IRENA
International Renewable Energy Agency

REmap 2030
A Renewable Energy Roadmap

EXECUTIVE SUMMARY

RENEWABLE ENERGY PROSPECTS:

UNITED STATES OF AMERICA

January 2015

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 country report for the United States, the REmap 2030 report, summary of findings and other supporting material are available at www.irena.org/remap

For further information or to provide feedback, please contact the REmap team at remap@irena.org

REmap reports are available for download from www.irena.org/publications

Disclaimer

HIGHLIGHTS

- REmap 2030, a global roadmap by the International Renewable Energy Agency (IRENA), looks at the realistic potential for higher renewable energy uptake in all parts of the US energy system, including power, industry, buildings, and the transport sectors. It also provides an overview of how higher shares of renewable energy can be achieved, what the technology mix would entail, and the benefits of renewable energy deployment. With such comprehensive scope, REmap fills an important knowledge gap for renewables in the US.
- The renewable energy share in the US energy mix was 7.5% in 2010 (the base year of REmap 2030 analysis). This included 2.5% renewable power, 1.6% liquid biofuels and the remaining, 3.4%, largely solid biomass used for heating in the manufacturing industry and buildings.
- Under a conservative "business as usual" case, known in this report as the Reference Case, this share will only increase to 10% by 2030. The REmap analysis shows that it is technically feasible and cost-effective to increase the renewable energy share in total final energy consumption to 27% by utilizing existing renewable energy technologies.
- Increasing the renewable energy share to 27% would save the US economy between USD 30 and USD 140 billion per year by 2030 when accounting for benefits resulting from reduced health effects and CO_2 emissions.
- Increasing the renewable energy share to 27% would require an additional investment of USD 38 billion per year in energy capacity over the business as usual, resulting in total investment flows into renewable energy capacity of USD 86 billion per year.
- If the renewable energy deployment envisioned in this study was achieved the US would reduce its CO_2 emissions 30% compared to the projected 2030 level, or equivalent to a 33% reduction over the 2005 level.
- The share of renewable power would increase from around 14% today to almost 50% in REmap 2030. With the share of variable renewable power reaching 30%, the grid system would need to be enhanced with technologies and investments to strengthen transmission and interconnection.
- Significant potential for renewable energy technologies exists in the end-use sectors of transport, industry and buildings: solar thermal heat, biofuels, and electrification technologies than can utilise renewable power such as electric vehicles and heat-pumps could all see significant growth.
- Market certainty needs to be created through policy support, which must be consistent, predictable and long-term.
- Policies are particularly needed to attract investments in grid transmission and biomass logistics.
- The US needs to adopt systems that better account for the external costs of using fossil fuels, including human healthcare costs, local environmental damages, and the effect of greenhouse gas emissions and climate change on the US macroeconomy.

Leading the global transition

The United States (US) has the potential to lead the global transition to renewable energy. It has some of the best wind, solar, geothermal, hydro, and biomass resources in the world. It also has a vibrant culture of innovation, plentiful financing opportunities, and a highly skilled workforce, alongside an agile and entrepreneurial business sector.

With the right policies and support, using technologies available today, the share of renewables in the US energy mix (total final energy consumption, TFEC) could more than triple by 2030, from 7.5% in 2010 to 27%. The share of renewable energy in the power sector alone could rise to almost 50%. Renewable energy (RE) technologies can also play a much bigger role in providing fuels for the manufacturing, buildings and transport sectors.

Attaining that potential would require an investment of USD 86 billion per year between today and 2030, an incremental investment volume of USD 38 billion per year more than would have been invested into the conventional variants that are replaced. Higher shares of renewables would result in overall cost-savings to the US economy of USD 30-140 billion per year by 2030, and in net job creation, better human health, as well as reduce US carbon dioxide (CO_2) emissions by nearly one third, compared to a business as usual scenario.

