating energy efficiency deployment within an integrated energy system

Priority actions over the next 4 years

- The renewables share in power generation is already substantial today. But this share needs to grow further from 25% in 2017 to 60% by 2030. Enabling this acceleration are rapidly declining costs of renewable generation technologies, making the energy transformation economically and technically feasible (IRENA, 2017d).
- Efforts must be strengthened in end-use sectors, particularly in buildings, industry and transport where opportunities for increased deployment of renewable energy exist. Energy system integration through electrification of these end-use sectors enables both the increase of their renewables shares and the improvement of the system flexibility. At the same

time it yields a higher overall energy efficiency. Business cases supporting this evolution are often constrained by current regulation. Innovation and awareness raising is needed in these areas.

- Increased attention needs to be drawn to renewable heat as this can play a role in the energy transition. A holistic planning of renewable heat and electrification has to be pursued within the context of an integrated energy system. A more narrow limited focus can introduce additional barriers and hinder the transition.
- Increased focus is needed for enabling technologies, such as electric vehicles (EVs), which have seen breakthroughs with numerous GigaWatt-scale battery factories coming online in China, United States and elsewhere. Global EV capacity doubled to 2 million in 2016 alone (IRENA, 2017b).
- Energy sector reforms are required to facilitate the implementation of renewable energy projects, including: long term policies; strong roles for electricity regulatory agencies; flexible financing regimes/mechanisms dedicated for renewables projects; incentives; and promotion of smart grid technologies to support grid connections with renewable power projects.
- Energy markets and the associated regulation should be upgraded in order to facilitate the participation of DER, including its aggregation, with special focus on unlocking the available flexibility potential.
- Ambitious renewable energy targets, policies and measures are needed to enable substantial increases in renewable energy shares by encouraging increased private sector and community-based investment.
- Necessary frameworks that promote investments in renewable energy development and deployment must be developed, including enhanced dialogue among public and private renewable energy stakeholders, facilitating social financing, and enabling the redistribution of macroeconomic flows (carbon taxes, expenditures, and others).
- Skills of the public and private sectors at the national level, to identify, develop, promote and implement renewable energy investment projects through matchmaking support activities, must also be developed.

Priority actions towards 2030

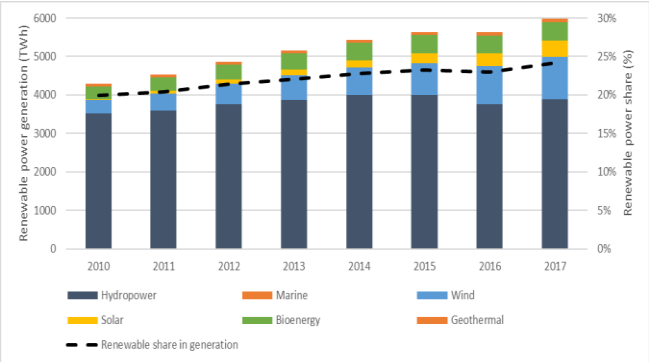
- Additional action is needed to push the modern renewable to 36% of TFEC or beyond by 2030. The share of modern renewables in TFEC stood at 10% in 2015. Under BAU, the share would only increase to around 17% by 2030.
- Energy system integration through direct and indirect electrification should be facilitated through policy and regulatory action. Energy system integration allows significantly increasing the shares of renewables while simultaneously sourcing the required flexibility to operate a renewables-based energy system.
- Market design for the power sector needs to be structurally modified to properly deal with a renewables-based electricity system. All long term (capacity), short term (dispatch) and very short term (balancing) markets need to be adapted to the techno-economical characteristics of renewables, while fostering the participation from all the available flexibility mechanisms so that a proper techno-economical optimization can be achieved.
- Renewable energy and energy efficiency measures need to be pursued in tandem. Accelerated deployment of renewable energy and energy efficiency measures form the key elements of the energy transition, accounting for 90% of the decarbonisation needed to stay within the Paris Agreement boundaries (IRENA, 2017d).
- Around one third of the activities that contribute to energy-related emissions in the 2030-2050 time frame have at present no economically viable options for decarbonisation. Higher R&D investment is needed to find technology solutions for sectors where more innovation is required, particularly for transport and manufacturing and buildings. Innovation efforts, in both electricity and other energy sectors, needs to be expanded beyond R&D into other areas such as market design (IRENA, 2017a).
- Substantive experience in renewable energy policy-making and project implementation has been made across the world, and there is large potential for the sharing of experiences and learning from each other. Formats including regional cooperation and exchange of lessons learned need to be strengthened so as to accelerate the deployment of renewable energy.
- The progress of renewable energy deployment needs to be continuously tracked while improving the quality of data and indicators.

