IRENA
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REthinking Energy

2015

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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REthinking Energy

RENEWABLE ENERGY AND CLIMATE CHANGE

2015

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EXECUTIVE SUMMARY

- Renewable energy offers an immediate means to decarbonise the global energy mix. Doubling the share of renewable energy by 2030 could deliver around half of the required emissions reductions and, coupled with energy efficiency, keep the average rise in global temperatures below 2 °C and prevent catastrophic climate change.
- Renewable energy deployment brings economic growth and sustainable development. Promoting renewables means providing secure and clean energy supply while supporting GDP growth, improving trade balances, creating local value and jobs. Solar photovoltaic (PV) deployment, for example, creates twice the number of jobs per unit of electricity generation compared with coal or natural gas. IRENA analysis shows that, with the right policies, renewable energy could generate over 24 million jobs worldwide by 2030. If environmental and human health externalities are priced into the global energy mix over time, the renewable energy transition would result in net savings.
- Transition to a sustainable energy future by 2030 is technically feasible and economically viable. The falling cost of renewable energy technologies, notably solar and wind power, contributes considerably to the growing competitiveness of renewables vis-à-vis conventional fuels. Solar PV modules, for instance, cost three-quarters less today than in 2009, while wind turbine prices have declined by almost a third over the same period. Cost reductions coupled with effective enabling policies have meant that renewable energy capacity additions have continued to outpace those of nuclear and fossil fuels in the power sector since 2011. For this remarkable growth to become global, further investment is needed in countries and regions that are embarking on a transformation of their energy systems over the coming decade.
- Effective action against climate change calls for scaling up investments in renewable energy. IRENA's analysis shows that global annual investment in renewables can reach USD 900 billion by 2030. In order to avoid lock-in with unsustainable energy systems, annual investments between now and 2020 should reach USD 500 billion, almost a doubling from current levels of investments. For successful climate action, the renewable share must continue to increase in electricity but must also rise in transport, heating and cooling.

Five actions for a sustainable energy future:

1. Strengthen the policy commitment to renewable energy. Enabling policies and regulatory frameworks create stable and predictable investment environments, help to overcome barriers, and ensure predictable revenue streams for projects. Setting renewable energy targets and formulating dedicated policies to implement them provides strong market signals, reflecting government commitment to the sector's development. Depending on the national context, complementary measures can level the playing field for renewables through the introduction of appropriate energy pricing structures.
2. Mobilise investments in renewable energy. Public funding will remain an important catalyst and will need to increase, but the lion's share of new investment in renewables will have to come from the private sector. To mobilise private investment, the strategy pursued must focus on risk mitigation instruments and structured finance tools to develop a strong pipeline of projects, and to unlock project financing and refinancing opportunities. To scale-up investments in developing countries, dedicated risk mitigation facilities are needed using both climate finance and traditional development finance channels.
3. Build institutional, technical and human capacity to support renewable energy deployment. Clarity of institutional roles accompanied by transparent and streamlined procedures can reduce transaction costs and make projects more attractive. From policy and regulatory design to project preparation, evaluation, development and financing, a wide array of skills needs to be built up in government ministries, financing institutions and regulatory agencies. Coordination is also vital between the different stakeholders in order to ensure, for instance, that physical infrastructure and complementary regulations, such as grid codes, keep pace with accelerating renewable energy development.
4. Harness the cross-cutting impact of renewable energy on sustainable development. Achieving the Sustainable Development Goal (SDG) on energy will transform the energy system while helping meet other SDGs such as for health, poverty alleviation, water and cities. Access to reliable, cost-effective and environmentally sustainable modern energy services can have a multiplier development impact in both advanced and access

contexts. In particular, renewable energy solutions can expand electricity access, increase productivity, create jobs, improve water security and bolster poverty alleviation efforts. The wider sustainable development impact of renewable energy must be taken into account when strategies for the implementation of SDGs are developed.

5. Enhance regional engagement and international cooperation on renewable energy development. Regional approaches and common initiatives can reduce costs, generate economies of scale, attract investments, boost financial capacity, stimulate cross-border trade and enable common progress in accelerating the deployment of renewable energy worldwide. To meet national goals and ambitions, countries would benefit from concerted action that regional and international cooperation offers. Governments should tap into opportunities for engagement and cooperation on renewables and climate mitigation.

1 THE RENEWABLE ENERGY OPPORTUNITY

KEY POINTS:

» Action to reduce the impact of climate change is critical, and limiting the increase in average global temperatures to less than 2 °C requires concerted global action.

» Renewable energy plays a key role in mitigating global greenhouse gas emissions by radically lowering the emissions profile of the global energy system.

» IRENA's analysis (*REmap 2030*) demonstrates that doubling the share of renewables in the global energy mix by 2030 is possible with existing technologies, and this, combined with improved energy efficiency, would put the world on track to keep global warming under 2 °C.

The Need for Stronger Climate Action

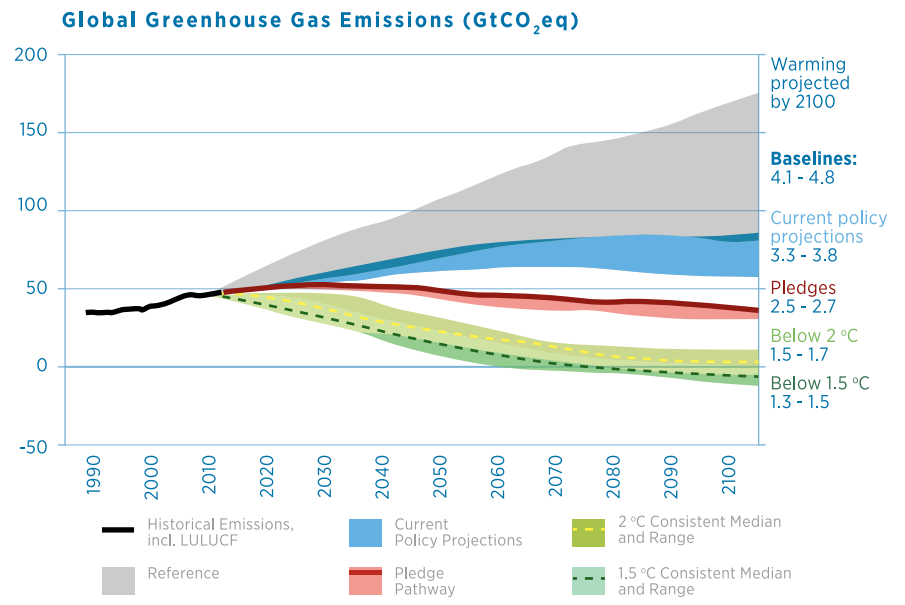
Action to reduce the impact of climate change is criticial. The consequences of rapidly rising global temperatures will be far-reaching and devastating for humans and the environment unless urgent action is taken globally to curb emissions. The 21st session of the United Nations Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP21) in December 2015 could be a turning point in the world's efforts to reach a global agreement on climate change and avert the worst-case scenario by limiting the rise in average global temperatures to less than 2 °C by the end of the century (UNFCCC, 2011).

Limiting the global temperature rise requires concerted global action. At the Conference of the Parties in Warsaw (COP19), governments were invited to submit a set of policy pledges, or Intended Nationally Determined Contributions (INDCs). These would help achieve the objective of the UNFCCC (Article 2), which calls for the stabilisation of greenhouse gas (GHG) concentrations in the atmosphere "*at a level that would prevent dangerous anthropogenic interference with the climate system*" (United Nations, 1992).

