# Renewable Energy Sources Can Satisfy Energy Demands

*Renewable Energy*, 2012

> "A fully sustainable renewable power supply is the only way we can secure energy for all and avoid environmental catastrophe."

The following viewpoint is an extract from a report undertaken by the World Wildlife Fund (WWF), Ecofys (a consulting firm for sustainable energy projects), and the Office for Metropolitan Architecture. The viewpoint summarizes the findings of an Ecofys study that predicted the world can switch from fossil fuels to a fully renewable energy future by 2050. According to the study, most energy will be electricity-based, and that energy will be supplied chiefly by solar power. Wind power, geothermal heat, and water power will also serve to create electricity and heat homes. Finally the Ecofys scenario argues that biofuels will be needed to power some transport systems and industrial processes that require liquid fuels. According to the WWF and Ecofys, the renewables-driven future will save money, stall climate change, and create a sustainable energy system.

As you read, consider the following questions:

1. According to the WWF, by what percent does the International Energy Agency predict oil and gas reserves will fall by 2030?
2. What percent of the world's energy needs does Ecofys claim can be satisfied by renewables in 2050?
3. Why does Ecofys's scenario only provide for a small increase in hydropower by 2050?

The way we produce and use energy today is not sustainable. Our main fossil fuel sources—oil, coal and gas—are finite natural resources, and we are depleting them at a rapid rate. Furthermore they are the main contributors to climate change, and the race to the last 'cheap' fossil resources evokes disasters for the natural environment as seen recently in the case of the [2010] BP oil spill in the Gulf of Mexico. In the developing world, regional and local desertification is caused by depletion of fuelwood and other biomass sources that are often used very inefficiently, causing substantive indoor pollution and millions of deaths annually. A fully sustainable renewable power supply is the only way we can secure energy for all and avoid environmental catastrophe.

## Risks and Harms of Fossil Fuels

While most of us take energy for granted as a basic right, a fifth of the world's population still has no access to reliable electricity—drastically reducing their chances of getting an education and earning a living. As energy prices increase, the world's poor will continue to be excluded.

At the same time, more than 2.7 billion people are dependent on traditional bioenergy (mainly from wood, crop residues and animal dung) as their main source of cooking and heating fuel. This is often harvested unsustainably, causing soil erosion and increasing the risk of flooding, as well as threatening biodiversity

and adding to greenhouse gas emissions. Traditional stoves are also a significant health problem: the World Health Organization (WHO) estimates that 2.5 million women and young children die prematurely each year from inhaling their fumes. With many developing societies becoming increasingly urban, air quality in cities will decline further.

Finite and increasingly expensive fossil fuels are not the answer for developing countries. But renewable energy sources offer the potential to transform the quality of life and improve the economic prospects of billions.

## Vanishing Oil and Gas

Supplies of cheap, conventional oil and gas are declining while our energy demands continue to increase. It is clear that our reliance on fossil fuels cannot continue indefinitely. With the world's population projected to increase to over nine billion over the next 40 years, "business-as-usual" is not an option.

According to the International Energy Agency (IEA), production from known oil and gas reserves will fall by around 40-60 per cent by 2030. Yet the developed world's thirst for energy is unabated, while demand is rocketing in emerging economies, such as China, India and Brazil. If everyone in the world used oil at the same rate as the average Saudi, Singaporean or U.S. resident, the world's proven oil reserves would be used up in less than 10 years. Competition for fossil fuel resources is a source of international tension, and potentially conflict.

Energy companies are increasingly looking to fill the gap with unconventional sources of oil and gas, such as shale gas, oil from deep water platforms like BP's Deepwater Horizon, or the Canadian tar sands. But these come at an unprecedented cost—and not just in economic terms. Many reserves are located in some of the world's most pristine places—such as tropical rainforests and the Arctic—that are vital for biodiversity and the ecosystem services that we all depend on, from freshwater to a healthy atmosphere. Extracting them is difficult and dangerous, and costly to businesses, communities and economies when things go wrong.

Processing and using unconventional fossil sources produces large quantities of greenhouse gasses and chemical pollution, and puts unsustainable demands on our freshwater resources, with severe impacts on biodiversity and ecosystem services....

