IRENA
International Renewable Energy Agency

REmap 2030

A Renewable Energy Roadmap

Questions & Answers

June 2014

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 cooperation, 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.

The full REmap 2030 report, a summary of findings and other supporting material are available for download through *www.irena.org/remap*

REmap reports are also available at *www.irena.org/publications*

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Disclaimer

Contents

Why do we need renewable energy? 5

What does REmap 2030 tell us? 6

Which countries does REmap 2030 analyse? 8

How will we obtain our energy in 2030? 10

What are the health and environmental consequences 12

Are there other benefits to adopting renewable energy? 12

What about people who lack energy access? 13

Does energy efficiency still matter? 13

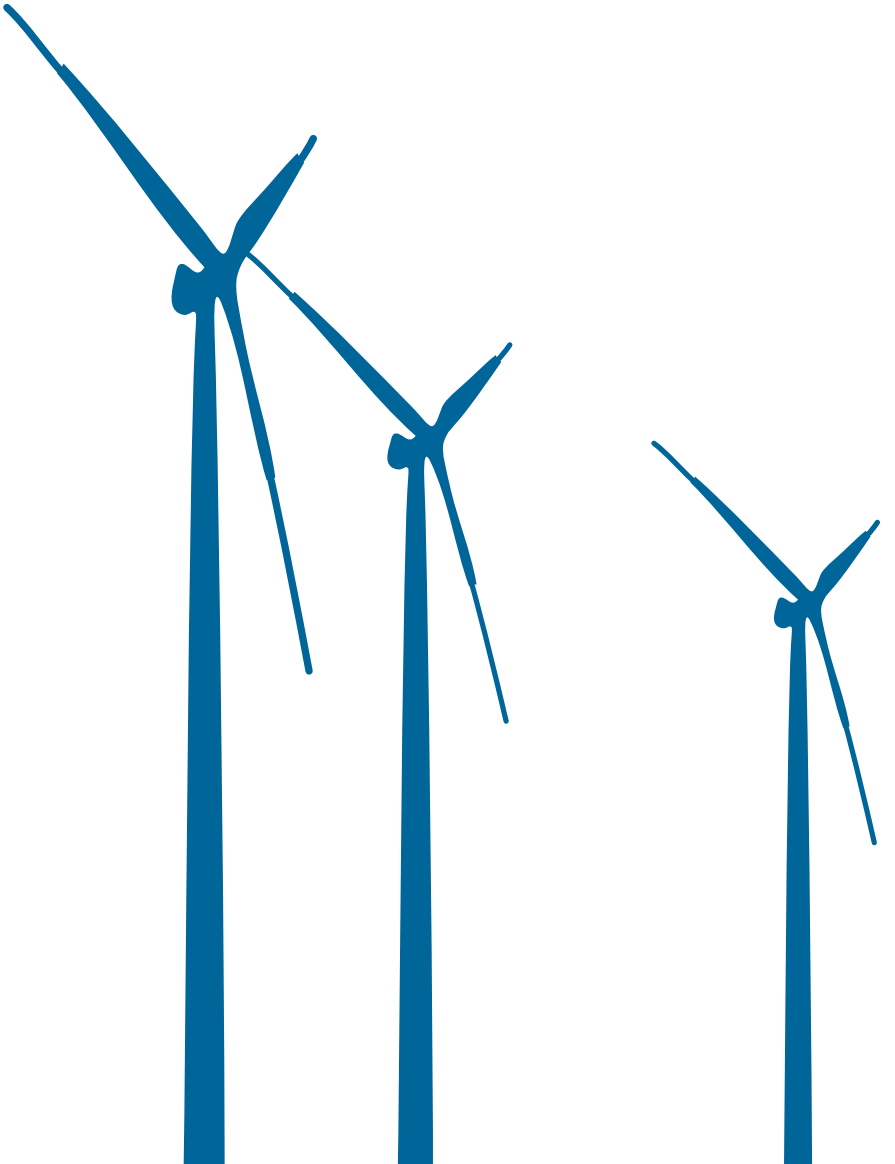
How much will all this cost? 14

Why don't countries recognise the advantages of renewable energy? 16

What can governments do? 17

How do we reach 36% renewable energy use? 19

Can't we push the energy transition even further? 20



Why do we need renewable energy?

Energy is a key challenge of our current times. Three-quarters of the world's people live in developing countries, whereas half of global gross domestic product (GDP) is generated in high-income and industrialised countries. Over the coming decades, an even higher share of the global population will live in the developing world, and those countries will generate an increasing large share of global GDP. Population and economic growth in both developed and developing countries leads to increasing demand for energy – of which more than 80% of the current global supply is provided by fossil fuels.