According to an analysis carried out by Climate Action Tracker (2015), the INDCs seen thus far offer higher reduction potential compared to

pledges announced earlier. When INDCs submitted by 1 October 2015[1] are aggregated and scaled up to the global level, total GHG emissions amount to 53-55 gigatonnes (Gt) of carbon-dioxide equivalent (CO_2eq) in 2030. Although this represents a significant improvement, there is still a gap of 15-17 Gt CO_2eq to reach the 2 °C target. If all INDCs are fully implemented, there would still be an estimated increase in average global temperature rise of approximately 2.7 °C by the end of the century (Figure 1) (Climate Action Tracker, 2015). This analysis does, however, not account for the inherent dynamics of markets, such as the renewable energy market, and the potential for economies of scale and further cost reductions.

Figure 1: Effect of Current Pledges and Policies on Global Temperature



Source: Climate Action Tracker, 2015

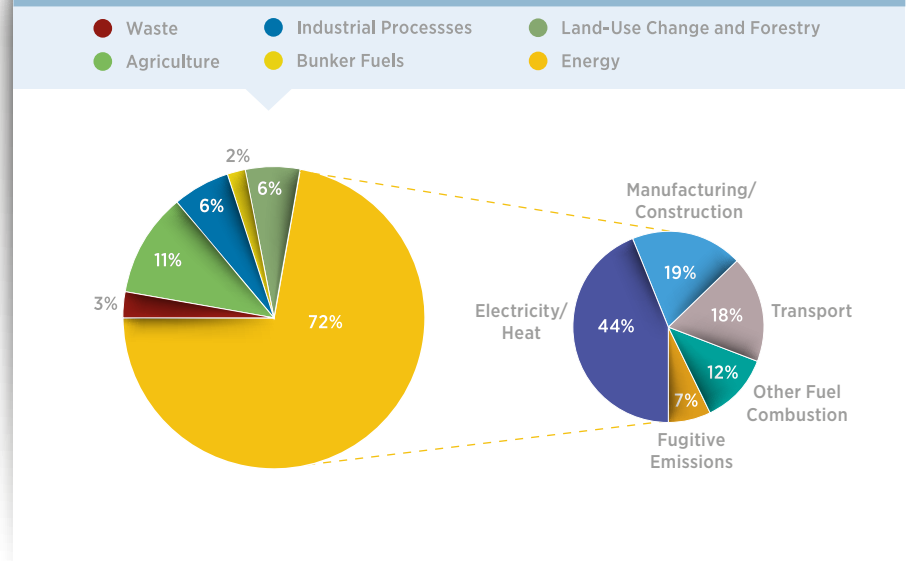
Emissions Savings Through Renewable Energy

A key pillar of several countries' mitigation strategies is decarbonisation of the energy sector through renewable energy deployment. Energy use accounts for just over two-thirds of total annual GHG emissions. A closer look shows that power generation is responsible for the bulk of these emissions, followed by manufacturing and transport (Figure 2).[2]

1 As of mid-November 2015, 134 INDCs have been submitted, reflecting 161 countries (including the European Union member states) and covering around 91% of global emissions in 2010.

2 Greenhouse gas emissions include emissions of carbon dioxide (CO_2), methane, nitrous oxide, Ozone and chlorofluorocarbons. Carbon dioxide is by far the greatest source of emissions, but the other gases all have a higher impact on global warming per tonne of emissions. Thus, total GHG emissions are usually expressed in tCO_2eq, which includes the contributions from the other gases after converting them into an equivalent amount of carbon-dioxide that would produce the same effect.

Figure 2: Global Greenhouse Gas Emissions by Sector (2012)



Source: World Resources Institute, 2015

Renewable energy already contributes to emissions reductions in the power sector. Renewable power plants currently account for more than 22% of total global electricity generation (REN21, 2015). In 2012, an estimated 3.1 Gt CO_2eq of emissions was avoided through renewable energy use, compared to the emissions that would otherwise have occurred from fossil fuel-based power. While these avoided emissions come primarily from hydropower, the production of electricity from wind, solar and bioenergy sources has seen a spectacular increase over the past decade, driven by enabling policies and sharp cost reductions (see Box 1). Without renewable-based power generation, total emissions from the power sector would have been 20% higher.[3]

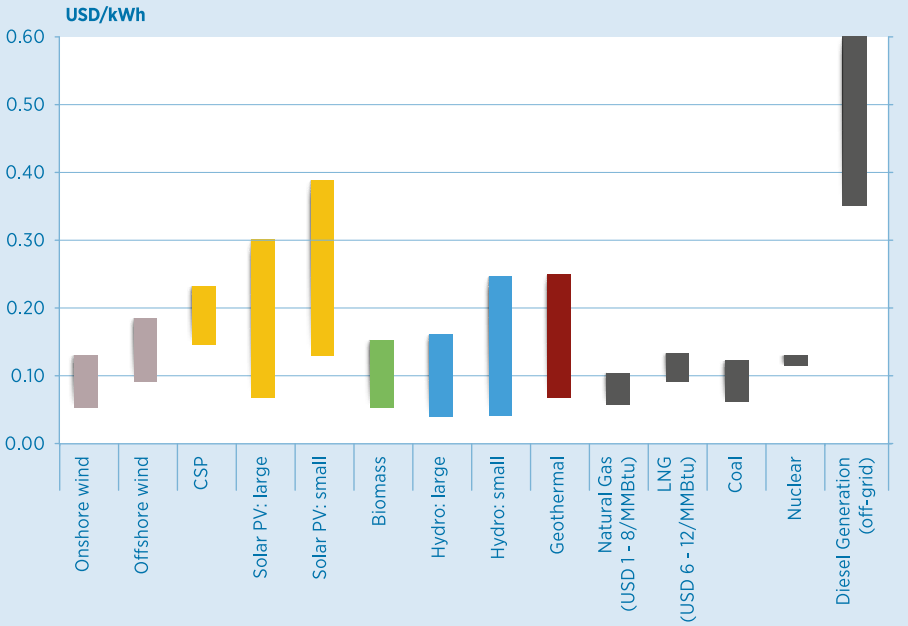
[3] *IRENA calculations based on the Intergovernmental Panel on Climate Change (IPCC, 2012) and World Bank (2015a) "World Development Indicators", available online at: www.tsp-data-portal.org/Historical-Electricity-Generation-Statistics#tspQvChart*

BOX 1: FALLING COSTS, INCREASING COMPETITIVENESS

Costs for renewable energy technologies have fallen dramatically in recent years. Solar photovoltaic (PV) modules in 2014 cost up to 80% less than at the end of 2009, while wind turbine prices declined by almost a third over the same period (IRENA, 2015c). Falling costs have made renewable energy technologies increasingly competitive with conventional fossil fuels (Figure 3).

One of the world's lowest-cost utility-scale solar PV power plants is currently being built in Dubai and will provide electricity for just USD cents 5.84 per kilowatt-hour (IRENA, 2016a). Onshore wind is one of the most competitive forms of generation capacity, with electricity costs of about USD cents 4 per kWh. At the same time, where untapped economic resources remain, biomass for power, geothermal and hydropower can all provide electricity at very competitive prices.

