Climate solutions – nuclear vs sustainable pathways

- Energy efficiency represents an economic bonanza, which will enable a significant share of energy demand to be provided by renewable sources and allowing nuclear power to be phased out.
- The biggest single obstacle to improving energy efficiency is that in most countries, utilities are rewarded for selling more energy. We need to reward them for cutting their customers' bills.
- Electricity production in the 25 (pre-2007) European Union countries is responsible for 1.2 billion tons of carbon dioxide (CO_2) and over 2600 tons of dangerous radioactive waste every year.
- It is perfectly feasible to phase out nuclear power at the same time as reducing CO_2 emissions. An Energy Scenario produced for Greenpeace shows that Europe could produce 70% of electricity and 50% of heat from renewable sources by 2050.
- Europe and Japan are about twice as efficient as the US. But even then they have barely begun to tap energy efficiency's profitable potential. And developing countries are about three times less efficient than the US.
- Combined Heat and Power plants can make much more efficient use of fossil fuels by producing heat for district heating as well as electricity. They can also be converted to run on renewable sources.
- 12% of the world's electricity needs could be provided by wind power alone by 2020. Onshore wind electricity would cost around 2.3-3.8 Euro-cents per kWh and offshore around 3 - 4.5 Euro-cents per kWh compared with 4.5 - 6 Euro-cents per kWh for electricity from new nuclear reactors.
- Offshore wind could provide up to a third of Europe's electricity by 2020.
- Concentrating Solar Power (CSP) technologies could provide 5% of global electricity supplies by 2040, offering a comparable opportunity to the sunniest countries of the world as offshore wind offers to Europe at a cost around 5 Euro-cents per kWh.
- Solar photovoltaics could be providing 1% of global electricity by 2020, rising to 21% by 2040. PV electricity is economically viable in a large variety of applications where no mains electricity is available.
- Even France, which depends on nuclear power for 80% of its electricity, could phase out nuclear power AND reduce carbon emissions by up to 40% by 2050 by implementing a sustainable energy strategy.

Introduction

Using energy more efficiently offers an economic bonanza—not because of the benefits of stopping climate change but because saving fossil fuel is a lot cheaper than buying it. It is possible to make dramatic reductions in primary energy consumption, which then enable a significant share of overall energy demand to be met from renewable energy sources, allowing nuclear energy to be phased out, and fossil fuel consumption to fall dramatically.

Energy efficiency is about wringing more work from each unit of energy delivered to businesses and consumers. It is not about doing without or using less energy by doing less. The International Energy Agency says:-

"*An improvement in energy efficiency is regarded as any action undertaken by a producer or a consumer of energy products that reduces energy use per unit of output, without affecting the level of service provided*." (1)

The United States, for example, now uses 47% less energy per dollar of economic output than it did 30 years ago, but there are plenty more savings to be captured. Converting coal into incandescent light uses the energy in the coal at an efficiency of about 3%. (2) But we no longer need to use incandescent light bulbs, and we can capture and recycle waste heat from power stations. Recycling the waste heat discarded at U.S. power stations would save more energy than Japan uses for everything. On top of this we could design our appliances to make better use of electricity. As much as 5% of domestic electricity consumption in the U.S. is simply wasted by computers, televisions and other appliances on standby.

The European and Japanese economies are already up to twice as efficient as the U.S., but there are still large improvements available. Within the 25 (pre-2007) European Union nations primary energy demand could be reduced by at least 30% by 2050. (3) The biggest single obstacle to improving efficiency is that most countries, and all U.S. states except California and Oregon, reward utilities for selling more energy and penalize them for cutting their customers' bills. This could be fixed by decoupling profits from energy sales, and allowing utilities to profit from reducing consumers' bills.

Maximising the amount of useful work delivered by each unit of primary energy we consume would then make it much easier to produce our primary energy from sustainable sources, rather than in the environmentally damaging ways currently used. In the 25 (pre-2007) European Union countries, for example, electricity production is responsible for releasing more than 1.2 billion tons of carbon dioxide (CO_2) and over 2600 tons of dangerous radioactive waste every year. Energy scenarios produced for Greenpeace show that it is perfectly feasible for Europe to phase out nuclear power and dramatically reduce fossil fuel consumption. (4)

A sustainable energy pathway could be much more cost effective than following our current trajectory. Delivering a kilowatt-hour from a new nuclear plant costs at least three times as much as saving one through efficiency measures, and efficiency improvements can be implemented much more quickly too, because it takes so long to build reactors. (5) Wind power and some other renewables, as well as cogeneration, (also known as combined heat and power [CHP]) are already more cost effective than new nuclear reactor technologies. Efforts to make nuclear power appear more cost effective through subsidies or by taxing carbon dioxide emissions are likely to fail because the margin is too great. Keeping nuclear power alive will simply divert investment from these cheaper market winners—cogeneration, renewables, and efficiency—to the costlier market loser. (6)