Renewable energy and the sustainable development goals

The energy sector needs significant and accelerated change, with a transformation from one largely based on fossil fuels, to a zero-carbon energy system by the second half of this century. Accounting for two-thirds of greenhouse gas (GHG) emissions, the energy sector presents a large opportunity to combat climate change through a shift towards renewable energy. Substantially increasing the share of renewables isn't just needed for alignment with global climate goals, but it would lead to USD trillions in economic growth between now and 2050 (IRENA, 2017d). The health, environmental and climate benefits would save up to six times more than the additional costs associated with reconfiguring the energy sector, all while creating millions of jobs in the process and improving the quality of life, wellbeing and self-realisation of people living in rural areas (IRENA, 2017d).

Current status

In 2016, approximately 80% of energy use came from fossil fuels, with just under 20% derived from renewables. In power generation however, renewables represented a quarter of all power generation in 2017 – an increase of around 5 percentage points over the period 2010 to 2017 (IRENA, 2017j). Renewable power generation constitutes the majority of power sector capacity additions since 2012, driven by their economic viability (IRENA, 2018a). Biomass for power, hydropower, geothermal, solar photovoltaic (PV) and onshore wind technologies can all now provide electricity that is competitively priced compared to fossil fuel-fired electricity generation (IRENA, 2018b).



Source: IRENA, 2017j

The share of renewable energy in TFEC grew modestly from 2012 to 2014, from 17.9 per cent to 18.3 per cent. The share increased further in 2015 to 19.3% (REN21, 2017). Most of the increase was from renewable electricity from water, solar and wind power. Solar and wind power still make up a relatively minor share of energy consumption, however their growth has gathered significant pace just in the last 2-3 years.

The energy transition is technically and economically feasible; energy and climate policies have unlocked cost reductions and technology improvements have opened the door to an energy transformation that makes economic sense. Over the past seven years, solar PV module prices dropped by over 80% and wind turbine prices by 30-40%. The global weighted average levelized cost of electricity (LCOE)[1] from solar PV fell by 73% between 2010 and 2017 to USD 0.10/kWh, while onshore wind fell by 23% to USD 0.06/kWh.

Recent auction and tender results have signalled that costs for solar and wind technologies will continue to fall (IRENA, 2017i), with solar PV and onshore wind to achieve LCOEs of between USD 0.03 and USD 0.04/kWh for delivery by 2020 (IRENA, 2018b).[2] Auction data for 2016 and 2017 have heralded the imminent arrival of competitive offshore wind and CSP, where LCOEs could fall to USD 0.06/kWh to USD 0.10/kWh by 2020/22.[3] Meaning all commercially available solar and wind will be competitive with, or even substantially undercut, conventional power generation technologies at utility scale by 2020.. Taken on the whole, the continuously falling costs of renewable power generation present a compelling economic case for the increased use of renewable energy moving forward (IRENA, 2018b).

Are we on track to substantially increase the share of renewable energy in the global energy mix?