Rising demand for fossil fuels will result in fundamental problems. With their depletion, increasing scarcity of supply will lead to intensified competition for a finite resource, while their unequal geographic distribution represents a threat to energy security for many countries.

In addition, fossil fuels release carbon dioxide (CO2), the main driver of climate change. A recent report from the Intergovernmental Panel on Climate Change (IPCC) expressed the need for the world to act quickly and reduce greenhouse gas emissions to avert the catastrophic effects of climate change. The IPCC has identified energy efficiency and tripling – or even quadrupling – the share of renewable energy in the global energy mix by 2050 as the key ways to achieve substantial emission reductions.

Renewables account for only 18% of global total final energy consumption. Half of the total renewables demand comes from the traditional use of biomass. In view of the increasing demand for energy, particularly in developing countries, this also poses important concerns because of its unsustainable supply and the negative effects of indoor air pollution.

In view of these challenges, in 2011 the United Nations Secretary General launched the Sustainable Energy for All (SE4ALL) initiative with three interlinked objectives to be achieved by 2030: ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; and double the share of renewable energy in the global energy mix. The International Renewable Energy

Agency (IRENA) joined this global effort as the SE4ALL Hub for renewable energy.

Tasked by member countries to explore ways to put SE4All's renewable energy objective into practice, IRENA has developed REmap 2030, a global renewable energy roadmap.

REmap 2030 provides a plan to double the share of renewable energy in the world's energy mix between 2010 and 2030. It determines the realistic potential for countries, regions and the world to scale up renewables in order to ensure a sustainable energy future. It is the first study of worldwide renewable energy potential essentially assembled from the bottom up, starting with separate country analyses and then aggregating the results to arrive at global picture. Together, the 26 REmap countries represent approximately three-quarters of world energy demand.

REmap shows practical, realistic ways to meet the renewable energy objective of the SE4All initiative. Along with technological challenges and opportunities, IRENA's analysis takes account of the need for financing mechanisms, skills, political will and planning.

What does REmap 2030 tell us?

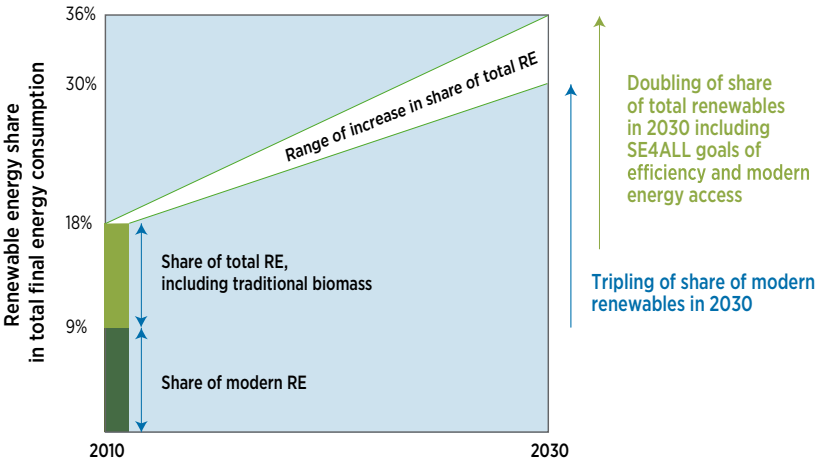
The global share of renewable energy can really be doubled by 2030, as long as the right policy frameworks are adopted now. IRENA's analysis also shows that when the benefits – particularly pollution reduction – are fully considered, this vital shift to renewable energy use costs less than other pathways for energy development.

Renewable energy accounted for 18% of total energy use in 2010. With current policies, this would only increase to 21% by 2030. Yet with a concerted effort and enabling policies, the renewable share could rise as high as 36% (see Figure 1), in conjunction with improved energy access and efficiency. Energy access includes the substitution of unsustainable traditional biomass use with modern forms of renewable energy.

This ambitious transition must happen in the face of a fast-expanding energy demand, especially in developing countries and cities. The

world's total final energy consumption, which increased from 232 exajoules (EJ[1]) in 1990 to 335 EJ in 2010, is projected to reach 470 EJ by 2030, marking a doubling of global energy use over 40 years. Electricity use will rise faster than other forms of energy consumption.