REmap 2030 Country Focus

This is one of the first country reports in the REmap 2030 series from the International Renewable Energy Agency (IRENA), which explores how to double the share of renewable energy worldwide by 2030. REmap requires raising the worldwide renewable energy share from 18% today to 36% in 2030.

The US must play a major role in this transition if it is to be successful. It has the potential to become a centre of renewable energy thought and innovation, and to become the world's second largest user of renewables after China, accounting for 13% of the global use in 2030.

Without a widespread and systematic policy shift, the US risks falling far short of this potential. Under a conservative business as usual scenario (the Reference Case in this study), according to the projections of the US EIA's Annual Energy Outlook, the renewable energy share in the US energy mix will rise from around 7.5% today to only slightly above 10% by 2030. Recent proposals to limit CO_2 emissions from the power sector could increase this share, but would still be far below the potential of 27% identified in this study.

A strategy for a diverse mix of renewables

Under REmap 2030, nearly three-quarters of total US renewable energy use (across all sectors, including power generation and end-use) would come from wind and various forms of bioenergy. However a rich mix of renewable technologies is possible.

Wind: Wind offers the greatest potential for growth in US renewable power generation. The best resources primarily lie in the centre of the country (the Midwest), stretching from Texas to North Dakota. REmap 2030 would

entail a fivefold increase in onshore wind capacity, from 63 gigawatt-electric (GW_e) in 2014 to 314 GW_e by 2030. It also envisages an additional 40 GW_e of capacity in offshore wind. To make this happen, the US needs to begin a large-scale investment in its transmission infrastructure.

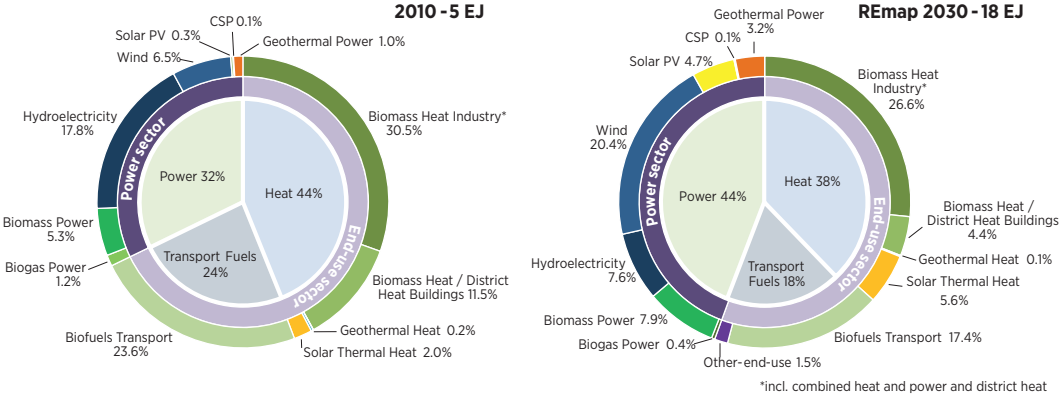
Solar photovoltaics (PV) and concentrated solar power (CSP): Recent years have seen rapid drops in the price of solar PV technologies, as well as the launch of several landmark CSP plants. Solar resources in the US vary between regions, but across the whole lower 48 and Hawaii are higher than in Germany, the current world leader in solar PV capacity.

REmap 2030 envisages that by 2030 total installed capacity of solar PV could reach 135 GW_e, compared to 7 GW_e in 2012. This raises the prospect of a revolution in distributed generation, with over one-third of solar PV capacity installed on rooftops. Many users would also become producers, requiring reform of the grid system.

Biomass and biogas: The US can lead in modern bioenergy technologies, using its vast arable land resources, world-class potential in residues from agriculture sector, forest and mills, as well as unutilised waste and methane from landfills.

There is significant potential for biomass to be used in heating, particularly in the manufacturing industry, where its use could triple between 2010 and 2030. Biomass offers the potential for an additional 46 GW_e of power generation capacity, taking the total to 84 GW_e by 2030. About 40% of this growth would be from industrial co-generation, which also provides benefits for renewable heat generation.