According to the 2017 GTF report, the world is not on track to substantially increase the share of renewable energy in the global energy mix by 2030. The joint IEA/World Bank report shows that with a global share of renewable energy in total final energy consumption of 18.3% in 2014, and based on the rate of progress in this and previous tracking periods, the 36% or higher renewable energy share target by 2030 cannot be attained (IEA, World Bank, 2017) unless the world deviates signficantly from past trends. To substantially increase the share of renewables, growth needs to take place across the spectrum of energy use – not just in the power sector. Energy efficiency deployment and energy system integration through electrification are key components to attain the required growth rates.

According to IRENA analysis, the share of modern renewables in TFEC stood at 10% in 2015 and will increase to around 17% by 2030 under business as usual. Total renewables, including traditional forms from bioenergy, would total around 22% in 2030, up from 19% in 2015 (IRENA, 2016b). Other analyses show a similar increase to between 18-20% over the period

[1] All the 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.

[2] Care needs to be taken in interpreting the results of comparing LCOE and auction price trends, as they are rarely calculated with the same system boundaries. However, the volume of data available and the substantial agreement in average costs of both datasets allow meaningful comparisons about overall trends to be made.

[3] Headline auction prices below USD 0.03/kWh for 2020 are not equivalent to LCOE calculations as additional revenue streams are often not included (e.g. clean energy certificate values in Mexico).

under business as usual (IEA, 2017). Therefore, additional action is needed that will push the share of modern renewables to 36% or higher of TFEC by 2030, requiring a tripling of the average annual growth rate in renewable share.

The highest growth will be seen in the power sector, where renewables are expected to increase from 25% of global electricity generation in 2017, to over 60% by 2030 (IRENA, 2017d). However, progress on energy consumption for heating and transport is lagging, with no increase in renewable shares seen in recent years. A scale up of the overall renewable energy share in TFEC must also include significant increases in the renewable energy share in the end-use sectors (residential and commercial buildings, manufacturing industry and transport). Energy system integration through electrification allows to significantly increase the rate of renewables deployment in these demand sectors, while simultaneously providing the energy flexibility needed to operate the power system with high shares of renewables. While the precise data vary also other scenario studies suggest that a significant acceleration of renewables deployment is technically and economically feasible, see eg (IEA, 2017).

Key Challenges

New challenges and opportunities have emerged for renewable energy and the entire power sector, calling for a shift in policy and regulatory focus. The growing share of variable renewable energy (VRE) requires changes in power system planning and operations, and the rise of distributed ownership and generation are challenging conventional actors and business models. To capitalise on the opportunities, adjustments are required in power market design, system regulations, and operating procedures. Some of these relate to physical infrastructure, and others are defined by market design and regulation (IRENA, 2017h).

Short-term energy market design falls short to fully integrate renewables, particularly with respect to time frames, bidding formats, clearing and pricing rules and integration with reserves and regulation markets (IRENA, 2017h). Current markets restrict the effective participation of distributed resources and their aggregation, preventing the procurement of the required flexibility to operate a renewables-based power system (IRENA, 2017h).

With regards to battery storage, a key tool to enable higher shares of renewable power generation, there are several barriers to be overcome before it can be fully integrated as a mainstream option in the power sector. However, there are promising signs of progress. Barriers to the widespread use of electricity storage include uncertainty on regulatory treatment; system costs; limitations to monetising the value of storage projects; market access for prosumers and aggregators; utility acceptance; materials use; and performance and safety issues. In addition, many stakeholders do not understand storage technologies in general or their potential benefits. Cost remains the most significant obstacle (IRENA, 2017f).

In the coming decades, transport and industry will remain the most challenging sectors for increasing its renewable energy share. Some sectors currently have limited economic, scalable solutions, including: iron and steel making; cement making; chemical and petrochemical production (notably production of synthetic and organic materials); waste handling and emissions from non-energy use of fossil fuels; maritime transport; aviation; long-range freight; and replacement of non-sustainable traditional biomass.