Figure 3: The Levelised Cost of Electricity from Renewable, Fossil and Nuclear Technologies (2014)

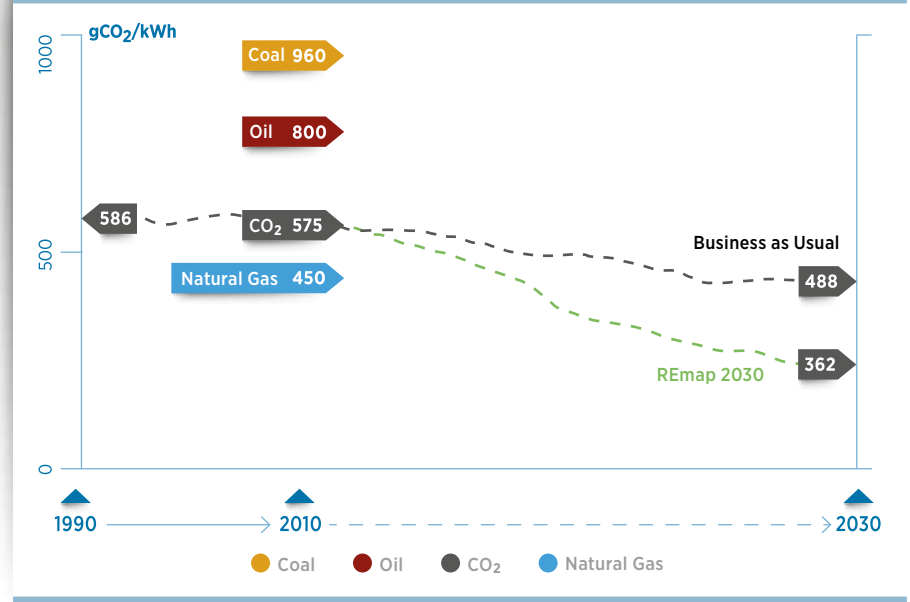


Source: IRENA, 2014b; IRENA, 2015c; Mills, 2015

To limit the global temperature rise, renewable energy deployment must be accelerated. For the electricity sector, achieving a further reduction in absolute emissions will require a substantial decrease in the emissions intensity of power generation. The average emissions intensity has barely

changed over the past 20 years (Figure 4). Under current policies and national plans, it is expected to fall from 575 grams per kilowatt hour (g/kWh) in 2010 to 488 g/kWh by 2030. A further reduction of the emissions intensity to 362 g/kWh – equivalent to a 40% intensity reduction from 1990 levels – could be achieved by scaling-up renewable energy deployment. Additional opportunities for emissions reductions lie in other end-use sectors (heating/cooling and transport), thus building the case for accelerating the energy transition.

Figure 4: Carbon-Dioxide Emissions Intensity of Power Generation



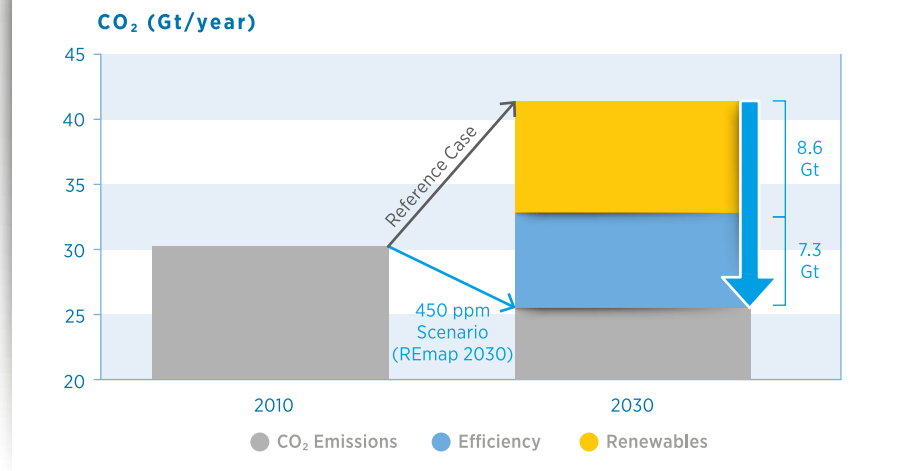
Source: IEA, 2010 and IRENA, 2014b

Accelerating the Energy Transition

Ramping up renewables is essential to meet climate goals without decelerating economic growth and reducing welfare. IRENA's analysis in *REmap 2030*[4] reveals that doubling the share of renewable sources in total final energy consumption (TFEC) from 18% in 2010 to 36% by 2030, combined with significant improvements in end-use energy efficiency, is required to limit global temperature increases to under 2 °C.

[4] *IRENA's REmap 2030 is a roadmap of technology options to increase the global share of renewables. It is based on national sources of 40 countries, which account for 80% of the expected total global energy demand in 2030. Current national plans and targets are collated to produce the Reference Case. The realistic potential of technology options beyond the Reference Case are examined to develop a roadmap (REmap 2030) towards a doubling of the share of renewables. The methodology is described in greater detail in the Appendix.*

Figure 5: Carbon-Dioxide Emissions under REmap 2030



Source: IRENA, 2014a

Under business-as-usual (Reference Case), current policies and those under consideration will increase the renewables share of TFEC to only 21% by 2030. In this case, annual global energy-related CO_2 emissions will actually increase from 30.3 Gt/year in 2010 to about 41.4 Gt/year by 2030 (Figure 5).

Boosting renewables to 36% of the energy mix makes a significant difference to global GHG emissions projections. The gap between the Reference Case and the *REmap 2030* options (36%) corresponds to a reduction of 8.6 Gt of energy-related CO_2 emissions per year by 2030, due to to avoided combustion of fossil fuels (of which 64% would have been coal, 20% oil and 16% natural gas)[5]. In other words, this is renewable energy's untapped potential for additional CO_2 reduction that would be lost, unless we accelerate renewable energy implementation. This would require the rate of renewable energy uptake to rise by around 1% per year in TFEC until 2030, which represents a six-fold increase compared to current levels.

Emissions reduction from renewables deployment, coupled with achievable energy efficiency improvements (7.3 Gt of CO_2), could limit global temperature rise to below 2°C (IRENA, 2014a). Realising these reductions will require substantial efforts to mobilise investments in the renewable energy sector.

[5] *This estimate excludes any life cycle emissions of fossil fuels and renewables.*

2 GLOBAL INVESTMENT NEEDS

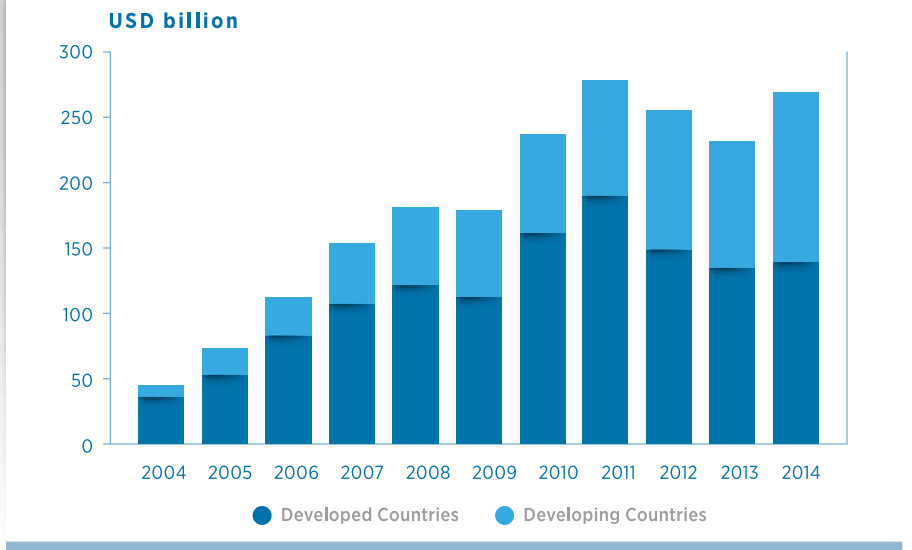
KEY POINTS:

» To realise the emissions-reducing potential of renewables by 2030, investments need to be scaled up significantly and rapidly. IRENA estimates that global annual investment in renewable energy would need to double from current levels to reach over USD 500 billion in the period up to 2020, and be further scaled up to an annual average of USD 900 billion between 2021 and 2030.

