



EXECUTIVE SUMMARY

An alignment of economics, demographics, climate change and technology has set in motion an ongoing transformation of the global energy system.

Growing populations, with improved living standards and increasingly concentrated in urban centres, have dramatically raised the demand for energy services. At the same time, a growing consensus over the dangers posed by climate change has prompted people and governments worldwide to seek ways to generate that energy while minimising greenhouse gas emissions and other environmental impacts.

Rapid technological progress, combined with falling costs, a better understanding of financial risk and a growing appreciation of wider benefits, means that renewable energy is increasingly seen as the answer. REmap 2030, a global roadmap developed by the International Renewable Energy Agency (IRENA), shows that not only can renewable energy meet the world's rising demand, but it can do so more cheaply, while contributing to limiting global warming to under 2 degrees Celsius – the widely cited tipping point for climate change.

A technology once considered as niche is becoming mainstream. What remains unclear is how long this transition will take, and how well policy makers will handle the change.

As this transformation gets underway, it will affect every aspect of society. *REthinking Energy*, a new series by IRENA, will explore how renewable energy is financed, produced, distributed and consumed, and will chart the changing relationships it is bringing about between states, corporations and individuals.

This first volume focuses upon the power sector. It tells a story – about the trends driving this change, how the technology is evolving, who is financing it, and the wider benefits it will bring. Finally, it examines what an energy system powered by renewables might look like and how policy makers can further support the transformation.

Why the world of energy is transforming

At the heart of the energy transformation lies demand, the aim to strengthen energy security and the imperative of a sustainable future.

Over the past 40 years the world's population grew from 4 billion to 7 billion people. An increasing proportion is middle class and living in cities. During the same period, electricity generation grew by more than 250%.

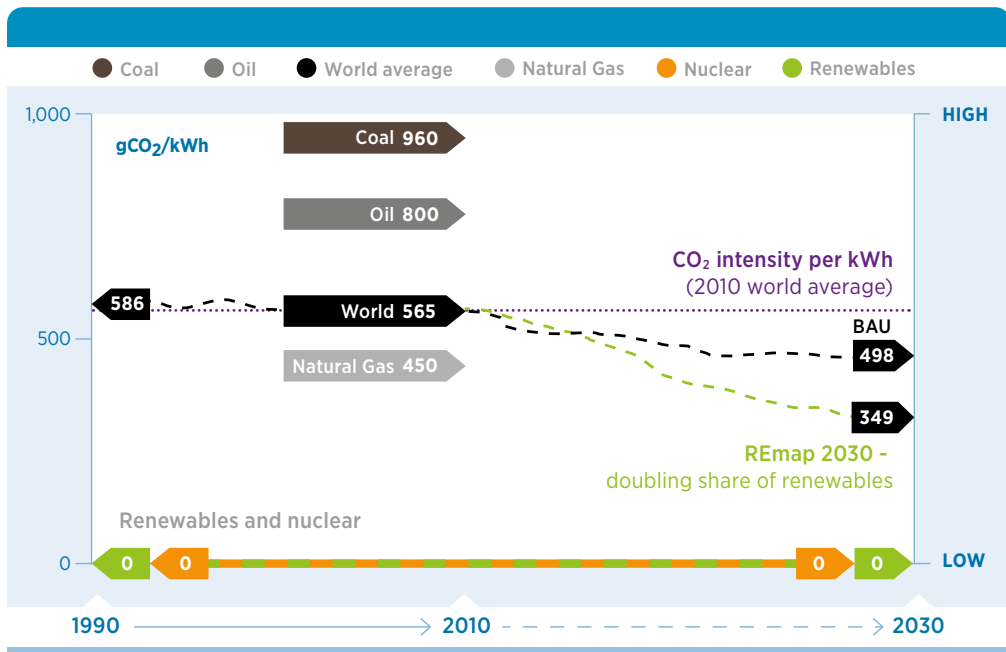
This growth will continue. In 2030 there will be more than 8 billion people, with 5 billion in urban conglomerations. Global spending by the middle classes is expected to more than double, from USD 21 trillion in 2010 to USD 56 trillion in 2030. World electricity generation is forecast to grow by 70% from 22,126 terawatt-hour (TWh) in 2011 to 37,000 in 2030.

But this energy is coming at a cost. There is growing consensus on the threat of climate change brought on by increasing atmospheric concentrations of greenhouse gases, prompting worldwide efforts to reduce emissions.