## Switching to Renewables

The global energy crisis is a daunting challenge. Yet we do not have to look far for the solutions. Energy derived from the sun, the wind, the Earth's heat, water and the sea has the potential to meet the world's electricity needs many times over, even allowing for fluctuations in supply and demand. We can greatly reduce the amount of energy we use through simple measures like insulating buildings, recycling materials and installing efficient biomass stoves. Biomass from waste, crops and forest resources has potential to provide a renewable source of energy—although this raises significant social and environmental issues....

Around the world, people are taking steps in the right direction. In 2009, China added 37 GW [gigawatts] of renewable energy, bringing its total renewable capacity to 226 GW—equivalent to four times the capacity required to satisfy the total peak electrical power consumption of Great Britain or over twice the total electric capacity of Africa! In Europe and the U.S., more than half of all new power capacity installed in 2009 came from renewable sources. In the developing world, more than 30 million households have their own biogas generators for cooking and lighting. Over 160 million use "improved" biomass stoves, which are more efficient and produce less greenhouse gas and other pollutants. Solar water heating is used by 70 million households around the world. Wind power capacity has grown by 70 per cent, and solar power (PV) by a massive 190 per cent in the last two years (2008 and 2009). During the same period, total investment into all renewables has increased from about $US 100 billion in 2007 to more than $US 150 billion in 2009.

But the pace of change is far too slow. Non-hydro renewables still only comprise a mere 3 per cent of all electricity consumed. Huge quantities of fossil fuels continue to be extracted and used, and global carbon emissions are still rising. Government subsidies and private investments in fossil fuels and nuclear power ventures still vastly outweigh those into renewable energy and energy efficiency, even though the latter would give a far greater long-term return. While thousands of houses throughout the world, especially in Germany and Scandinavia, have been built to "passive house" standards that require almost no energy for heating and cooling, many more construction projects follow old-fashioned, energy-inefficient designs.

## An Ambitious Undertaking

Moving to a fully renewable energy future by 2050 is a radical departure from humanity's current course. It is an ambitious goal. But WWF [World Wildlife Fund] believes that it is a goal we can and must achieve. This conviction led us to establish a collaborative partnership with Ecofys, one of the world's leading climate and energy consultancies. We commissioned Ecofys to assess whether it would be possible to secure a fully renewable, sustainable energy supply for everyone on the planet by 2050.

The Ecofys scenario ... is the most ambitious analysis of its kind to date. It demonstrates that it is technically feasible to supply everyone on the planet in 2050 with the energy they need, with 95 per cent of this energy coming from renewable sources. This would reduce greenhouse gas emissions from the energy sector by about 80 per cent while taking account of residual land-based emissions from bioenergy production.

The task ahead is, of course, a huge one, raising major challenges. However, the scenario Ecofys has mapped out is practically possible. It is based only on the technologies the world already has at its disposal, and is realistic about the rate at which these can be brought up to scale. Although significant investment will be required, the economic outlay is reasonable, with net costs never rising above 2 per cent of global GDP [gross domestic product]. The Ecofys scenario accounts for projected increases in population, long-distance travel and increased economic wealth—it does not demand radical changes to the way we live.

The scenario ... is not the only solution, nor is it intended to be a prescriptive plan. Indeed, it raises a number of major challenges and difficult questions—particularly for a conservation organization like WWF.... To realize our vision of a 100 per cent renewable and sustainable energy supply, we need to further advance the Ecofys scenario; and we propose some of the social and technological changes that could help us do this.

In presenting the Ecofys scenario, WWF aims to show that a fully renewable energy future is not an unattainable utopia. It is technically and economically possible, and there are concrete steps we can take—starting right now—to achieve it.

## The Ecofys Scenario

In 2050, energy demand is 15 per cent lower than in 2005. Although population, industrial output, passenger travel and freight transport continue to rise as predicted, ambitious energy-saving measures allow us to do more with less. Industry uses more recycled and energy-efficient materials, buildings are constructed or upgraded to need minimal energy for heating and cooling, and there is a shift to more efficient forms of transport.