Energy Efficiency

The UK Government's 2003 Energy White Paper recognised energy efficiency as the cheapest and safest way of addressing all its energy policy goals: cutting carbon emissions; maintaining secure energy supplies; promoting competitive markets and ensuring that every home is adequately and affordably heated. Governments around the globe will have similar, if not identical policy goals. (7)

Government energy efficiency schemes are generally successful, but too modest. In order to realise the full potential of demand-side measures much more needs to be done – we should be developing schemes which could be hugely successful on a huge scale. And saving energy will almost always be cheaper than generating energy. The European Commission estimates that the average cost in Member States of saving a unit of electricity in the domestic sector is

around 2.6 Euro cents per kWh, compared to the average off-peak price for delivered electricity of 3.9 Euro-cents per kWh and on-peak price of 10.2 Euro-cents per kWh. (8)

According to Amory Lovins of the Rocky Mountain Institute we have barely begun to tap energy efficiency's profitable potential. (9) He says the good news about climate change is that it is cheaper to fix than ignore. (10) The climate problem was created by millions of bad decisions over decades, but climate stability can be restored by millions of sensible decisions, by individuals, municipalities, regional and national governments.

Europe and Japan are about twice as efficient as the US, but there are still huge savings to be made. Nevertheless the greatest opportunities are in developing countries, which are on average three times less efficient than the US. Their power sector currently uses about 25% of development funds – industrial countries are exporting inefficiency. Instead richer nations should help developing countries build an energy-efficient infrastructure, such as energy-efficient light bulb or glass manufacturing plant. (11)

Energy efficiency can be improved by taking simple steps, such as retrofitting houses with extra insulation or replacing appliances with energy efficient models. However, re-thinking the whole building or machine design will make the biggest savings. Insulating the whole outer shell of a house properly, which requires an additional investment, would reduce the demand for heat and allow you to install a smaller and cheaper heating system – offsetting the cost of the extra insulation. The result is a house that only needs one third of the energy without being any more expensive to build. Thousands of these super-efficient houses have been built in Europe over the past decade. (12) Energy demand for heating can be reduced in existing buildings by 30-50% and by 90-95% in new buildings.

Low carbon generation

In the transition to a sustainable energy system, the electricity sector will continue to be the forerunner of renewable energy utilisation. The Greenpeace Energy Scenario for Europe shows that by 2050, more than 70% of electricity could be from renewable sources (including large hydro). (13) But we need to look at the whole energy system, not just electricity. Carbon dioxide (CO_2), the main gas responsible for climate change, is produced by other parts of the energy system – by the fossil fuels we use to produce heat for example. In the US, electricity generation is responsible for only 40% of CO_2 emissions. Nuclear power can only supply electricity, so, even if we weren't worried about safety or nuclear waste, it could only ever have a small role in reducing carbon dioxide emissions. (14)

A Combined Heat and Power (CHP) plant produces heat as well as electricity at or near the point of consumption. Although currently often fuelled by fossil fuels, CHP plants use them more efficiently than in large centralised plant, because the heat is used either as process heat in industry or distributed around buildings via a district heating system. The availability of district heating networks means the CHP plant can be converted to run on other fuels such as biomass, geothermal energy, or solar collectors in the future. In the Greenpeace Energy Scenario for Europe the contribution renewables could make to heat supply continues to grow to more than 50% by 2050 as direct heating system are converted from fossil fuels. (15)

Wind Power

Wind energy is one of the most effective and cheapest renewable technologies available today for global deployment on a scale that can help tackle the threat of climate change, rising energy demand and safeguard security of supplies. It can be installed far quicker than conventional power stations. Greenpeace and the Global Wind Energy Council (GWEC) have published a blueprint which demonstrates the feasibility of supplying 12% of the world's electricity needs with wind power alone by 2020 - and this against the challenging backdrop

of a projected two thirds increase of electricity demand. The wind industry is one the world's fastest growing energy sectors offering the best opportunity to begin the transition to a sustainable energy economy. (16)

Three countries - Germany, Spain and Denmark, have largely driven the success of the wind industry. If other countries matched their efforts, the impact would be far reaching. With the arrival of new market players in 2005 such as the USA, and China this could be beginning to happen. Greenpeace and GWEC highlight 13 key countries which are beginning to play a leadership role and helping to reach the 12% global target by 2020. These countries are Australia, Brazil, Canada, China, France, India, Italy, Japan, the Philippines, Poland, Turkey, the UK, and the USA.