» The majority of the investment will go into the power sector, driven by rising demand in Asia, Europe and North America. Public finance cannot achieve the scale-up required, but if used catalytically it can mobilise private investments enabling growth to the levels required.

Doubling the share of renewable energy in the world's total final energy consumption within the next fifteen years is technically and economically feasible. Global investment in renewable energy has seen a sustained momentum over the past decade reaching USD 270 billion in 2014 (Figure 6).

Figure 6: Global Annual Investment in Renewable Energy (excluding large hydro)



Source: UNEP, BNEF and FS, 2015

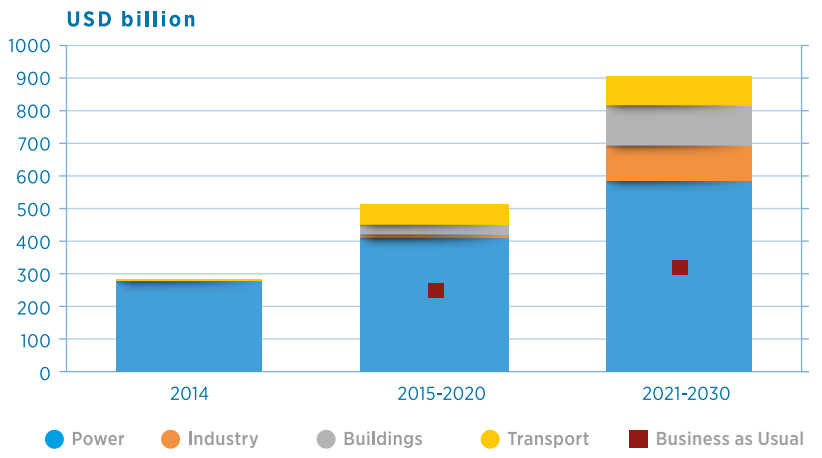
Further increase can be expected as investment opportunities in emerging markets are unlocked. Europe and North America, as early adopters, have accounted for the majority of past investments, but trends indicate a rise in investments in developing markets in Africa, Asia and Latin America (49% in 2014). Many of these markets are experiencing a rapid growth in energy demand, and renewable energy is seen as an increasingly important part of the future energy mix.

Investment Needs and Opportunities

Directing energy sector investment towards renewables will help realise their substantial potential for climate stabilisation. Action is required immediately, prior to 2020, so that annual investment in renewable energy across all sectors would surpass USD 500 billion[6] (Figure 7). In the period between 2020 to 2030, investment will need to further rise to around USD 900 billion annually. Under business-as-usual (Reference Case), investment is expected to remain around the same levels.

The power sector will continue to attract the majority of new investments, but end-use sectors will need to receive growing attention. IRENA's analysis shows that global annual investment in renewable energy in the power sector should be at least USD 600 billion by 2030. In order to avoid lock-in with unsustainable energy systems, annual investments between now and 2020 should reach USD 410 billion, which is USD 133 billion more than the current level.

Figure 7: Current Renewable Energy Annual Investment and Needs for REmap 2030

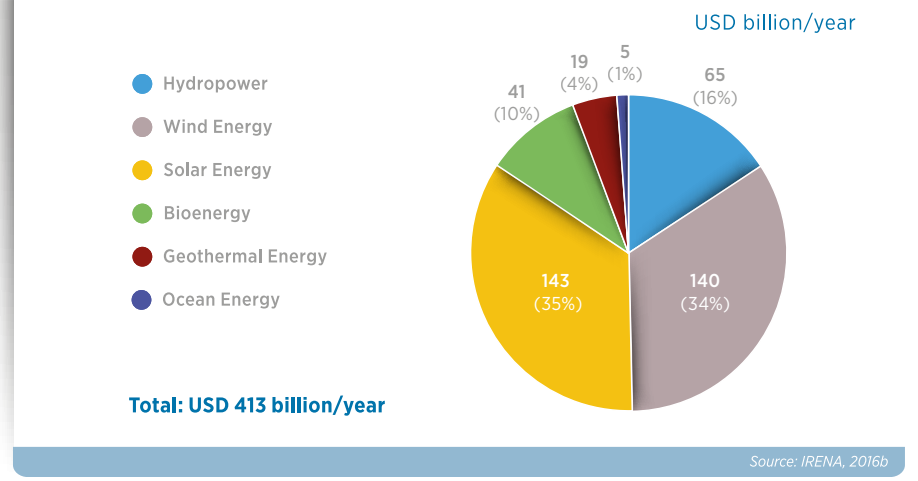


Source: IRENA analysis, based on UNEP, BNEF and FS, 2015

[6] *For IRENA estimations, investment in 2014 includes asset finance, small distributed capacity and biofuels (data from UNEP, BNEF and FS, 2015) as well as large-hydro investments (data from IRENA). It does not include public or private RD&D, public markets and venture capital/private equity.*

Solar and wind power will remain the leading technologies for renewable energy investment up until 2020, with roughly USD 140 billion investment each per year (Figure 8). Investment in less mature technologies – biomass, geothermal and tidal, wave and ocean energy – is expected to increase more rapidly, albeit starting from much lower levels.

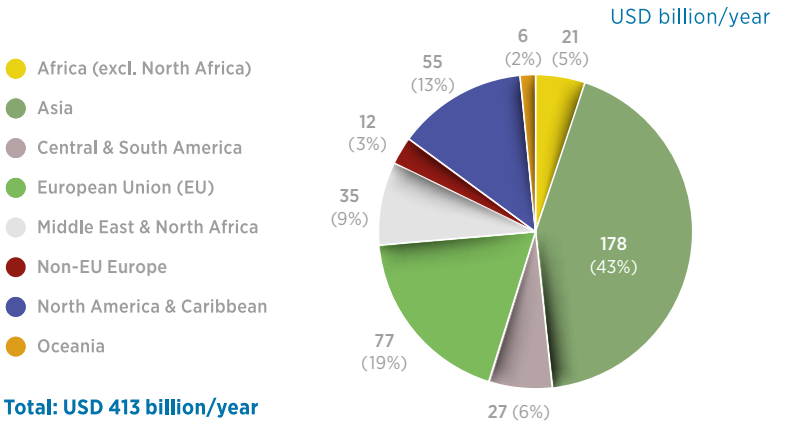
Figure 8: Renewable Power Investment under REmap (2015-2020, by technology)



Source: IRENA, 2016b

Asia, Europe and North America will continue to drive the renewables market. In the coming years, the largest share of global renewable power investment would be required in Asia (USD 178 billion per year until 2020), followed by the European Union (EU) (USD 77 billion), and North America and the Caribbean (USD 55 billion) (Figure 9). The fastest increase would take place in Sub-Saharan Africa (around six-fold compared to 2014) and in the Middle East and North Africa (around three-fold).