The available solutions for these sectors are process changes (for example, using non-carbon alternatives a reducing agent for iron and steel making, like biomass, hydrogen, or direct electrolytic reduction), changes in feedstock from fossil fuel-based products to biomass-based products or renewables-based P2X (chemical and petrochemical industries, maritime transport, aviation and log-range freight), and direct electrification (long-range fright and some industrial processes). Energy system integration, through direct and indirect electrification (renewables-based hydrogen or synthetic fuels production – P2X), constitutes an important component for these sector's transition, often associated to the synergic enabling of energy flexibility mechanisms.

These sectors all have non-technical barriers. Creating a better enabling environment for innovation so the private sector receives the right incentives (IRENA, 2017a), as well as focusing public R&D towards the transition can help streamline new technical solutions and refine the existing ones. But from a technical point of view enough solutions are already available to start articulating the transition right now, and governments should focus on eliminating the non-technical barriers, often related to regulatory aspects, economic resources transition alignment, and enabling the appropriate context for transition-friendly business models to take off.

Corporate electricity procurement strategies can also play a major part in accelerating renewable energy deployment. However, to further scale up corporate renewable energy procurement, barriers such as regulatory challenges will need to be addressed and energy markets will need to be opened to third-party sales (IRENA, 2017f)

Direct and effective social involvement is a cornerstone for successful energy system transition substantially increasing the shares of renewables, and we are lagging well behind in this dimension:

- Community-based direct participation in the energy system, both through the deployment of distributed generation and its contribution to sourcing the required energy flexibility, holds a huge potential for increasing renewables-shares. The effective integration of DER aggregators into market systems facilitates reaping this potential.
- Social financing can also play a major role in renewables deployment by aligning economic resources with the transition requirements, facilitating energy access, and articulating compensatory mitigation contributions to address the fair share of transition burdens.

How to fill the gap to enable substantial increases in renewable energy share

The energy sector transition needs to go beyond the power sector, to include all end-use sectors. Energy system integration through direct and indirect electrification of final energy services facilitates this process while unlocking flexibility resources, building on the continued rapid growth especially of solar and wind power in combination with enabling grids and new operating practices.

Buildings, industry and transport sectors need to aim for the right balance between direct and indirect renewables-based electrification, bioenergy and solar heating. Electric vehicles need to become the predominant car type on the road and liquid biofuels production must grow substantially for the use in transport modes such as shipping and aviation. Sustainability constraints associated to the use of biomass should be properly incorporated into the transition planning, prioritizing the use of this scarce resource for those applications that do not have other options available for incorporating renewables. High efficiency all-electric buildings should become the norm and the deployment of heat pumps must accelerate (IRENA, 2017a).

The level of energy transition that has been achieved in individual sectors varies. While renewables deployment in the power sector has progressed over the past years, the same cannot be said for all end-use sectors. In these end-use sectors, progress and technology successes have been mixed. All sectors will require continued improvements in existing low-carbon technologies and in some cases, the emergence of breakthroughs or major changes in production processes will be vital. The required transformative innovation must not target technology development alone. It also must be aimed at enabling active social involvement in energy system planning and operation, creating new businesses and jobs, pursuing a just transition, and helping citizens and industries to flourish providing additional economic opportunities to increase wealth (IRENA, 2017a), while respecting climate and sustainability constraints.

As the technology to drive the transformation in the energy sector develops and reaches commercialisation, the next stage to scale-up renewable energy shares requires the integration of these technologies in dynamic energy systems. Technology innovation needs to be complemented by business models tailored to articulate appropriate socio-economic interactions with a fair approach to share benefits and responsibilities between the different stakeholders with the support of emerging novel technologies. Regulations also need to enable small and distributed power generators to be able to participate in the power market. Innovative business models can create impact, as technology breakthrough technologies can, when appropriate enabling policies and regulations are in place.

For the integration of renewables, the design of the wholesale markets (day-ahead and intra-day markets), balancing markets, and long-term investment signals should be reinforced. Increasing the time granularity of energy trading and reducing the minimum size of energy products could be some of the options to better represent variable renewables and increasing flexibility in the system. The balancing market should be designed to provide accurate incentives to renewables and other flexibility service providers. In the context of the long-term support, one of the options could be to incorporate transition-focused capacity mechanisms and/or premium tariffs as potential tools for complementing the energy market revenues (IRENA, 2017h).