If business continues as usual, these efforts will not succeed. The average emissions intensity of electricity production has barely changed over the past 20 years. Gains from the increasing deployment of renewables, and less intensive fossil fuels such as natural gas, have been offset by less efficient power plants and the rising use of coal. Without a substantial increase in the share of renewables in the mix, climate change mitigation will remain elusive.

REmap 2030 shows that under current policies and national plans (business as usual case), average carbon dioxide (CO₂) emissions will only fall to 498 g/kWh by 2030. That is insufficient to keep atmospheric CO₂ levels below 450 parts per million (ppm), beyond which severe climate change is expected to occur. A doubling in the share of renewables could help mitigate climate change by reducing the global average emissions of CO₂ to 349 g/kWh – equivalent to a 40% intensity reduction compared to 1990 levels, as seen in the figure below.

CO₂ emissions intensity per kWh – 2030 outlook



Source: International Energy Agency (2010) and IRENA (2014a)

There is also increasing concern about the direct health impact of burning fossil fuels as fast-growing economies confront rapidly declining air quality and a sharp rise in respiratory disease. The United States Environmental Protection Agency recently found that ill health caused by fossil fuels nationally costs between USD 362 billion and USD 887 billion annually. The European Union's Health and Environment Alliance found that emissions from coal-fired power plants cost its citizens up to EUR 42.8 billion in yearly health costs. Localised catastrophes, such as the Deepwater Horizon oil spill in the United States, or the Fukushima nuclear accident in Japan, are becoming global news with profound implications. Governments have taken note.

Countries are increasingly looking to reduce their dependence on imported fossil fuels. By reducing energy imports, countries are striving for greater energy independence; avoiding potential supply disruptions (for example, in case of conflicts or disasters), high energy prices and price fluctuations.

There is growing pressure, meanwhile, to bring electricity to the 1.3 billion people currently without electricity access, many in remote areas, for whom traditional large-scale power plants and transmission systems have not yet provided an answer. Also, 2.6 billion people rely on traditional biomass and cook using traditional stoves that cause severe health impacts.

These trends have prompted a widespread conviction that something has to change. Fossil fuels powered the first industrial revolution, but even in the new era of shale oil and gas, questions remain about their compatibility with sustainable human well-being. The stage is set for the era of modern renewable energy that is cost competitive, mainstream and sustainable.

The cost of renewable energy plummets as deployment increases

Large-scale hydro, geothermal and biomass power have been competitive for some time, but for many years wind and solar power struggled to compete with coal, oil and natural gas. Over the past decade, however, and in particular over the last five years, that picture has changed dramatically.

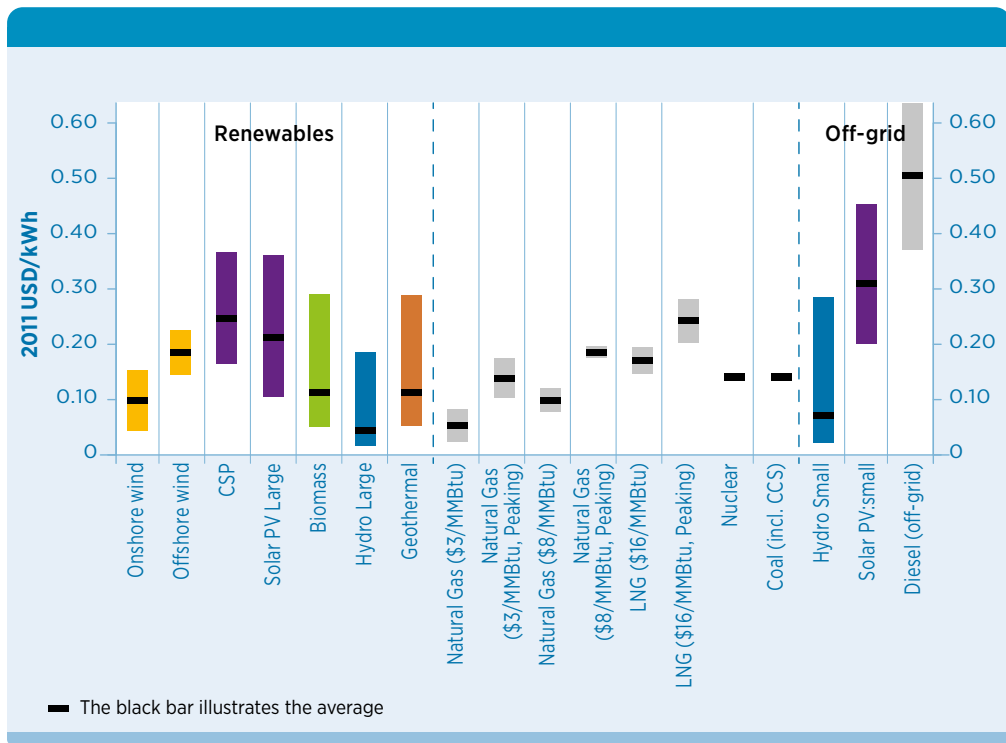
Renewable energy technologies have grown more robust and more efficient and are increasingly able to generate power even in suboptimal conditions such as low wind speeds and low solar irradiation. Energy storage technologies are improving fast. Buoyed by state support in Europe and the United States, and boosted by the rise of new manufacturing powerhouses such as China, costs have plummeted. These trends are illustrated in the graphic below which charts the levelised cost of electricity (LCOE) for different forms of utility and off-grid power.