Figure 9: Renewable Power Investment under REmap (2015-2020, by region)



Source: IRENA, 2016b

Investment Strategies for the Power Sector

To close the investment gap and ensure a rapid increase in renewable energy uptake through 2030, public funding will remain important as a catalyst to mobilise private investment. Public funding will need to increase, but the larger amount of new investment in renewables will need to come from private finance. IRENA analysis shows that the share of public funding would remain at 15%, which still represents a substantial increase in absolute terms given the growth in investment needs in the renewable power sector. Policymakers, representing the main shareholders of public institutions like Development Financing Institutions (DFIs), Climate Finance Institutions (CFIs) and green banks, have an essential role to play in establishing renewable energy targets.

To mobilise private investment and close the power sector investment gap of USD 133 billion per year to 2020, an effective strategy is needed. It would focus on risk mitigation instruments and structured finance tools to develop a strong pipeline of projects as well as unlock project financing and refinancing opportunities. The strategy needs to be tailored to each phase of renewable energy project cycle (planning, construction and operation) and include private and public actors (Table 1). Successful implementation could help meet the renewable energy deployment objectives.

Given that today's investment decisions could lock-in power systems and associated emissions for decades, in the short-term greater focus must be placed on the planning phase to ensure there are attractive renewable energy projects in the pipeline. Strategies in this phase should focus on:

Table 1: Strategies to Close the Investment Gap in the Power Sector

BRIDGING THE RENEWBLE ENERGY INVESTMENT GAP TO 2020 OF USD 133 BILLION PER YEAR	PHASE	STRATEGY	ACTORS
	Planning (USD 8 billion)	Increase available risk capital	DFIs, CFIs, private equity funds and institutional investors
		Increase flow of bankable projects	Project developers, DFIs, CFIs and green
		Develop new planning stage risk mitigation mechanism	DFIs, CFIs and insurers
	Construction (USD 83 billion)	Increase public-private co-lending	All actors excluding project developers and insurers
		Scale-up existing risk mitigation mechanisms	DFIs, CFIs, insurers and export credit agencies
	Operation (USD 42 billion)	Use long-term financing instruments and structures for refinancing	Project developers, DFIs, CFIs, institutional investors, green and commercial banks

Note: *Public financial Institutions include DFIs and CFIs;*
The figures are illustrative of the magnitude of increased investment in the power sector in each phase.

Source: IRENA, 2016b

- **Increasing available risk capital:** Public finance institutions can play an important role in supplying early-stage risk capital. For instance, through a dedicated fund-of-funds structure, a small amount of public funding can be used to catalyse significant amounts of private funding.
- **Increasing the flow of bankable projects:** Comprehensive project preparation facilities can either support governments in setting up public-private partnerships, or support individual projects in structuring agreements and financing proposals. Project preparation facilities can also be coupled with DFI-led technical assistance projects that source pipelines of projects or create enabling conditions to support local market development.
- **Developing new planning-stage risk mitigation mechanisms:** Targeted public guarantees and new public-private risk sharing facilities enable more projects to reach the construction phase.

The large majority of renewable energy investment is made during the construction phase of projects, mainly in the form of debt financing. Strategies in this phase should focus on:

» **Increasing public-private co-lending:** DFIs, CFIs and green banks can adapt public-private partnerships and finance mechanisms to bring in commercial banks and non-traditional private participants such as institutional investors.[7]

» **Scale-up existing risk mitigation mechanisms:** The increased utilisation of existing risk mitigation instruments, such as guarantees and insurance from DFIs, insurance companies and Export Credit Agencies, to manage construction and operation risks for projects, would enable renewable energy projects to secure financing for construction.[8]

In the operation phase, banks and project developers can recycle capital to fund the next round of projects. A strategic focus in this phase could be:

» **Using long-term financing mechanisms and structures for refinancing:** Refinancing vehicles can increase the dedicated renewable energy capital and liquidity in the market. They free up the balance sheets of DFIs, commercial banks and project developers to continue investing in new projects, while tapping into institutional investor appetite for long-term stable cash flows through refinancing low-risk operational projects. For example, smaller projects can be aggregated into Green Bonds or Yieldcos.[9]

International financial support will need to play a critical role in financing renewable energy deployment in developing countries. A number of dedicated CFIs, such as the Global Environment Facility, the Clean Investment Funds of the World Bank, and most recently the Green Climate Fund (GCF) have been channeling climate finance to developing countries, including for renewable energy investment. The operationalisation of the GCF is underway: USD 10 billion have been pledged, 20 implementing entities have been accredited to undertake investments, and the first set of projects to receive funding were selected in November 2015.

Going forward, accelerated uptake of renewable energy in developing countries will require a significant increase in international financing efforts. Industrialised countries have committed under the UNFCCC to mobilise USD 100 billion annually by 2020. Climate finance and other public finance sources

[7] DFIs developing and implementing co-lending structures in emerging markets could mobilise USD 30 billion and new construction stage lending supported by DFI credit enhancements could mobilise another 30 billion in incremental investment for sustainable energy. The potential leverage ratios for public-private climate-specific investment can be 1:4 to 1:5 (SE4All Advisory Board Finance Committee, 2015).

[8] Many DFIs already offer many risk mitigation instruments. The challenge is to successfully deploy them for financing of renewable energy projects. For instance, guarantees can leverage between 1:3 and 1:15 of investment, including in markets with challenging political and regulatory environments (SE4All Advisory Board Finance Committee, 2015).

[9] According to SE4All Advisory Board Finance Committee (2015), scaling up green bonds could mobilise USD 35 billion of annual incremental investment for sustainable energy, and aggregation structures for project developers could mobilise a further USD 25 billion. The definition of Yieldcos: A publicly traded equity vehicle that pools operating renewable energy assets and that is designed to provide investors with long-term stable cash flows based on revenue generated by these assets.

can be targeted towards mobilising private sector investment, along the lines of the strategies outlined above, and complement other international efforts.

There is ample experience of public finance being utilised to de-risk investments and leveraging considerable funding from private sources, both domestic and international. Increased focus of public sector financing on the risks and barriers of renewable energy investment, and options for enhanced action can be identified at different levels building on proposed initiatives. These could use climate climate finance (*e.g.* a renewable energy risk mitigation facility funded by the Private Sector Facility of the Green Climate Fund) at the global level (such as a global risk mitigation facility initiated by the G20) or at a regional level (such as the guarantee fund of the European Juncker Plan).

Closing the investment gap is possible, but will require a combination of strategies to mobilise different investors. Recommendations on strategies and the mix of instruments would differ between regions and technologies. None of the strategies would be a solution in isolation but each would contribute to a broader action plan to accelerate renewable energy deployment.

3 ACCELERATING THE TRANSITION: FIVE ACTIONS FOR A SUSTAINABLE ENERGY FUTURE

KEY POINTS:

» Globally, there is a large amount of capital available to be invested, but governments must make significantly more systematic efforts to attract this funding into the renewable energy sector.

» Five actions are proposed for government policy to accelerate the transformation of the existing energy system to one based on considerably higher shares of renewable energy.

Globally, there is a large amount of capital available to be invested. The world's total financial assets are expected to increase to USD 900 trillion by 2020 (Bain & Company, 2012); managers of this capital will be seeking investment opportunities. Renewable energy projects can tap into this pool of capital; however, they must compete with other investments – including other infrastructure and energy projects – to secure financing. In this chapter, we discuss policy tools and strategies that can accelerate the transformation of the existing energy system to one based predominantly on renewable energy.