Regulators should allow distribution companies to interact more often with distributed energy resources or aggregators to efficiently manage network constraints by facilitating the participation of distributed flexibility resources into energy market, whereby facilitating the increase in RES shares. Regulators should enable new streams of revenue for distribution operators, allowing them to have a more active involvement in the transition, while simultaneously introducing performance-based economic regulation addressing total system costs (IRENA, 2017h).

Interlinkages with other SDGs

With right policies in place, the global energy transition will fuel economic growth, create employment opportunities and enhance welfare benefits to the society. An IRENA study has shown that the global GDP could be boosted around 0.8% in 2050 (USD 1.6 trillion), with the cumulative gain through increased GDP from now to 2050, amounting to USD 19 trillion (IRENA, 2017d). Renewables improve welfare in ways that are not captured by GDP (almost 4% welfare improvement, compared to 0.8% GDP growth), such as reduced health impacts from fossil fuel combustion (IRENA, 2016c). Additional welfare gains for society come from increased energy access, helping to generate sustainable livelihoods, social inclusion, gender equality and better quality of life in rural areas, reducing climate change adaption efforts and costs, and avoiding the collapse of the socio-economic system due to climate change. Therefore, policy making requires a holistic approach that factors in all externalities, including the environmental and health benefits of decarbonisation through the integration of renewables.

In light of the interlinkages between SDGs, renewable energy utilization can play an important role in reducing the vulnerability of water and energy resources. Using decision-support tools that have a nexus approach is highly valuable when evaluating the effects of different energy mixes on water, food and land resources at a local, national and regional level. Renewable energy, when implemented in a sustainable manner, can stimulate the food sector with new economic opportunities and bridge energy deficits along the supply chain to reduce losses and enhance food productivity. Renewable energy can

provide off-the-grid access to enable energy-intensive food production processes, such as water pumping and distribution, food storage and processing (ESCWA, 2016).

The transformation to a sustainable energy system with high shares of renewables would meet climate goals, significantly reduce local air pollution and pay for itself. Health, environmental and climate benefits would save up to six times more than the additional costs associated with reconfiguring the energy sector, all while creating millions of jobs in the process (IRENA, 2017d; IRENA, 2017e). Substantially increasing the share of renewables in the global energy mix in order to limit temperature rise to well below 2°C would reinforce a number of SDGs, including: climate action; health and well-being; clean water and sanitation; sustainable cities; life below water; and others through reduced emissions from the generation of energy from fossil fuels.

When renewable energy and energy efficiency are pursued in tandem, they result in a faster decarbonisation of the energy system. In fact, accelerated energy efficiency is expected to raise the share renewable energy in 2030 by 15% according to one study (IRENA, 2017k). A combined approach offers the most timely and feasible route to decarbonising the global energy system. Renewable energy and energy efficiency offer roughly the same amount of carbon mitigation potential through to 2030, but only when working in synergy. A holistic approach is required when planning for the energy transition and the increase of renewables shares. From an integrated energy system point of view, energy flexibility provides a very high transition value, and therefore the right balance between energy efficiency and energy flexibility should be pursued.

Since 1990 energy access has improved and nearly two billion more people have gained access. However, more than a billion people still lack electricity access and another billion have only an unreliable supply (IEA and the World bank, 2017). To achieve universal electricity access by 2030, the pace of expanding access needs to at least double, and estimates suggest that off-grid solutions will provide roughly 60 per cent of the additional generation needed (IRENA, 2016a). Renewables are now the default cost-competitive choice for off-grid installations, both stand-alone and mini-grids, in most rural and peri-urban areas. It's estimated that as many as 350,000 mini-grids will be needed to achieve universal access in Africa — 60,000 to be deployed in West Africa alone by 2020 (SE4All, 2017; ECREE 2015). Decreasing electricity production costs are resulting in more mini-grid development, which in turn, results in more renewable energy and increased access to affordable, reliable, sustainable and modern energy.