Geothermal: The US has some of the world's best geothermal resources, primarily in the west, but is currently using only 10% of its



Total renewable energy use will increase by over three-fold between 2010 and REmap 2030

Note: Exajoules (EJ) in figures refer to renewable energy use in total final energy consumption.

potential. REmap envisages an additional 18 GW_e in power generation from geothermal, adding to 6 GW_e under current plans.

Hydro: Hydropower is currently the largest source of renewable power generation in the US, but there is limited potential for new large scale developments. Additional potential can come from retrofitting and upgrading turbines at existing dams, the addition of power generation facilities at non-powered dams, and some new run-of-river hydro projects.

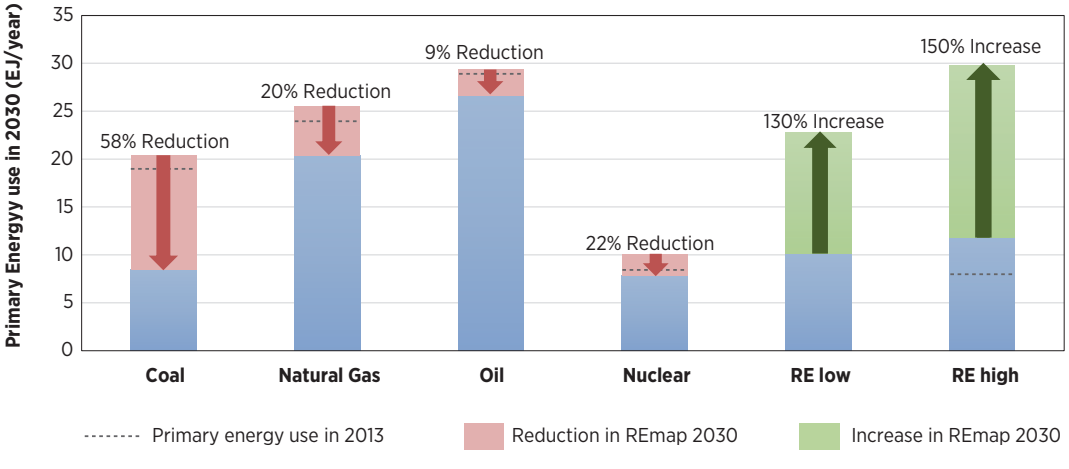
Power sector: the rise of wind and solar

In REmap 2030, the share of renewable power in the US will approach 50%, led by wind, but including a diverse mix of technologies. Wind power will surpass hydropower by a factor of three to become the largest renewable power source in the US. Solar PV will see an almost 60 times growth in generation over 2010 levels.

These increases would add less than one USD cent per kWh to wholesale power generation costs. However investments must be made in grid and transmission infrastructure to account for an increasing share (up to 30%) of variable renewable power.

The importance of the buildings, transport and industry sectors in the transition

In REmap 2030, 55% of all renewable energy in the US would be in the form of non-electricity energy use, i.e. bioenergy in solid, liquid or gaseous forms, or solar thermal or geothermal heat. These forms of energy are needed for heating, cooling and transport applications in the build-



Renewable energy could become the largest energy source

ings, transport and industry sectors. Total use would constitute a three to four-fold increase over 2010 levels.