Figure 1. Doubling the share of renewables by 2030



RE = renewable energy; SE4ALL = Sustainable Energy for All

Even so, increasing renewable energy only for power generation will not be enough to achieve the doubling goal, as power makes up less than one fifth of the world's final energy consumption. Renewable energy technologies must also be adopted in the end-use sectors of industry, buildings and transport, where fossil fuels currently predominate. Most renewable energy growth by 2030 is possible within the transport and power generation sectors.

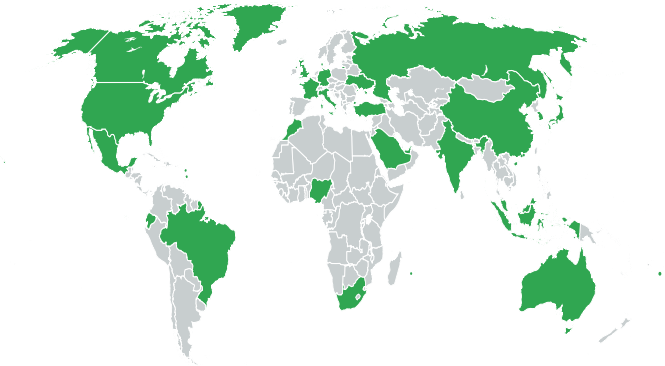
In other cases, the utilisation of renewable energy resources needs to be updated. More than a third of the world's population relies on wood and animal waste for energy, especially for cooking. At present, "traditional" biomass use accounts for half of renewable energy use (or 9 percentage points out of 18) worldwide. With the curbing of such unsustainable practices, however, doubling renewables in the energy mix actually requires quadrupling the share for modern renewables, from 9% to 36%.

[1] An exajoule is one quintillion (10^{18}) joules. 1 EJ is equivalent to the total energy content of oil carried by around 75 supertankers, each carrying 300 000 tonnes

Which countries does REmap 2030 analyse?

The roadmap currently encompasses 26 countries that together account for three-quarters of global energy demand (see Figure 2). This group includes the world's largest economies, as well as countries with ambitious renewable energy policy frameworks or outstanding renewable energy potential. The countries include: Australia, Brazil, Canada, China, Denmark, Ecuador, France, Germany, India, Indonesia, Italy, Japan, Malaysia, Mexico, Morocco, Nigeria, Russia, Saudi Arabia, South Africa, South Korea, Tonga, Turkey, Ukraine, the United Arab Emirates, the United Kingdom and the United States. The analysis was undertaken in cooperation with governments, research institutes, the private sector, non-governmental organisations and other stakeholders.