BOX 2: FIVE ACTIONS TO INCREASE THE DEPLOYMENT OF RENEWABLE ENERGY

1. Strengthen the policy commitment to renewable energy
2. Mobilise investments in renewable energy
3. Build institutional, technical and human capacity to support renewable energy deployment
4. Harness the cross-cutting impact of renewable energy on sustainable development
5. Enhance regional engagement and international cooperation on renewable energy development

1. Strengthen the Policy Commitment to Renewable Energy

Renewable energy enabling policies have played, and will continue to play, a fundamental role in attracting investments, increasing deployment and driving cost reductions. Globally, 164 countries have adopted renewable energy targets (IRENA, 2015g), with deployment aspirations featuring prominently in several countries' INDCs. Translating these broad aspirations into concrete technology-specific deployment targets is an important next step to provide both policy guidance and long-term planning security for the public and private sectors. These targets need to be backed by dedicated policies that are tailored to each country's local conditions as well as to the market segment where deployment needs to be supported. Enabling policies and regulatory frameworks could ensure predictable revenue streams for projects, create a stable and predictable investment environment, and can help to overcome non-economic barriers.

Sending appropriate price signals to the market is important in promoting renewable energy. Setting renewable energy targets and formulating dedicated policies to implement them provides a strong market signal, illustrating government commitment to the sector's development. Depending on the national context, complementary measures can also be adopted including levelling the playing field by pricing externalities and reducing fossil-fuel subsidies. Where appropriate, reducing fossil-fuel subsidies can level the financial playing field among different energy technologies, helping markets identify real economic advantages. An analysis modelling 20 countries that have eliminated fossil-fuel subsidies in a phased approach shows that redirecting some of the savings from subsidy reform (30%) towards renewables and energy efficiency could lead to their emissions reductions of almost 20% between now and 2020 (Merrill, et al., 2015). By contrast, in an increasing number of markets renewable energy does not need subsidies. Deployment can be accelerated by improving pricing signals, such as pricing environmental and human health-related externalities. While efforts to implement a global carbon price have not yet been successful, several national and regional pricing schemes have been introduced and cover an increasing share of the world's GHG emissions. When effectively implemented, all of these measures contribute to conditions that can trigger greater investments into the renewable energy sector and support its growth.

2. Mobilise Investments in Renewable Energy

Public funding will remain important as a catalyst and will need to increase, but the larger amount of new investment in renewables will undoubtedly need to come from the private sector. Overall renewable

energy investment in the coming years will have to grow considerably, well above current investment to levels over USD 500 billion. The largest portion of it will need to come from private investors. Given the increasing competitiveness of renewables, this is achievable if a strategy is pursued that focuses on risk mitigation instruments and structured finance tools to develop a strong pipeline of projects, and to unlock project financing and refinancing opportunities. The strategy should be tailored to the different phases of the renewable energy project cycle and involve a broad spectrum of private and public actors, including DFIs, CFIs, private equity funds, institutional investors, export credit agencies, green and commercial banks:

» It is imperative that in the next few years special attention is paid to the strategies supporting the planning phase. This requires enabling frameworks and ensuring a strong pipeline of projects that can be financed up to the year 2020 and beyond. The planning phase strategies increase the provision of risk capital, early stage risk mitigation mechanisms and facilities that assist in the preparation of project.

» A key priority in mobilising private investment in the sector will have to be effective risk mitigation strategies – enhanced utilisation of existing risk mitigation instruments and implementing new risk mitigation instruments - and promoting investment vehicles for refinancing renewable energy projects that can increase investor appetite, in particular for large institutional investors.

Improving the utilisation of risk-mitigation instruments could drive the accelerated uptake of renewable energy in developing countries. There are successful examples of using public funding for risk mitigation and the mobilisation of private sources, both at domestic and international levels, but there are currently not sufficient guarantee funds available for developing countries to scale up investment as required. The creation of new risk mitigation facilities that are dedicated to renewable energy could fill this gap. It is recommended that such risk mitigation facilities are prioritised and set up using climate finance and/or traditional development finance channels.

3. Build Institutional, Technical and Human Capacity to Support Renewable Energy Deployment

The effectiveness of renewable energy policies relies on an enabling institutional framework with clearly defined roles and responsibilities. As with most infrastructure projects, clarity of institutional roles (*e.g.* those related to project evaluation, permitting and licensing) accompanied by transparent and streamlined procedures can reduce transaction costs and make projects more attractive. The respective roles and responsibilities

of different institutions are often enshrined in dedicated renewable energy legislation. Given the wide array of stakeholders traditionally involved in the energy sector, including distribution companies, regulators and grid operators, coordination is also vital to ensure unfettered development, for instance planning for physical infrastructure and complementary regulations, such as grid codes, to keep pace with deployment.

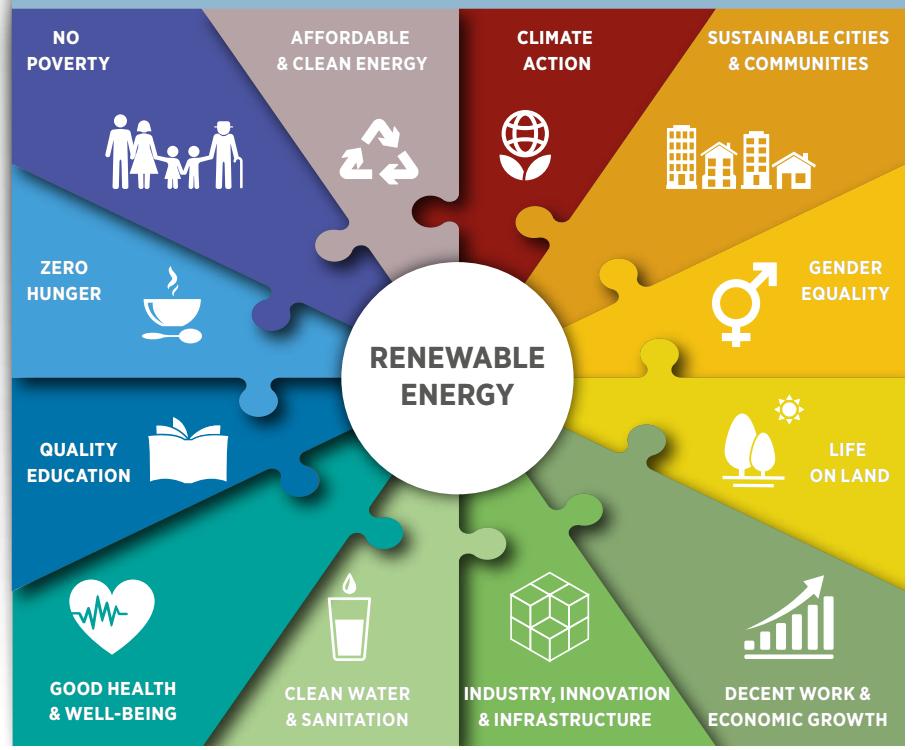
Capacity-building efforts should be undertaken across the value chain for renewable energy development. From policy and regulatory design and management to project preparation, evaluation, development, implementation and financing, a wide array of skills needs to be built up in government ministries, financing institutions, regulatory agencies and utilities. Inadequate skills and capacities could inhibit renewable energy development through slower permitting and licensing processes, higher perceived risk among financing institutions and regulators, and other consequences. The importance of cross-regional exchanges of best practices and lessons learned cannot be overstated. Globally, countries are at different stages of market development, and there is substantial potential for learning between different markets. Regional and global frameworks that facilitate such exchanges need to be put in place and actively supported.