As far as possible, we use electrical energy rather than solid and liquid fuels. Wind, solar, biomass and hydropower are the main sources of electricity, with solar and geothermal sources, as well as heat pumps providing a large share of heat for buildings and industry. Because supplies of wind and solar power vary, "smart" electricity grids have been developed to store and deliver energy more efficiently.

Bioenergy (liquid biofuels and solid biomass) is used as a last resort where other renewable energy sources are not viable—primarily in providing fuels for aeroplanes, ships and trucks, and in industrial processes that require very high temperatures. We can meet part of this demand from waste products, but it would still be necessary to grow sustainable biofuel crops and take more wood from well-managed forests to meet demand. Careful land-use planning and better international cooperation and governance are essential to ensure we do this without threatening food and water supplies or biodiversity, or increasing atmospheric carbon.

By 2050, we save nearly € [euro] 4 trillion per year through energy efficiency and reduced fuel costs compared to a "business-as-usual" scenario. But big increases in capital expenditure are needed first—to install renewable energy-generating capacity on a massive scale, modernize electricity grids, transform goods and public transport and improve the energy efficiency of our existing buildings. Our investments begin to pay off around 2040, when the savings start to outweigh the costs. If oil prices rise faster than predicted, and if we factor in the costs of climate change and the impact of fossil fuels on public health, the pay-off occurs much earlier.

At the moment, more than 80 per cent of our global energy comes from fossil fuels (oil, gas and coal). The remainder comes from nuclear and renewable energy sources, mainly hydropower, and traditional biomass fuels such as charcoal, which are often used inefficiently and unsustainably. Under the Ecofys scenario, fossil fuels, nuclear power and traditional biomass are almost entirely phased-out by 2050, to be replaced with a more varied mixture of renewable energy sources.

The Ecofys scenario takes into account each resource's overall potential, current growth rates, selected sustainability criteria, and other constraints and opportunities such as variability of wind and solar sources. Technological breakthroughs, market forces and geographic location will all influence the ways in which renewable energies are developed and deployed, so the final energy breakdown could well look very different—while still based on 100 per cent sustainable renewables.

# Solar Will Supply Half of Electrical Energy

The sun provides an effectively unlimited supply of energy that we can use to generate electricity and heat. At the moment, solar energy technology contributes only 0.02 per cent of our total energy supply, but this proportion is growing fast. In the Ecofys scenario, solar energy supplies around half of our total electricity, half of our building heating and 15 per cent of our industrial heat and fuel by 2050, requiring an average annual growth rate much lower than the one currently sustained year on year.

Solar energy provides light, heat and electricity. Photovoltaic (PV) cells, which convert sunlight directly into electricity, can be integrated into devices (solar-powered calculators have been around since the 1970s) or buildings, or installed on exposed areas such as roofs. Concentrating solar power (CSP) uses mirrors or lenses to focus the sun's rays onto a small area where the heat can be collected—for example to heat water, which can be used to generate electricity via a steam turbine or for direct heat. The same principle can be used on a small scale to cook food or boil water. Solar thermal collectors absorb heat from the sun and provide hot water. Combined with improved insulation and window architecture, direct sunshine can also be used to heat buildings.

For developing countries, many of which are in region that receive the most sunlight, solar power is an especially important resource. Solar energy can generate power in rural areas, on islands, and other remote places "off-grid".

One obvious drawback of solar power is that the supply varies. Photovoltaic cells don't function after dark—although most electricity is consumed in daylight hours when sunshine also peaks—and are less effective on cloudy days. But energy storage is improving: CSP systems that can store energy in the form of heat—which can then be used to generate electricity—for up to 15 hours, are now at the design stage. This issue of variability can also be addressed by combining solar electricity with other renewable electricity sources.

# Wind Power

Wind power currently supplies around 2 per cent of global electricity demand, with capacity more than doubling in the last four years. In Denmark, wind already accounts for one-fifth of the country's electricity production. Wind could meet a quarter of the world's electricity needs by 2050 if current growth rates continue—requiring an additional 1,000,000 onshore and 100,000 offshore turbines. Electricity from offshore wind is less variable, and turbines can be bigger.