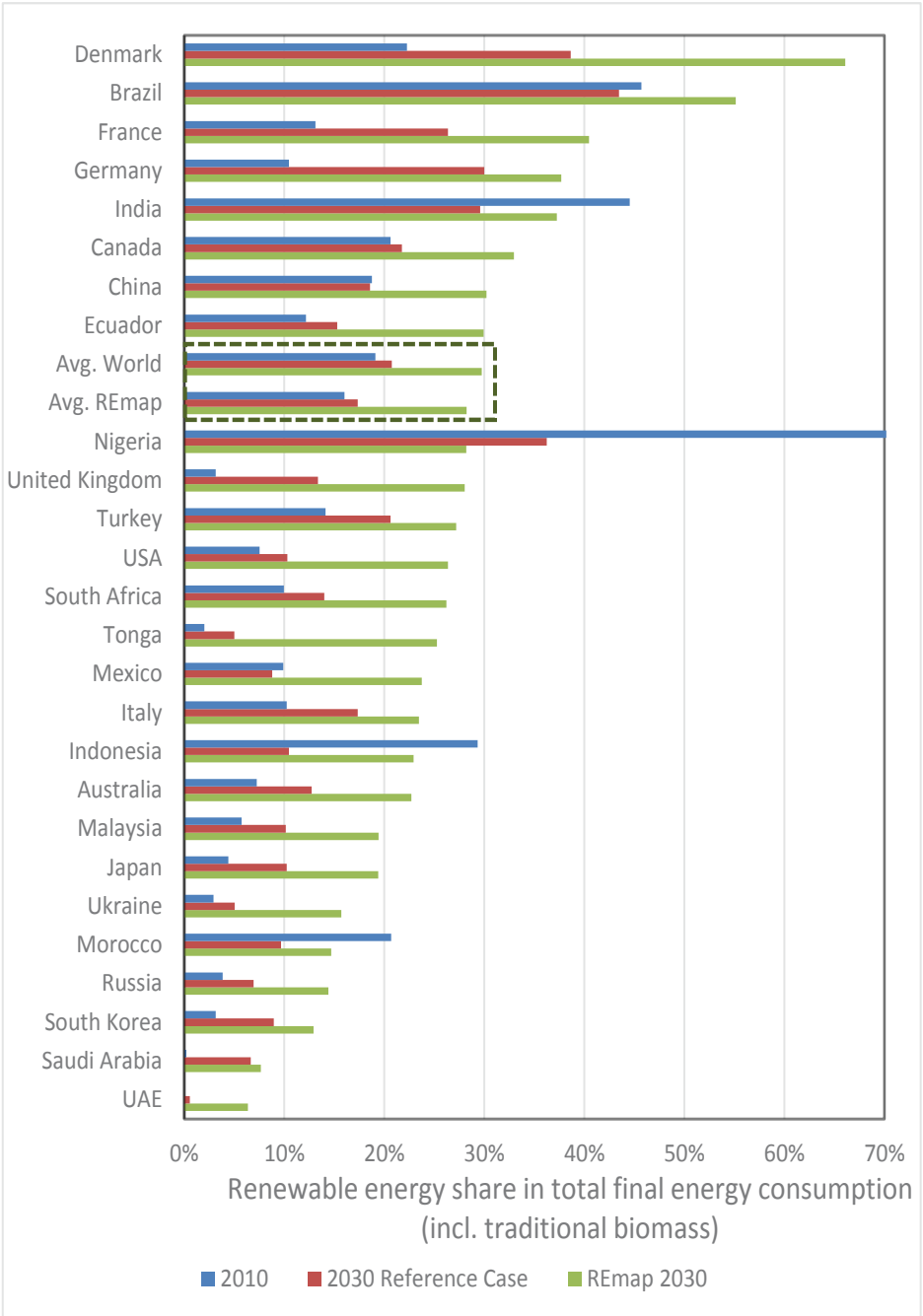
Figure 2. The 26 REmap countries



Country experts provided national energy plans up to 2030, along with insights into the technical, economic and political feasibility of various renewable energy options. These findings were collated and aggregated to provide a global picture.

Increases in the renewable energy share in the 26 REmap countries remain country-specific, depending on the level of renewables in each country's current energy mix. For example, Denmark and Germany are set to achieve at least 30% renewable energy use by 2030 thanks to enabling policies that have been in place for more than 30 years. In contrast, the Gulf countries, Russia and Ukraine are headed, under current plans, for less than 5% (see Figure 3). The difference reflects varying shares of renewable energy as the starting point, as well as different resource potential, economic conditions and policy frameworks.

Figure 3. Shares of renewables in the energy mix, by country, with divergent options



How will we obtain our energy in 2030?

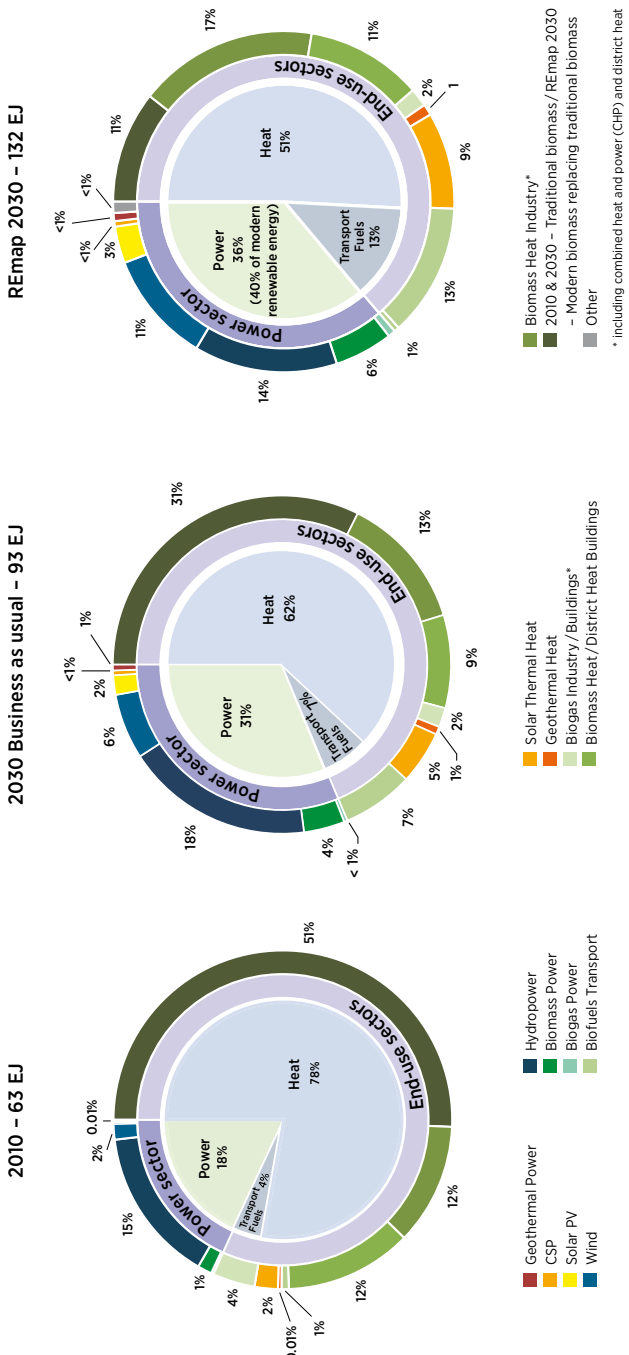
All renewable energy forms, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy, are considered, as they are all needed for a successful energy transition. The envisaged scale-up by 2030 involves major new investments in wind and solar energy, along with a decisive shift from traditional to modern, fully sustainable, uses of bioenergy. Hybrid solutions, particularly for rural electrification, will be crucial to ensure a smooth transition. uses of bioenergy. Hybrid solutions, combining renewables with conventional energy sources, will also be crucial to ensure a smooth transition.