A view to 2050 and longer-term decarbonisation

Energy-related CO_2 emissions from all sectors totalled 37 gigatonnes (Gt) in 2017. These need to fall to around 10 Gt in 2050 to set the world on a pathway to achieving the 2C degree target set forth in Paris, a reduction of 70% compared to business as usual, under which emissions are estimated to reach 45 Gt in 2050. Further emission reductions would be required to achieve alignment with the 1.5C climate goal. Renewable energy could provide 44% of the CO_2 emission reduction (20 Gt per year in 2050) with the bulk of the remainder of reductions coming from increased energy efficiency – together renewable energy and energy efficiency could account for 90% of emission reductions needed (IRENA, 2017d). To enable this dramatic emissions reduction, the share of renewable energy in final consumption must rise to over 65% in 2050, from under 20% today (IRENA, 2018a).

By 2050, emissions from electricity generation would plummet by 85% in the REmap scenario, despite the fact that electricity generation is expected to increase by nearly 80%, due in part to significant electrification of transport (IRENA, 2017d). Coal-based power generation would nearly cease all together. Besides increasing shares of renewables, the decrease in power sector emissions is also due to energy efficiency measures taken in industry and buildings. Emissions in the buildings sector would decrease by about 70% by 2050. Transport emissions would be halved, while industry would become the largest emitter of CO_2.

Under REmap, the share of wind and solar in power generation would increase to over 50% by 2050, requiring a range of flexibility options to ensure grid stability, including demand response, storage and active participation of renewable generation in system regulation. Market designs need to be adapted to enable the optimum deployment of available flexibility resources (IRENA, 2017h). New business models including DER aggregation, and time-of-use electricity pricing are adequate instruments to facilitate this process. Additional interconnectors can also increase flexibility, thus enabling higher shares of variable renewable energy. An often-discussed flexibility option is storage, which comes in many forms. As of mid-2017, around 4 700 gigawatt hours (GWh) of electricity storage exists, 96% of which comes from pumped hydro (IRENA, 2017c). Under REmap, 11 900-15 300 GWh of electricity storage is expected by 2030, with only 51% from pumped hydro. With an average battery pack of 50 kilowatt hours (kWh) per passenger vehicle, electric vehicles alone could provide about 8 000 GWh of battery storage by 2030. This would help to accommodate higher shares of wind and solar through flexible charging, when there is surplus generation and electricity prices are low.

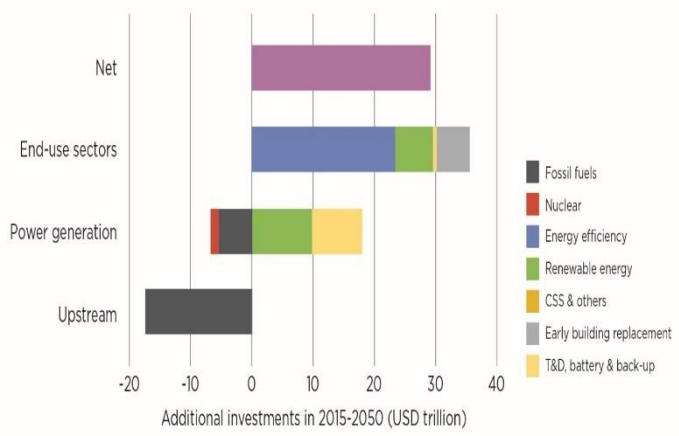
While the power sector holds great potential for renewables, electricity accounted only for around 20% of final energy use in 2016 and even with growth in this share it is forecasted to reach just a quarter by 2030. As a result, IRENA analysis points to an essential role for renewable energy technology deployment in end-use sectors. Such a role is especially important because together they account for approximately 80% of all global energy demand. System integration through electrification

facilitates the penetration of renewables in these sectors. In the end-use sectors, REmap shows that the renewable energy share can grow to 78% in buildings, 38% in industry and 53% in transport by 2050 (IRENA, 2017d).[4] In transport, the number of electric vehicles needs to grow and new solutions will need to be developed for freight and aviation, such as advanced biofuels and renewables-based P2X. New buildings will have to meet the highest efficiency standards, while existing buildings must be rapidly renovated. Buildings and city designs should facilitate renewable energy integration.