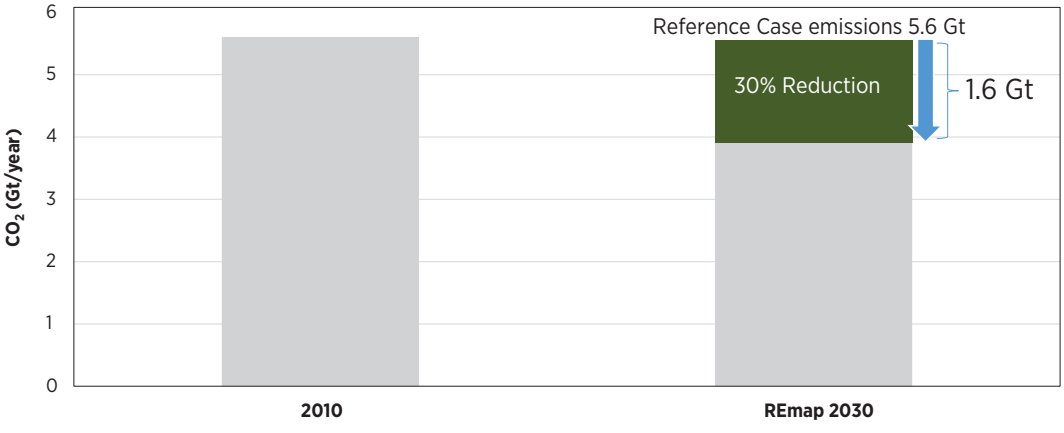
Heating and cooling in buildings and industry: Renewables for heating in buildings and the manufacturing industry is currently dominated by bioenergy, with around one-quarter consumed in the residential and the rest in industrial applications.

In addition to solar technologies for power generation, solar thermal technologies that harness the sun's energy for space, water and low-temperature process heat have large yet overlooked potential. In REmap 2030, solar thermal capacity could increase ten-fold over today's levels.

Geothermal energy can also be harnessed through the use of heat pumps. Including aerothermal heat pumps, REmap shows the potential for an additional 7 million heat-pump systems mainly in residential and commercial buildings by 2030.

Transport: In 2012, the US produced 13 billion gallons of biofuels which originated mainly from corn. Under REmap 2030, total biofuel production could nearly triple to 39 billion gallons – 60% of the increase would come from advanced bioethanol. Production capacity for advanced biofuels is new, and will require greater support for research and development in production processes.

However in the transport sector a shift away from fuels is underway as the economics of electric vehicles improve. Efforts in states such as California to promote zero-emission vehicles could result in a rapidly expanded market. REmap 2030 envisages a total of



The US could reduce its CO_2 emissions by 30% in 2030 through the accelerated renewable energy uptake identified in REmap

27 million electric vehicles in the US car stock, compared to only 5 million under current projections. Such a shift reduces fuel use by a factor of three at least, due to the significantly higher efficiency of electric drivetrains, and increases renewable electricity production as additional power demand is assumed to be met by renewable energy sources.

The costs and benefits of REmap 2030

Increasing the renewable energy share to 27% under REmap 2030 would require a slight incremental cost for the US energy system, but would also save money when taking into account the external costs of fossil fuels.

IRENA quantifies this cost separately from the perspective of businesses and governments. The business perspective is based on national energy prices which include end-user tax and subsidies. From this perspective, REmap Options could be deployed at an average savings of USD 3.2 per megawatt-hour (MWh) (USD 0.9 per gigajoule, GJ) compared to fossil fuels with the type of fuel being coal in the power sector, gasoline in the transport sector, and mostly natural gas for heating. From the perspective of governments, which excludes energy tax and subsidies and is therefore a better metric of understanding energy system costs, the cost would rise to USD 7.2 per MWh (USD 2.0 per GJ) – or the equivalent of paying 0.7 cents more per kWh on a typical consumer's electricity bill. This translates to a bottom line additional cost of USD 20 billion per year for the energy system as whole. When wider benefits are taken into account, such as improved human health and CO_2 emission reductions, REmap 2030 would result in net savings of USD 30-140 billion per year.

The investment need to achieve the level of renewable energy deployment in REmap 2030 would require a total investment flow of USD 86 billion per year between now and 2030 in renewable energy technologies – an increase of USD 38 billion in energy capacity investments over current projections.

Reducing CO_2 emissions

The US is currently the world's second largest emitter of CO_2, producing around 5.6 gigatonnes (Gt) of CO_2 per year, equivalent to 16% of global emissions. Given limited growth in total final energy consumption to 2030, emissions will remain flat according to the Reference Case.