REmap 2030 envisages an extra 5 400 terawatt-hours (19 EJ) of renewable power on top of business-as-usual in 2030 – equivalent to China's total electricity consumption today. A broad portfolio of technologies offer potential for a power sector where 43% of renewable power would be sourced from wind (onshore and offshore), 23% from biomass, 19% from solar photovoltaics (PV) including rooftop power on buildings, 5% from hydropower, 3% from geothermal and 7% from other renewable sources. By 2030, the power sector makes up only 40% of total modern renewable energy use, while 60% would be in the end-use sectors, with renewables replacing conventional fuels in buildings, industry and transport.

Recently, the rapid growth of wind and solar power has made headlines. However, modern forms of biomass offer the most important source of renewable energy growth in the next few years, particularly for heating in buildings and industry, and fuels for transport (see Figure 4). If the biomass demand foreseen in REmap 2030 cannot be met sustainably, the doubling of renewables in the energy mix by 2030 will be difficult – although not impossible – to achieve.

Under current national plans, fossil-fuel use would grow 40% by 2030. This increase can, however, be reduced to 12% through the rapid scaling-up of renewable energy. Compared to business-as-usual consumption levels in 2030, REmap 2030 implementation would result in a 26% reduction in coal use and a 15% reduction in natural gas and oil use.

Figure 4. Modernising the mix: Global renewable energy use in 2010 and according to REmap 2030, by technology and sector



What are the health and environmental consequences?

Reducing the need for fossil fuels as outlined in REmap 2030 would in turn reduce health costs by up to USD 200 billion per year.

Furthermore, renewables will have a crucial role in any solution to mitigate climate change. Global CO2 emissions from energy consumption were 30 gigatonnes (Gt) in 2010 and are expected, based on today's trends and policy frameworks, to rise to over 40 Gt by 2030. Emissions need to drop below 25 Gt by 2030 to keep atmospheric CO2 concentrations on a trajectory consistent with 450 parts per million (ppm) – the limit beyond which catastrophic climate change is projected to occur. Analysis shows that the deployment of renewable energy can reduce annual CO2 emissions by 8.6 Gt by 2030. Such emissions savings, combined with energy-efficiency gains, would be sufficient to set the world on a path to preventing catastrophic climate change.

The climate-mitigation benefits of reducing CO2 emissions are valued between USD 165 billion and USD 640 billion per year, far exceeding the costs of adopting pro-renewable energy policies under REmap 2030.

Are there other benefits to adopting renewable energy?

One advantage is job creation. Switching to renewable energy will create new jobs in the renewable energy sector – more jobs than the ones that would be lost in the conventional energy sector. REmap 2030 foresees a net gain of 900 000 additional jobs.