4. Harness the Cross-Cutting Impact of Renewable Energy on Sustainable Development

Achieving the Sustainable Development Goal (SDG) on energy will transform the energy system while helping meet other SDGs such as for health, poverty alleviation, water and cities. Access to reliable, cost-effective and environmentally sustainable modern energy services can have a multiplier development impact in terms of reduced health effects, improved livelihoods, poverty alleviation, job creation, gender equality and enhanced access to water and food. The discourse on the SDGs lays emphasis on the interlinkages between the goals and the importance of adopting an integrated approach towards their implementation. Energy will be needed to meet nearly all of the development goals, and stakeholders will benefit from formulating strategies that recognise the role of renewable energy solutions in directly and indirectly contributing to at least 12 goals (Figure 10). Some notable examples of these linkages include:

» **Off-grid renewable energy solutions are essential to expand electricity access.** An estimated 1.1 billion people live without electricity access (World Bank, 2015c). The transformative impact of access on productivity, incomes, outreach of education and health services, and livelihoods is

Figure 10: Linkages Between Renewable Energy and SDGs



well documented. Off-grid renewable energy solutions, including stand-alone and mini-grid systems, are now among the most economic options to expand access to many rural areas (IRENA, 2014d). These solutions can be deployed rapidly and customised to local needs, and offer an attractive option for electrifying areas where grid extension is technically or financially unviable. In Africa, where about 600 million people are without access, more than 28.5 million people benefit from solar lighting products (Lighting Africa, 2015). Off-grid solutions are also being deployed for productive uses, such as solar-powered irrigation on farms, thus increasing yields and incomes, reducing vulnerability to erratic rainfalls and hardship especially among women. In this way, renewables not only help societies access modern and sustainable energy, but also in building climate-resilient infrastructure, protecting and restoring ecosystems in rural areas.[10]

» **Renewable energy can improve energy and water security.** The energy sector relies heavily on water for energy extraction and production, accounting for 15% of water withdrawals globally. In a water-constrained world, conflicts with other end-uses, such as agriculture, are intensifying and further impacted by climate change. With access to water increasingly recognised as a risk for energy security, it is becoming necessary to

[10] *For a background to the Sustainable Development Goals passed in September 2015, see https://sustainabledevelopment.un.org/?menu=1300*

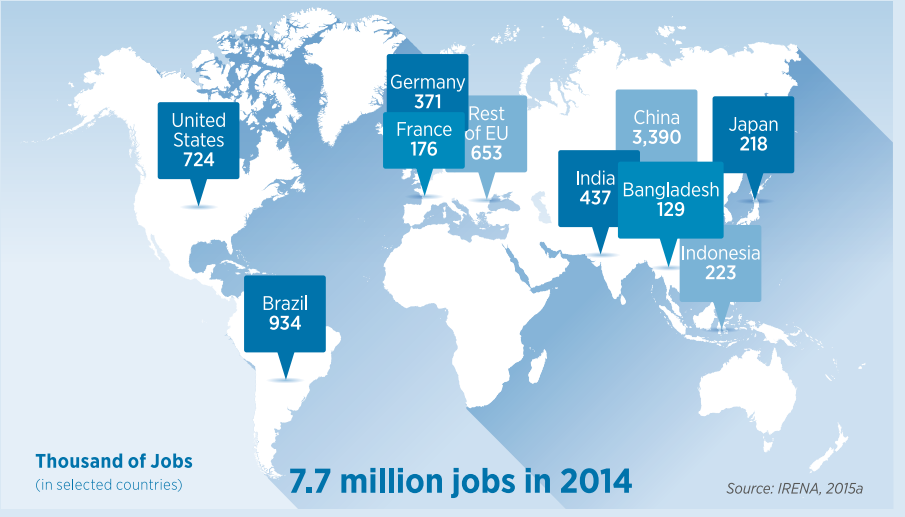
decouple energy sector expansion from water use. Solar PV and wind, the most rapidly growing technologies, consume up to 200 times less water than conventional options including coal, natural gas and nuclear (IRENA, 2015d). Substantial water savings are already being realised. In the drought-prone states of Texas and California, for instance, water savings from wind are estimated to be 50 billion and 9.5 billion litres respectively in 2014, (AWEA, 2015). Renewable energy can also meet energy needs across the water supply chain, including for pumping, desalination and heating, thus directly contributing towards water and energy SDGs.

» **Renewable energy helps create employment.** Project level data indicates that, on average, renewable energy technologies create more jobs than fossil fuel technologies. For instance, solar PV creates twice the number of jobs per unit of electricity generation compared with coal or natural gas. Globally, IRENA estimates that the renewable energy sector (excluding large hydro) created around 7.7 million direct and indirect jobs in 2014, an 18% increase over last year's count (IRENA, 2015a) (Box 3). China employs

BOX 3: RENEWABLE ENERGY AND JOB CREATION

China, Brazil, the US, India, Germany, Indonesia and Japan are leading renewable energy employers (Figure 11). The rise in employment spreads across the spectrum with solar, wind, bioenergy and small hydropower all seeing increases in 2014. The solar PV industry was the largest employer worldwide with 2.5 million jobs, followed by liquid biofuels with 1.8 million jobs, and wind power, which surpassed one million jobs for the first time in 2014 (IRENA, 2015a). Jobs in large-hydro rose to 1.5 million according to the first-ever global estimate conducted by IRENA.

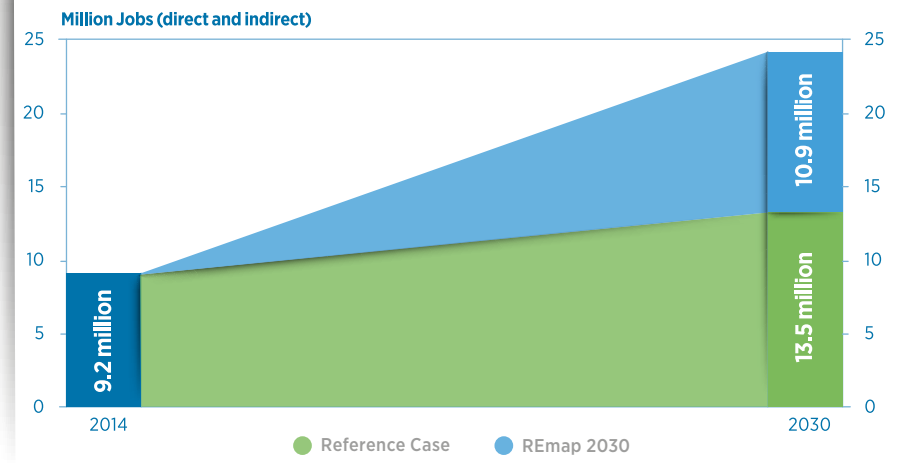
Figure 11: Renewable Energy Employment Worldwide (excluding large hydro)



more than 3.4 million people in its renewable energy sector, which represents around 20% of the total workforce in the country's energy sector, and is significantly more than the number of job in the oil and gas sectors combined (2.6 million). Looking forward, with 164 countries having adopted renewable energy targets, the employment in the sector is bound to experience substantial growth.

Under existing government plans, the deployment of renewable energy would lead to 13.5 million jobs in 2030. If deployment follows the trends outlined by *REmap 2030*, IRENA estimates that global direct and indirect employment in renewable energy could reach up to 24.4 million[11] by 2030 (Figure 12) (IRENA, 2016c). Most of these jobs will be concentrated in bioenergy, hydropower, wind and solar.