Although wind farms have a very visible effect on the landscape, their environmental impact is minimal if they are planned sensitively. When turbines are sited on farmland, almost all of the land can still be used for agriculture, such as grazing or crops. Unlike fossil fuel and nuclear power plants, wind farms don't need any water for cooling. Both on- and offshore wind developments need to be sensitively planned to minimise the impact on marine life and birds, and more research is needed in this area. Floating turbines, which would have less impact on the seabed and could be sited in deeper water, are being trialled.

# Geothermal to Heat Buildings

The ancient Romans used the heat from beneath the Earth's crust to heat buildings and water, but only relatively recently have we begun to rediscover its potential. Under the Ecofys scenario, more than a third of building heat comes from geothermal sources by 2050. This is not restricted to volcanically active areas: direct geothermal heat can provide central heating for buildings in almost all parts of the world.

When temperatures are high enough, geothermal energy can be used to generate electricity and local heating, including high-temperature heat for industrial processes. Unlike wind or solar power, which vary with the weather, geothermal energy provides a constant supply of electricity. Iceland already gets a quarter of its electricity and almost all of its heating from its molten "basement". In the Philippines, geothermal plants generate almost a fifth of total electricity.

Geothermal electric capacity is growing at around 5 per cent each year; the Ecofys analysis suggests we could reasonably hope to at least double this growth rate to provide about 4 per cent of our total electricity in 2050. Geothermal would also provide 5 per cent of our industrial heat needs. Exploiting geothermal resources will undoubtedly affect the surrounding environment and the people who live there. Geothermal steam or hot water used for generating electricity contains toxic compounds, but "closed loop" systems can prevent these from escaping. If sites are well chosen and systems are in place to control emissions, they have little negative environmental impact. In fact, because geothermal plants need healthy water catchment areas, they may actually strengthen efforts to conserve surrounding ecosystems.

## Tidal Power and Hydropower

The motion of the ocean, through both waves and tides, provides a potentially vast and reliable source of energy—but there are significant challenges in converting it into electricity. Several pilot projects are underway to harness wave energy and to design sustainable tidal systems, but this is a relatively new technology. Recognising this constraint, the Ecofys scenario assumes that ocean power accounts for only 1 per cent of global electricity supply by 2050. However, it is likely to provide a significantly larger percentage in some particularly suitable areas, like America's Pacific Northwest and the British Isles.

Wave and tidal power installations could affect the local marine environment, coastal communities, as well as maritime industries such as shipping and fishing. It is critical that appropriate sites are selected and technologies developed that minimize any negative impacts.

Hydropower is currently the world's largest renewable power source, providing nearly one-fifth of all electricity worldwide. Large-scale hydropower plants store water in a reservoir behind a dam, and then regulate the flow according to electricity demand. Hydropower can provide a relatively reliable source of power on demand, helping to balance variable sources like wind and solar PV.

However, hydropower can have severe environmental and social impacts. By changing water flow downstream, dams threaten freshwater ecosystems and the livelihoods of millions of people who depend on fisheries, wetlands, and regular deposits of sediment for agriculture. They fragment habitats and cut off fish access to traditional spawning grounds. Creating reservoirs means flooding large areas of land: 40-80 million people worldwide have been displaced as a result of hydroelectric schemes.

The Ecofys scenario reflects these concerns with a relatively small increase in hydropower. Hydropower would provide 12 per cent of our electricity in 2050 compared with 15 per cent today. New hydropower schemes would need to meet stringent environmental sustainability and human rights criteria, and minimize any negative impacts on river flows and freshwater habitats.

## Biofuels for Transportation and Industry

Energy from biomass—materials derived from living or recently living organisms, such as plant materials or animal waste—is potentially the most challenging part of the Ecofys scenario. Bioenergy comes from a large variety of sources and is used in many different ways. Wood and charcoal have traditionally provided the main source of fuel for cooking and heating for hundreds of millions of people in the developing world. More recently, biofuels have begun to replace some petrol and diesel in vehicles.