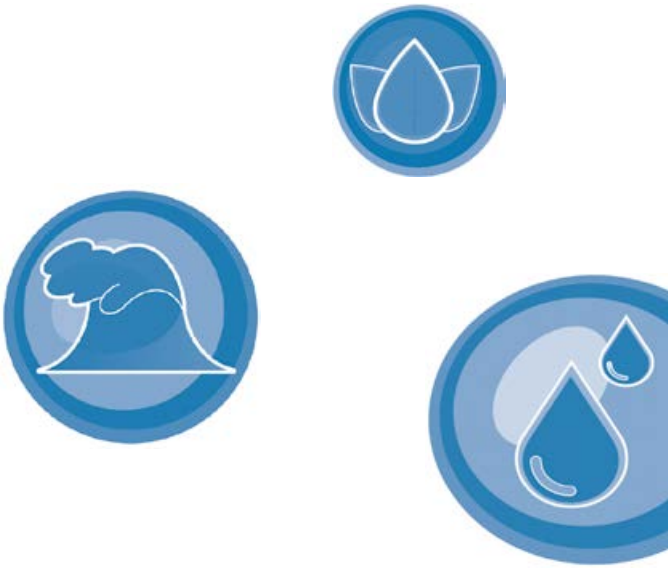
Reducing dependence on costly, often volatile, energy imports is another advantage. For many countries, reducing their reliance on fossil fuels – and on distant producers – is a goal in itself. Although the cost of potential supply disruptions is hard to quantify, it is bound to be high.

What about people who lack energy access?

Under current projections, 1 billion people, mostly in Asia and Africa, will still lack access to electricity in 2030. Decentralised renewable energy deployment offers the chance to close that gap through mini-grids and off-grid systems. Bangladesh, for example, has deployed more than 2.4 million solar home systems, creating jobs for 70 000 people along the supply chain.

Does energy efficiency still matter?

With greater energy efficiency, the same amount of renewable energy covers a larger share of energy demand. Improving energy efficiency and increasing renewable energy use, will result in substantial reductions in CO2 emissions.



How much will all this cost?

The more we invest, the cheaper renewable energy becomes, with each increase in capacity resulting in more effective use of our natural resources. Even by conventional standards, which does not factor in the external costs inflicted on society by burning fossil fuels, renewable energy is becoming cost-competitive (see Figure 5). Technology costs have fallen significantly and will continue to decline through innovation, competition, growing markets and regulatory streamlining.

The net incremental investment needed to double the renewable share in global energy use amounts to some USD 265 billion per year until 2030, or around 1% of global investment activity. With cost savings resulting from fuel substitution taken into account, this yearly figure drops to USD 133 billion until 2030.

The subsidy needs for renewables are estimated at USD 315 billion per year in 2030. Per unit of modern renewable energy delivered, the subsidies would halve between today and 2030. To put this into perspective, fossil fuels received subsidies of USD 544 billion in 2012, according to the International Energy Agency (IEA).

Without externalities being taken into account, the cost of doubling the share of renewable energy by 2030 averages out at USD 2.5 per gigajoule (GJ[2]) .

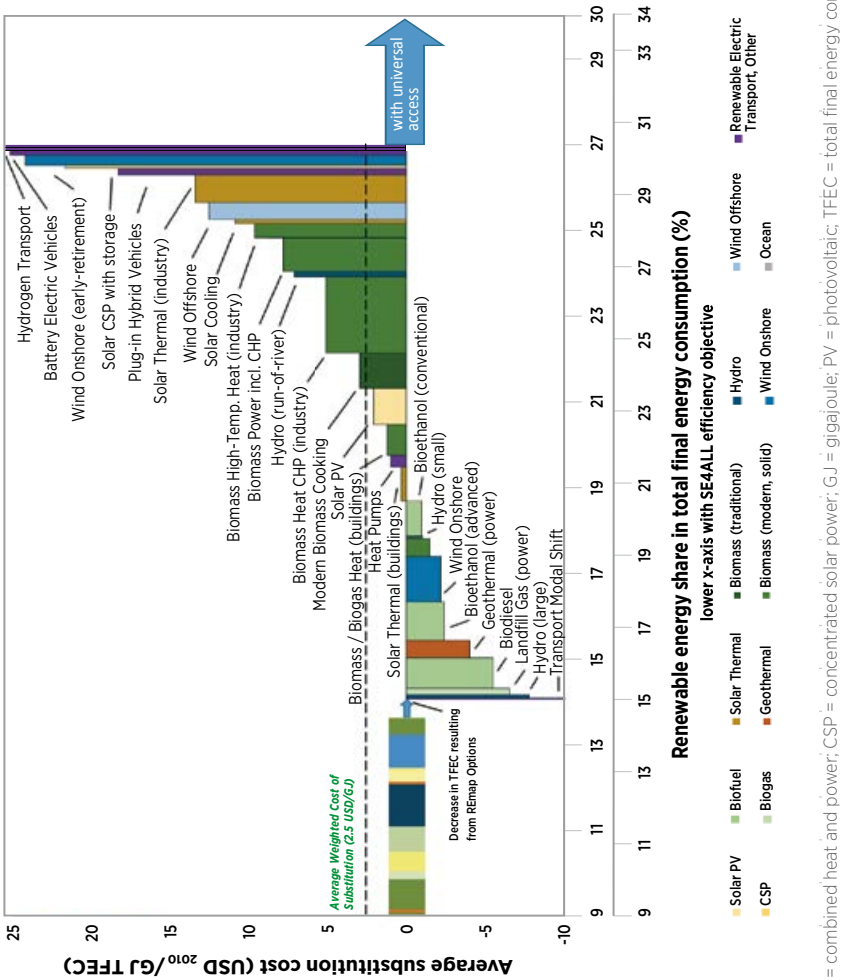
Overall, based on local energy prices (with subsidies and taxes accounted for) and discount rates, replacing fossil fuels with renewable energy offers an average saving of USD 0.7 per GJ. This creates a strong business case for the energy transition[3]. The cost of replacing fossil fuels with renewable energy varies from country to country, due to a mix of resources, policy frameworks and economic conditions.