REmap 2030 shows that it is possible to reduce CO_2 emissions of the US by 1.6 Gt per year in 2030, or around 30% compared to the projected 2030 level. This would be a reduction of 33% compared to 2005 levels, and consistant with the reduction goal of 26-28% by 2025 that was recently announced by the Obama Administration in the landmark climate agreement with China. Accelerated renewable energy uptake in power generation would be the main driver, accounting for over 70% of the total reduction with the remaining 30% coming from the end-use sectors.

If all REmap Options were achieved worldwide, coupled with higher energy efficiency, atmospheric CO_2 concentration would stay below 450 parts per million (ppm) of CO_2, helping to prevent average global temperatures from rising more than two degrees Celsius above pre-industrial levels.

Barriers to accelerated renewable energy growth

If renewable energy is to grow rapidly as envisioned in this report, a number of challenges need to be overcome.

Transmission: The cost of investing in transmission tends to be higher for renewable power because of distances between resource-rich areas and centres of population, the relatively smaller size of generation facilities, and the intermittent nature of some renewable sources. Building a grid for transmission and distribution that is suitable for high shares of renewable energy will take time, meaning it needs to begin now. Numerous institutional barriers stand in the way, including a lack of enforceable energy system planning, and lengthy permitting processes.

The biomass challenge: REmap 2030 envisages an increase in demand for biomass in all sectors, with demand coming close to the total available biomass supply of the US. Meeting this supply can be done sustainably; however, investments are needed to improve recovery operations and supply-chain logistics. REmap also explores an alternative case – called REmap-E – that assumes significantly lower biomass growth, and instead relies on the greater use of electricity in end-use sectors. This would include more EVs, instead of cars running on biofuels, and heat pumps.

Inertia: Transition to higher shares of renewable energy will depend on the capital stock turnover rate which varies substantially from sector to sector, from about a decade for passenger cars to more than a few decades in the manufacturing industry. Conventional energy plants in the US are reaching the end of their lifes which creates the opportunity to invest in new renewable energy capacity, but capital stock turnover relies on the relative generation costs, reliability constraints and the age profile which may result in lifetime to be extended beyond the technical limit. Stranded costs should be avoided in the transition process.

Policy needs

The making and implementing of energy policy in the US takes place at several levels: federal, state and local. This means that realising dramatic change by overcoming regulatory and economic inertia will require a concerted focus on what can be done nationwide at all government levels. The full report goes into detail about the US policy landscape and includes specific policy recommendations. In this summary these recommendations are categorised into five core areas where action can be taking to realise higher renewable energy shares.

Planning transition pathways – setting plans and developing long-term strategies to support renewable energy growth based on credible and attainable targets.

Creating an enabling business environment – in uncertain policy environments, risks related to investments increase, and hence technology costs. Policy frameworks should create appropriate conditions for investment and increase investors confidence. Additionally fossil fuel externalities should be accounted for in these policy frameworks.

Integrating renewable energy into the system – enhance the effectiveness of the elec-

tricity grid system with enabling technologies including responsive load, energy storage, hydrogen fuel cell, waste heat and smart grid technologies. Expanding transmission capacity is essential to deliver the renewable resources from remote areas to densely populated demand centers, to ensure the integration of variable energy sources and increase the transfer capacity of interconnections.

Creating and managing knowledge – the US has extensive renewable energy knowledge. However programmes to increase awareness for renewable energy and its benefits among user, installer and manufacturers should be expanded.

Unleashing innovation – A global leader in innovation, the US should continue to support innovation in new and existing technologies as well as in finance schemes to develop and deploy cost-effective and efficient renewable energy technologies. This will also ensure that high levels of renewable energy deployment will also continue after 2030 through the development and commercialization of new and breakthrough technologies.

IRENA Headquarters
P.O. Box 236, Abu Dhabi
United Arab Emirates

IRENA Innovation and Technology Centre
Robert-Schuman-Platz 3
53175 Bonn
Germany

www.irena.org

International Renewable Energy Agency

www.irena.org