In principle, biomass is a renewable resource—it is possible to grow new plants to replace the ones we use. Greenhouse gas emissions are lower than from fossil fuels, provided there is enough regrowth to absorb the carbon dioxide released, and good management practices are applied. Bioenergy also has potential to provide sustainable livelihoods for millions of people, particularly in Africa, Asia and Latin America. However, if produced unsustainably its environmental and social impacts can be devastating. We need comprehensive policies and mandatory certification to ensure bioenergy is produced to the highest standards.

Although the Ecofys scenario favours other renewable resources wherever possible, there are some applications where bioenergy is the only suitable replacement for fossil fuels. Aviation, shipping and long-haul trucking require liquid fuels with a high energy density; they cannot, with current technology and fuelling infrastructure, be electrified or powered by hydrogen. Some industrial processes, such as steel manufacturing, require fuels not only for their energy content, but as feedstocks with specific material properties. By 2050, 60 per cent of industrial fuels and heat will come from biomass. 13 percent of building heat will come from biomass and some biomass will still be needed in the electricity mix (about 13 per cent), for balancing purposes with other renewable energy technologies.

We can derive a significant proportion of the bioenergy needs in the Ecofys scenario from products that would otherwise go to waste. These include some plant residues from agriculture and food processing; sawdust and residues from forestry and wood processing; manure; and municipal waste. Using these resources up to a sustainable level has other environmental benefits, such as cutting methane and nitrogen emissions and water pollution from animal slurry, and reducing the need for landfill. In developing countries, more than 30 million households have their own biogas digesters for cooking and lighting. Some residues and waste products are already used, for example as soil conditioners; the Ecofys scenario accounts for these.

The second major source of biomass comes from forests. According to the Ecofys scenario, we will need more than 4.5 billion cubic metres of wood products for energy purposes by 2050 coming from harvesting and processing residues, wood waste and "complementary fellings"—the difference between the amount of wood we use and the maximum amount that we could sustainably harvest in forests that are already used commercially. This is preferable to taking wood from virgin forests and disturbing important habitats, although more intensive forestry is bound to affect biodiversity. In addition, some of the biomass traditionally

used for heating and cooking in the developing world, which will largely be replaced by renewable energy sources such as solar energy, can also be used for more efficient bioenergy uses. All the same, meeting demand sustainably will be a huge challenge.

Bioenergy crops provide a possible source of liquid fuel—either vegetable oils from plants such as rapeseed, or in the form of ethanol derived from crops high in sugar, starch or cellulose. The Ecofys scenario suggests we will need around 250 million hectares of bioenergy crops—equal to about one-sixth of total global cropland—to meet projected demand. This has the potential to cause deforestation, food and water shortages, and other social and environmental impacts, so must be considered with utmost care.

With an expected 2 billion more mouths to feed by 2050, it is vital that increased biofuel cultivation does not use land and water that is needed to grow food for people or to sustain biodiversity. This is no easy challenge. While Ecofys has applied a series of safeguards in its analysis, land and water implications of bioenergy feedstock production will need further research, especially at the landscape level.

A possible long-term alternative source of high-density fuel included in this scenario is algae. Algae can be grown in vats of saltwater or wastewater on land not suitable for agriculture. Large-scale cultivation of algae for biofuel is currently in development. In the Ecofys scenario, algae begins to appear as a viable energy source around 2030, and only a fraction of its potential is included by 2050.

The apparent need for large amount of land for bioenergy is the aspect of the Ecofys scenario that produces the hardest challenges and raises the hardest questions.

## Further Readings

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**Source Citation**

World Wildlife Fund, Ecofys, and Office for Metropolitan Architecture. "Renewable Energy Sources Can Satisfy Energy Demands." *The Energy Report: 100% Renewable Energy by 2050*. 2011. Rpt. in *Renewable Energy*. Ed. David M. Haugen and Susan Musser. Detroit: Greenhaven Press, 2012. Opposing Viewpoints. *Opposing Viewpoints in Context*. Web. 6 May 2014.

Document URL

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**Gale Document Number:** GALE|EJ3010573246

VOL - Danville Village School ""