Solar photovoltaic (PV) prices have fallen by 80% since 2008 and are expected to keep dropping. In 2013, commercial solar power reached grid parity in Italy, Germany and Spain and will do so soon in Mexico and France. Increasingly, solar PV can compete without subsidies: power from a new 70 megawatt (MW) solar farm under construction in Chile, for example, is anticipated to sell on the national spot market, competing directly with fossil fuel-based electricity. The cost of onshore wind electricity has fallen 18% since 2009, with turbine costs falling nearly 30% since 2008, making it the cheapest source of new electricity in a wide and growing range of markets. More than 100 countries now use wind power. Offshore wind is also expected to grow rapidly as costs fall, with the United Kingdom leading the market with 4.2 gigawatts (GW) of installed capacity as of mid 2014.

These and other developments have made renewables increasingly attractive in many more markets. In 2013, for the first time, new renewable capacity installations were higher in countries not members of the Organisation for Economic Co-operation and Development (OECD). China's deployment of solar PV and wind in 2013 was estimated at 27.4 GW: nearly four times more than the next largest, Japan.

Worldwide, renewable power capacity has grown 85% over the past 10 years, reaching 1,700 GW in 2013, and renewables today constitute 30% of all installed power capacity.

LCOE for utility and off-grid power – OECD countries (ranges and average)



Source: IRENA Costing Alliance (n.d.) for renewable energy technologies and PwC database for non-renewable energy technologies.

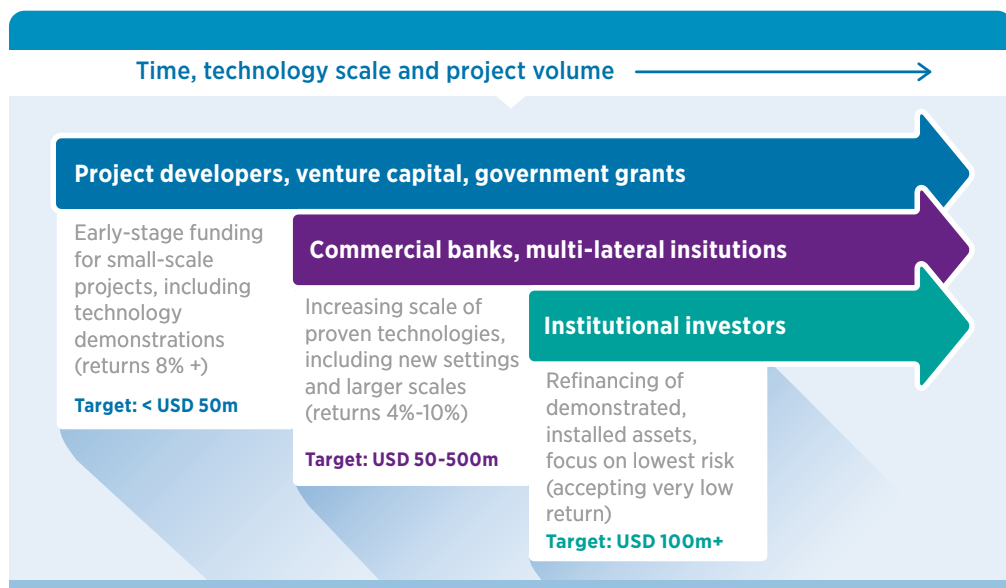
The challenge has moved on from whether renewable energy can power modern lifestyles at a reasonable cost – which we now know it can – to how best to finance and accelerate its deployment.