For the world to reach these renewables shares and to meet its long-term decarbonisation targets, net additional investment needs are estimated at around USD 29 trillion between 2015 and 2050, or an average of USD 830 billion per year over the period. To put this in comparison, global annual investment in renewable energy rose steadily between 2013-2015, peaking at USD 330 billion in 2015, before falling to USD 263 billion in 2016 (IRENA, 2018c).

The cumulative economic gains from decarbonisation, however, would total USD 19 trillion from now until 2050. Early action is essential to capitalise on the economic opportunities available while avoiding the substantial future costs of stranded assets (IRENA, 2017d).

Figure 4: Additional investment needs by sector and technology in REmap relative to the Reference Case



Source: IRENA, 2017d

- *Meeting the 2°C target requires investing an additional USD 29 trillion between 2015 and 2050 compared to the Reference Case. Alignment with the 1.5C target would require even more additional investment.*
- *The largest additional investment needs are in energy efficiency, followed by renewables.*
- *Total investment cost is reduced by the avoided investments in the upstream sector and in fossil-fuelled power generation.*

Delayed policy action would result in significantly more asset stranding compared to an energy transformation where accelerated renewable energy and energy efficiency deployment begins today. In the REmap scenario, cumulative stranded assets from 2015 to 2050 would total USD 10 trillion, coming largely from upstream energy infrastructure and assets (gas, oil and coal that must stay in the ground), and buildings that need to be renovated because of low energy efficiency. This would double to USD 20 trillion to reach the same emissions objective by 2050 if effective mitigation policy was delayed by only one decade (IRENA, 2017g). To put this into context, USD 20 trillion is approximately 7% of global wealth in 2016 terms.[5]

Policy Implications/Recommendations

Around one third of energy-related emissions in 2050[6] currently have limited options for decarbonisation; end-use sectors represent a particular challenge. Higher R&D investment is needed to develop technology solutions for sectors where more innovation is required, particularly for transport and industry, while appropriate regulation and planning has also a big role to play. Innovation, however, needs to be expanded beyond technological R&D. A systematic and integrated approach is required, encompassing technical, policy, business model, regulatory and socio-economic considerations. Concentrating all efforts solely on a narrow suite of measures, such as R&D spending or market signals, will not bring the expected results. Instead, renewable energy uptake ultimately depends on economics and enabling frameworks in conjunction with broad innovation advances.

To secure the USD 29 trillion of additional investment needed between 2015 and 2050 to enable the REmap energy transformation, private sector participation is key. Public funding is unlikely to increase above its current level of 15% and private finance will have to supply the lion's share of new investments. Social financing can also play an important role, especially in the energy access context, but also linked to community-based energy systems and compensatory mitigation associated to fait transition contributions. Key challenges exist however, in unlocking renewable energy investment from the private sector, including: limited experience; limited access to capital; exposure to political, policy and regulatory risk, among others; and financial regulations and administrative burdens that inhibit investment scale-up.

[4] Including the use of electricity and district heat sourced from renewables.

[5] Estimated at USD 280 trillion (Credit Suisse, 2017).

[6] Reference Case, which is the most likely case based on current and planned policies and expected market developments for each country's energy sector. IRENA has collected data from the G20 countries about their national energy plans and goals for the period 2015 to 2050.

Political announcements and vision statements, energy strategies and scenarios, detailed roadmaps and action plans, and finally legally binding renewable energy targets can help to surmount these challenges to private sector involvement. Currently, 173 countries have at least one type of renewable energy target – up from 43 in 2005. Trends in renewable energy support policies point to the evolution of feed-in tariffs (FITs), auctions and renewable purchase obligations (RPOs).