Figure 12: IRENA 2030 Employment Estimations



Source: IRENA, 2016c

5. Enhance Regional Engagement and International Cooperation

Regional approaches and common initiatives can reduce costs, generate economies of scale, attract investments, boost financial capacity, stimulate cross-border trade and enable common progress in accelerating the deployment of renewable energy worldwide.

[11] *IRENA's forthcoming publication "Renewable Energy Benefits: Measuring the economics" provides more details on this figure (e.g. its distribution across technologies and sectors) and complements it with estimations of the impacts on global GDP, welfare, trade, and other variables.*

For countries participating in regional initiatives, the potential benefits are numerous:

- Financing for investment opportunities in small and fragmented markets stands to gain from a regional approach. Aggregation helps renewable energy projects reach the scale necessary to attract larger-scale private investments into the sector.
- Increasing efficiency standards regionally reduces costs as well as energy waste. The same measures can also contribute towards greater energy security through the pooling of energy resources across borders. This maximises the use of regional renewable energy resources and can reduce each country's need for load shedding and power cuts.
- Costs for renewable energy products are reduced and climate-resilience can be improved by investing in joint, regional projects built in the most suitable locations, and by making use of cross-border economies of scale.
- Acting as a regional market can help create a stronger voice for negotiating with international trade partners, further reducing costs.
- Pooling human and technical resources between states or regions creates hubs of knowledge, excellence and innovation.

Regional initiatives can be complemented by greater international cooperation to scale-up renewable energy deployment (see Box 4). Global platforms, focusing on the promotion of specific renewable energy technologies or facilitating deployment across similar markets, could serve as an effective channel for facilitating technology transfer, expanding markets and sharing best practices with similar benefits as those described for regional initiatives.

To meet national goals and ambitions, countries would benefit from concerted action that regional and international cooperation offer. Governments are encouraged to tap into opportunities for engagement and cooperation on renewables and climate mitigation.

BOX 4: EXAMPLES OF IRENA REGIONAL AND INTERNATIONAL INITIATIVES

Africa Clean Energy Corridor: The initiative calls for accelerated deployment and cross-border trade of renewable power in a continuous network from Egypt to South Africa. Regional cooperation can enable the uptake of renewable power projects throughout Africa, sustainably transforming the regional energy mix to support economic growth. Specific priorities of the countries engaged include:

- Identification of cost-effective and environmentally sustainable development zones for wind, solar photovoltaic and concentrated solar power energy in the countries of the eastern and southern African power pools;
- Country and regional planning for cost-effective renewable power options for optimising investment in electricity generation and transmission infrastructure;
- Enabling regulatory environments for investment to open markets to independent renewable power producers, reduce the cost of renewable power financing, and facilitate renewable power trade; and
- Capacity building to develop skills required to build, plan, operate, maintain and govern power grids and markets with higher shares of renewables.

Global Geothermal Alliance (GGA): Geothermal energy can provide cost-effective, reliable, and dispatchable power and direct heat with a minuscule carbon footprint. Countries with geothermal potential are scattered around the globe, but share common challenges, including exploration risks, high upfront development costs, regulatory challenges, limited human resources and low awareness. The GGA serves as a platform for coordinated action to increase the share of geothermal energy in the global energy mix. The GGA offers customised support to regions and countries in addressing key investment challenges to scale-up geothermal energy deployment.

SIDS Lighthouses Initiative: Disconnected from mainland electricity grids, islands are especially vulnerable to price fluctuations for imported fossil fuels. But island states can overcome such challenges, as well as play their part in the global effort to mitigate climate change, through rapid renewable energy development. The Small Island Developing States (SIDS) Lighthouses initiative supports the transition of islands to greater renewable energy use by identifying efforts underway, pinpointing gaps, addressing barriers to implementation, fostering partnerships for project development and sharing crucial data, analysis and expertise. The IRENA-led initiative provides a framework for action for SIDS and partners to move away from a piecemeal approach towards a structured, holistic and sustainable one that takes into account medium and long-term energy needs.

Conclusion

Renewable energy offers an immediate means to decarbonise the global energy mix. Doubling the share of renewables by 2030 could deliver around half of the emissions reductions needed and, in combination with energy efficiency, keep the rise in average global temperatures within 2°C and prevent catastrophic climate change.

As this report shows, renewables are a viable, affordable and scalable solution. They are at the core of any strategy to meet climate goals while supporting economic growth, welfare, domestic value creation and employment generation. The potential of renewables is there for every country to harness.

For effective action against climate change, the share of renewables needs to grow not only in power generation but also in transport, heating and cooling, and more investment is urgently needed. Given the increasing competitiveness of renewables and the dynamism of the market, it is possible to dramatically scale-up investments in renewables. To avoid a lock-in with unsustainable energy systems, investments must grow immediately and must almost double to USD 500 billion annually between now and 2020.

To turn the prospect of a sustainable energy future into a reality, five clear actions are needed: strengthening policy commitment, enabling investments, building capacity, facilitating regional and international cooperation, and harnessing the cross-cutting impact of renewable energy on sustainable development.

The prize for taking the right steps, today, is immense. We have an unprecedented opportunity to limit temperature increase and propel the world into a sustainable, stable, prosperous and climate-resilient future through renewables.

APPENDIX

IRENA's REmap 2030 Methodology

REmap 2030 is a roadmap of technology options to increase the global share of renewables. It is based on national sources of 40 countries, which account for 80% of the expected total global energy demand in 2030. This plan is one of 'realistic potential' – one that can be accomplished with existing technologies, is economically practical, and achievable by 2030.

The REmap analysis starts with national-level data covering power, district heat and end-use sectors. Countries have provided their current national plans starting with the year 2010, forming the base year for the analysis. These were collated to produce business-as-usual Reference Cases, including each country's targets for renewables.

The Reference Cases represent policies in place or under consideration, including energy efficiency improvements. The Reference Case includes the final energy consumption for each end-use sector and the total generation of the power and district heat sectors, with a breakdown by energy type for the period 2010–2030.

The potential of technology options beyond the Reference Case was subsequently investigated. This realistic potential of technologies are described as REmap Options. The resulting roadmap essentially illustrates what a doubling of the share of renewables would look like. For each REmap Option, the analysis also considers the costs to substitute a conventional energy technology to deliver the same amount of heat or electricity.

REmap 2030 is an exploratory study, not a target-setting exercise, and countries can make informed choices as to how to use the options identified. The aim is to be practical and to co-operate directly with countries in order to analyse and discuss their specific cases in detail. Such an approach also creates an opportunity to discuss implementation of the options identified with each country, and to improve the analysis continuously over the years.

IRENA has developed a spread-sheet tool that allows national experts to evaluate and create their country's REmap 2030 analysis and assess the potential, cost and benefits of REmap Options. The tool provides a simplified but dynamic accounting framework to evaluate and verify Reference Case developments and REmap Options within each country.

The tool consists of two parts. In the first part, national experts can evaluate and adjust the country's Reference Case for REmap Options between 2010 and 2030. In the second part, they can substitute conventional technologies assumed to be in place in 2020 and 2030 with REmap Options based on the Reference Case. For ease of use, the tool offers a range of technology options to choose from in the power, district heat and end-use sectors.

The tool allows the national expert to choose REmap Options, assess the options' impacts on the country's renewable energy share and evaluate their position within the country's cost-supply curve. At any time, the user can increase or decrease the size of REmap Options and choose a different substitute. Furthermore, the tool allows for a consistent analysis and comparison of results among countries.

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