Financing renewables is getting cheaper, and easier

Renewable energy is competitive on a cost per kilowatt-hour basis. As most renewable technologies have a relatively high ratio of upfront to operating costs, their viability is particularly sensitive to the cost of capital. That is why government financial support has traditionally been critical for promoting renewables. However, as the technology has grown more competitive and pressure on budgets has increased, governments have been reducing their support.

The good news is that private finance is increasingly ready to step in. Due to growing experience, developers are getting better at forecasting cash flow and financiers are more able to accurately assess risk. The cost of capital is falling and products are being tailored for a wider range of investors, from small-scale communities to large institutions. Crowdfunding initiatives can also be used to attract capital, especially in developing countries where cost of capital is traditionally high. The figure below shows how sources of renewable energy investments evolve with increasing maturity of technologies and markets.

Investment progression through technology and market development stages



At the other end of the scale, institutional investors are also starting to get interested. They are increasingly taking into account the risk attached to fossil fuels and new long-term, low-risk instruments are being created to encourage them to invest in renewables.

Early-mover private developers in this space attracted USD 11 billion in 2013, up 200% in 12 months.

Large non-energy corporates are also becoming involved. For example, IKEA's turbines and solar panels now produce 37% of its energy consumption, and Google has invested over USD 1.4 billion in wind and solar – in most cases because of attractive financial returns.

But these positive trends are not yet enough. Total investment in renewable energy rose from USD 55 billion in 2004 to USD 214 billion in 2013 (excluding large hydropower). This falls short of the USD 550 billion needed annually until 2030 to double the global share of renewable energy and avert catastrophic climate change.

Policy makers have an important role to play. If they make it clear that renewable energy will be a larger part of their national energy mix, and commit to long-term, non-financial support mechanisms, they could reduce uncertainty and attract more investors. In emerging markets, public financing will remain important as domestic structures to support the deployment of renewables are developed. In this context, international cooperation and financial flows play an increasingly prominent role. With increasing competitiveness, financial support can gradually and predictably be scaled back, focusing instead on grid improvements, education and industry standards, which strengthen the market as a whole.

There is also an opportunity for traditional power utilities to do more. Joint projects between large utilities, small developers and clients could be a way forward, as business models adapt to the changing market conditions.

The wider benefits of renewable energy

There is growing evidence that renewable energy has a positive ripple effect throughout society, simultaneously advancing economic, social and environmental goals. Its costs and benefits are best understood not within traditional policy silos, but as part of a holistic strategy to promote economic prosperity, well-being and a healthy environment.

Renewables are good for a country's economy. A recent Japanese study, looking at a 2030 target of 14%-16% renewables, found the benefits were 2-3 times higher than the costs – including savings in fossil fuel imports, CO₂ emissions reductions and economic ripple effects. Spain's use of renewables avoided USD 2.8 billion of fossil fuel imports in 2010, while Germany saved USD 13.5 billion in 2012. For fossil fuel-exporting countries, deploying renewables at home makes more resources available for sale overseas.