[2] A GJ is the equivalent of the amount of petrol needed to drive from New York to Washington, D.C

[3] IRENA estimated the costs of substitution from two perspectives: government and business. In the government perspective, international costs exclude energy taxes and subsidies, and a standard 10% discount rate was used. This results in an average substitution cost of USD 2.5 per GJ. For the business perspective, the process was repeated to include national prices (including, for example, energy taxes, subsidies and the cost of capital). This results in an average saving of USD 0.7 per GJ.

Renewable energy becomes even more cost-effective if the socio-economic consequences of using fossil fuels, including air pollution and health effects, are taken into account. REmap 2030 considers the impact of a range of pollutants, including CO2, methane, sulphur dioxide and mono-nitrogen oxides. Other external considerations include employment and energy security. When costs associated with these factors are taken into account, switching to renewable energy results in savings of up to USD 740 billion per year by 2030.

Figure 5. Average cost of substituting fossil fuels with different forms of renewable energy



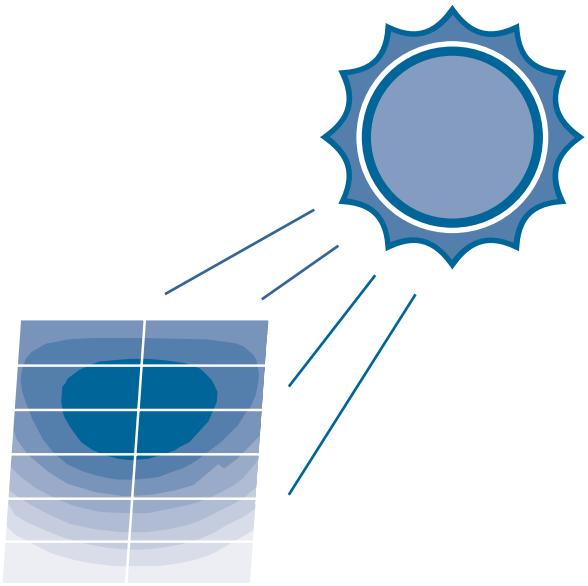
CHP = combined heat and power; CSP = concentrated solar power; GJ = gigajoule; PV = photovoltaic; TFEC = total final energy consumption; SE4ALL = Sustainable Energy for All; USD = United States Dollars

Why don't countries recognise the advantages of renewable energy?

Governments consistently underestimate the change that is coming. Renewable energy markets are already growing faster than official figures anticipate. In recent years, for example, the price of solar PV has plummeted so quickly that even recent statistics have become completely outdated, and the trend appears set to continue.

By 2030, citizen adoption of PV could fundamentally disrupt the conventional power sector in many countries. Current market trends, coupled with policies to enable renewable energy uptake, could result in 1 250 gigawatts (GW) of solar PV in 2030, compared with current government projections of less than 500 GW for that year.

REmap 2030 recognises far higher growth for most renewable energy types, particularly for today's niche technologies, such as offshore wind, concentrated solar and geothermal power. Governments need to update their information.



What can governments do?