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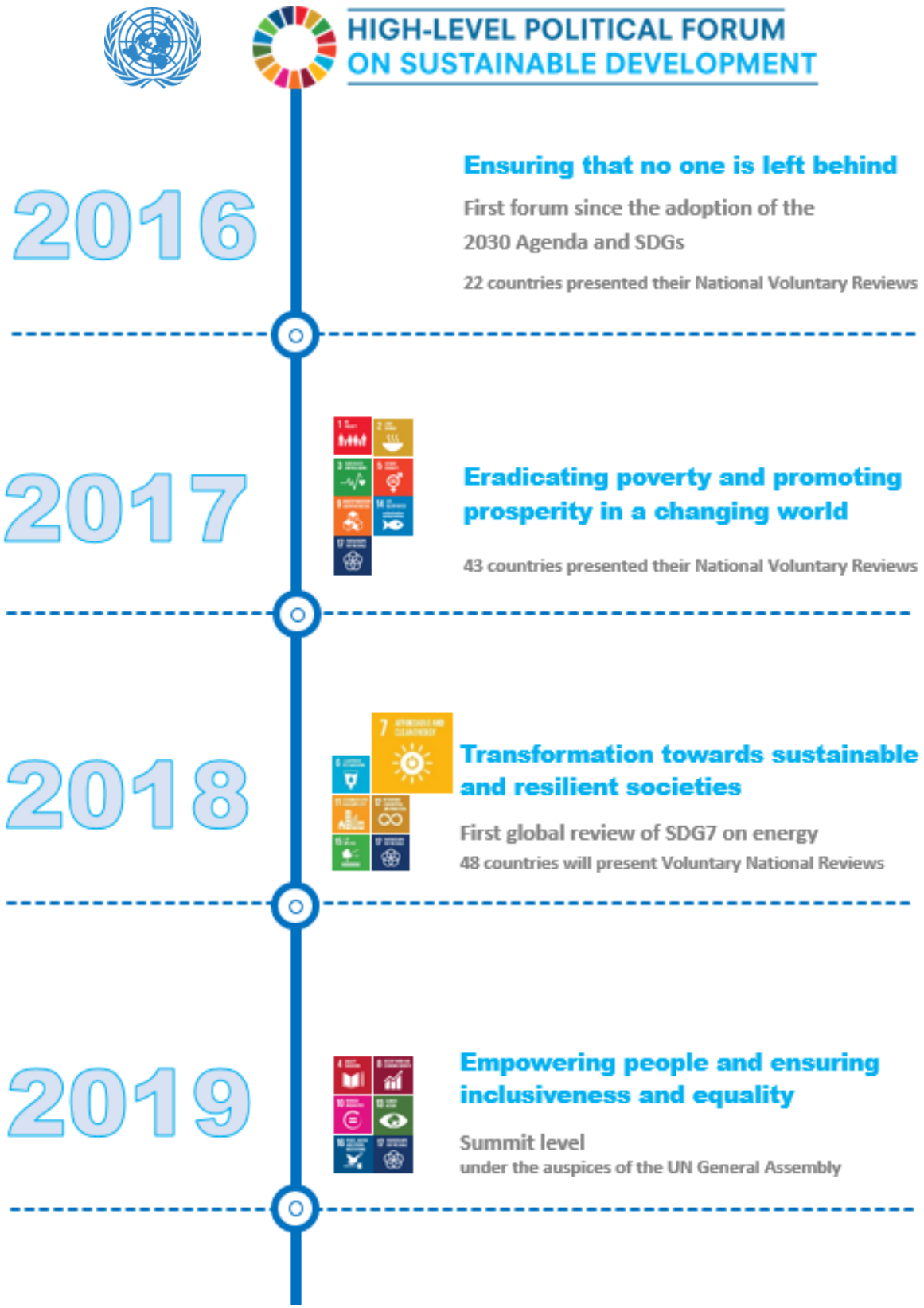

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