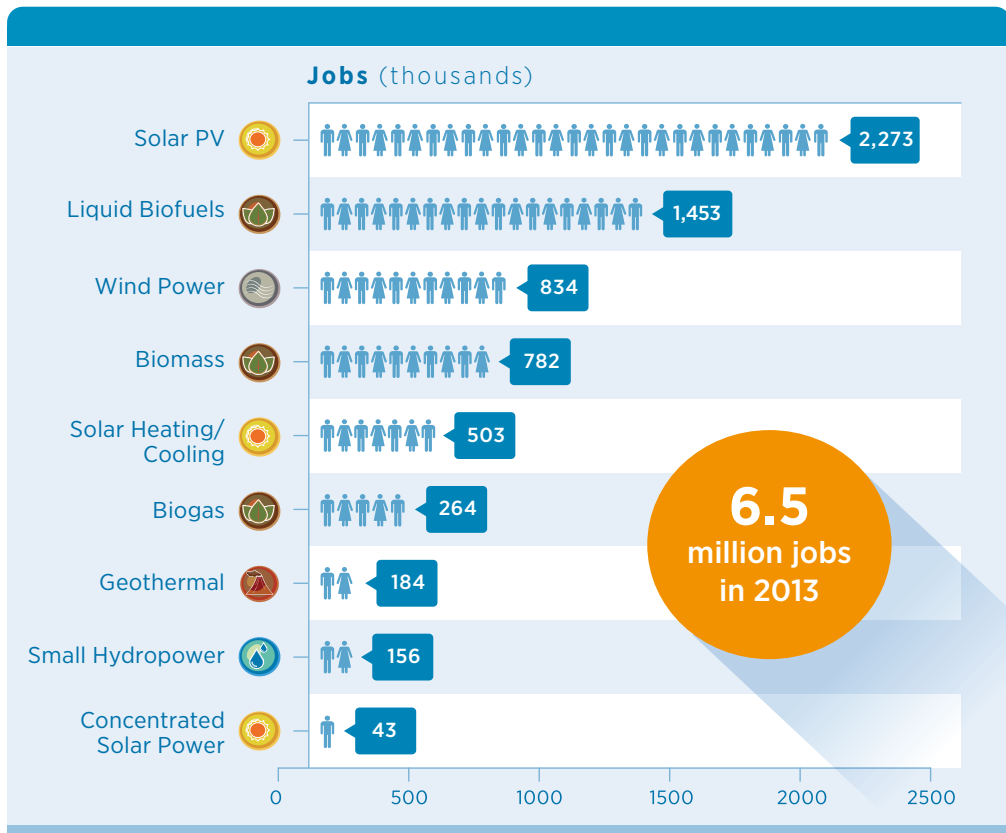
The benefits are felt through the value chain as renewable energy stimulates domestic economic activities and creates employment. In 2013, it supported 6.5 million direct and indirect jobs – including 2.6 million in China, as illustrated in the figure below.

Renewables can also bring electric power to people currently left off the grid, promoting productive uses, spurring education, allowing access to modern communications and offering a host of new opportunities.

The environmental benefits are just as compelling, on both local and global levels. Most renewables do not deplete finite resources (although water may be needed for cleaning and cooling, which can be a challenge in arid countries). Renewables also reduce the risk of ecological disasters.

Crucially, they offer a route to reducing greenhouse gas emissions, a major cause of global warming. Electricity alone accounts for more than 40% of man-made CO₂ emissions today. Solar, wind, nuclear, hydroelectric, geothermal and bioenergy are, across their lifetime, 10-120 times less carbon intensive than the cleanest fossil fuel (natural gas) and up to 250 times

Renewable energy employment by technology



Source: IRENA (2014e)

lower in carbon than coal. REmap 2030 estimates that doubling the share of renewables in the energy mix, coupled with greater energy efficiency, can keep atmospheric CO₂ below 450 ppm – the level beyond which catastrophic climate change would occur.

A new industrial paradigm?

As the share of renewable energy grows, the structure of the industry and the nature and role of power producers are undergoing change. A sector once dominated by large utilities is becoming more decentralised, diverse and distributed. In Germany, almost half of all renewable energy is now in the hands of households and farmers, and only 12% of renewable assets are owned directly by utilities.

New storage technologies, and smart technologies to support better demand-side management, will grow in importance – creating a whole new ancillary industry of smart appliances. In many emerging markets, renewables are already the most economic power source for off-grid and mini-grid systems. As with the shift from fixed telephony to mobile phones, many countries have an opportunity to leapfrog the development of a fixed network by moving to a flexible system of multiple, interconnected mini-grids.

These and other trends require a different way of thinking about energy, shifting from a system dominated by a few centralised utilities, to a diverse, distributed system, where consumers are also producers, with far more control over how and when they use energy.

Policy makers can do much to either promote or hinder this vision. Renewable energy investors need stable and predictable policy frameworks, which recognise the system-level benefits renewable energy can bring. They need a level playing field, including cutting back on the substantial subsidies currently enjoyed by fossil fuels worldwide. And they need a supportive grid infrastructure, including more regional interconnections to take advantage of synergies between different forms of renewable power.

Rethinking energy means policy makers need to consider the benefits of renewable energy as a whole, linking areas previously considered unrelated – such as healthcare, rural development and governance. Herein lies the biggest change: adopting a truly holistic approach, which not only takes into account the interests of short-term growth, but provides the opportunity of sustainable prosperity for all.

The changes at hand offer the potential for a new industrial revolution – creating a renewables-based system, which enhances access, health and security, creates jobs and safeguards the environment. The technology is ready to deploy. People, businesses and governments must now embrace its potential.