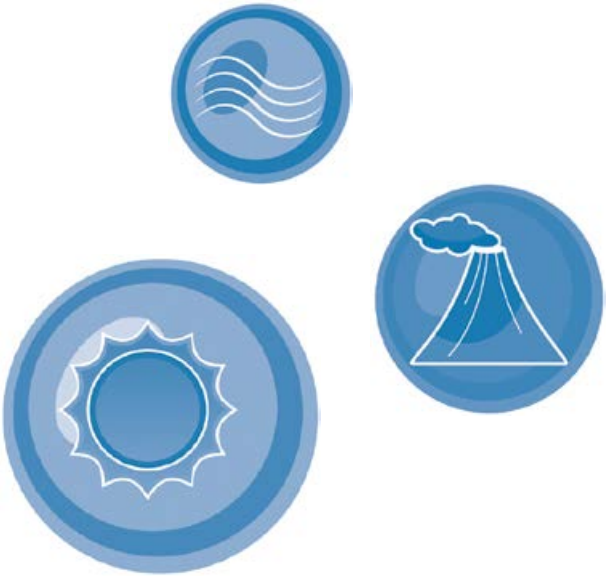
Governments need to focus on planning, enabling business, spreading knowledge and renewable energy integration and innovation.

Make a plan	• Assess situation today and forecasts for 2030 • Develop a national roadmap; monitor and re-evaluate • Ensure human and institutional capacity for transition • Streamline planning processes; maintain consistency and inclusiveness
Enable business	• Reduce the cost of capital and levelised cost of renewable energy generation • Consider renewable energy deployment as an alternative to fossil-fuel subsidies • Ensure a level playing field • Account for external effects in fossil fuel pricing • Ensure quality of products through standards and regulations • Establish long-term policy framework • Improve project implementation planning and regulatory framework
Integrate	• Build enabling infrastructure • Facilitate biomass supply and consider nexus issues: energy, land, water, agriculture, trade, infrastructure • Develop the market for affordable and reliable modern energy access equipment
Spread knowledge	• Build a strong, publicly accessible knowledge base • Expand project development knowledge • Collect and report best practice technology and policy information • Establish and improve awareness programmes • Consider product and service life-cycle sustainability impacts when designing new technologies
Innovate	• Support the complete technology life cycle • Review low-renewable energy applications and fill the gap with new technology

Governments differ in their capacity to achieve a doubling of renewable energy. The quality of statistics varies widely, as does the sophistication of objectives. Such challenges are not confined to the developing world.

The challenge is both technical and political. Where political parties agree on a goal, long-term objectives can be set. In other countries, even governing coalitions may be divided over energy policies, while compliance and enforcement vary considerably. One way to overcome these constraints is through the availability of open, transparent information.

Government support for an effective grid can change a disparate set of technologies, some based on variable resource availability, into a consistent, predictable whole. Solar and wind power, for example, may complement each other, while hydropower or biomass can fill any remaining gaps. In the transitional period to doubling, hybrid solutions with natural gas or diesel could help.



How do we reach 36% renewable energy use?

Doubling renewable energy in the global energy mix will be driven by both markets and government policies. While prices must fall in the market, governments must set targets, stimulate investment and level the playing field to account for external costs resulting from fossil energy use. Sound policy frameworks are also needed to facilitate exchange of information, integrate renewable energy into the grid and spur innovation.

REmap 2030 lays out goals that are achievable under current market conditions. But a significant and sustained policy change is needed across the board. Without the right policy frameworks and investments being put in place now, we will miss the goals that can ensure future energy sustainability and avert climate catastrophe.

Doubling the share of renewable energy by 2030, meanwhile, will be difficult for countries to achieve in isolation. International co-operation creates economies of scale, increased renewable energy trading and faster technology learning. A renewable share of 36% in the global energy mix is attainable by 2030, but only if we work together.

Can't we push the energy transition even further?

Increasing the global share of renewable energy beyond 36% is only possible with more dramatic measures. REmap 2030 considers an "RE+" case, which could bring the renewable share closer to 50%. This would include a shift towards renewable electricity in all sectors, including transport (electric vehicles) and heating (heat pumps). It would also require the relocation of industry to areas where renewable energy is abundant and inexpensive, which in itself might drive the integration of renewables into the overall energy supply. This has already started in Iceland (where aluminium production has followed cheap hydropower) and is also possible in areas with cheap wind and solar resources.

RE+ would also entail the early retirement of conventional energy plants. This has already begun in Germany, Spain and Italy, where overcapacity in wind and solar PV has led to the closure of natural gas and coal plants. Finally, a raft of emerging technologies – such as ocean and wave energy – could bear fruit over the longer term. But utilising their future potential requires investment today.

The world is at a tipping point, and the renewable energy era could be upon us. The future is not yet assured, and we could lose an extraordinary opportunity without firm policy decisions now. Yet the progress that can be achieved by 2030, with the technologies existing today, would set the world on the path towards a truly sustainable energy future. With the right policy frameworks, we will get there.

Notes

Notes

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