The UK Government's Performance and Innovation Unit (PIU) estimated the cost of onshore wind in 2020 at 2.3 - 3.8 Euro-cents per kWh, compared with 4.5 - 6 Euro-cents per kWh for nuclear electricity. (17)

Wind goes offshore

The industry has now developed technology of sufficient size; reliability and efficiency that it is ready to unlock the vast offshore wind resources that exist around the world. In Europe alone, the North and Baltic seas boast massive wind resources that have so far remained largely unexploited. Offshore wind is ideally placed to replace the 75 to 100 coal-fired plants, which will need to be retired over the next twenty years within the 25 EU member states.

Although the technology is still fairly new, experiences from the first offshore wind farms in Denmark, the United Kingdom, Ireland and Sweden – with a total capacity of more than 600MW – give cause for optimism that large-scale applications at sea are a very feasible prospect. Although, there are still significant obstacles to overcome, with the right political action offshore wind can pave the way for the phasing out of fossil and nuclear fuels. (18) The UK's PIU estimated that by 2020 offshore wind costs would be lower than nuclear electricity at around 3 - 4.5 Euro-cents per kWh. (19)

A report by Garrad Hassan, commissioned by Greenpeace in 2004, concluded that almost a third of Europe's total electricity demand could be met from offshore wind by 2020. (20) The European Wind Energy Association (EWEA) has set itself a more modest target for installed offshore wind power capacity of 10GW by 2010 and 70GW or 10% of demand by 2020. (21)

Power from the Sun

Concentrated solar thermal power is a relatively new technology, which offers a comparable opportunity to the sunniest countries of the world as offshore wind farms offer to Europe. Producing electricity from the sun's rays is a straightforward process: direct solar radiation can be concentrated and collected by a range of Concentrating Solar Power (CSP) technologies to provide medium- to high temperature heat. This heat is then used to generate electricity. Solar heat collected during the day can also be stored for use at night.

Because solar thermal power uses direct sunlight, it must be sited in regions with high direct solar radiation. Among the most promising areas of the world are the South-Western United States, Central and South America, North and Southern Africa, the Mediterranean countries of Europe, the Middle East, Iran, and the desert plains of India, Pakistan, the former Soviet Union, China and Australia.

Greenpeace, the European Solar Thermal Power Industry Association (ESTIA), and the International Energy Agency's (IEA) Solar PACES Programme have produced a practical blueprint, which shows that solar thermal power is capable of supplying 5% of the world's

electricity needs by 2040 – even against the challenging backdrop of a projected doubling in global electricity demand. (22)

From a current level of just 354 MW, CSP could reach a total installed capacity of 5,000 MW and by 2020 with additional capacity rising at almost 4,500 MW per year. By 2040 world capacity could have reached 630,000MW. (23) The five most promising countries in the near future, expected to have a capacity of over 1,000 MW by 2020 are Spain, US, Australia, South Africa and Mexico.

In many regions of the world, one square kilometre of land is enough to generate as much as 100-130 gigawatt hours (GWh) per year. This is equivalent to the annual production of a 50 MW fossil-fired plant. All current global electricity could be generated from just 0.3% of the area of the Earth's deserts. (24) CSP schemes have operated for 20 years in the Mojave Desert in the US, but the enormous global potential is only now being realized. The potential will only be used to a limited extent if it is restricted by regional demand and by local technological and financial resources, but countries such as Germany are already seriously considering importing solar electricity from North Africa and Southern Europe as a way of contributing to the long-term sustainable development of their power sector.

A collaborative vision between Europe and North Africa aims to build an electricity super-grid of low-loss transmission lines to harness the vast solar resources of the Sahara Desert. (25) The Trans-Mediterranean Interconnection for Concentrating Solar Power (Trans-CSP) aims to provide around 15% of European electricity demand from the South by 2050. The study estimates that imported solar electricity will cost around 5 Euro-cents per kWh. (26)

Photovoltaics

The solar electricity market is booming. The photovoltaics industry is one of the fastest growing worldwide. (27) By the end of 2003 more than 2,400 Megawatt peak (MWp) of photovoltaic (PV) systems had been installed around the world – supplying enough electricity for 700,000 households at average European consumption rates. At the same time global output has been growing at around 35% for the past few years. (28) It is a business worth more than €3 billion in annual sales, providing jobs for over 10,000 people. Three countries - Germany, Japan and the United States, so far have largely driven the success of the industry. If other countries matched these efforts the impact would be much greater.

A joint European Photovoltaic Industry Association and Greenpeace scenario suggests that photovoltaics could be providing more than 1.1% of global electricity demand by 2020, or to put it another way, this could replace the output of 75 coal-fired power stations. Global installed capacity would be over 200 GWp. Although the key markets are currently in industrialized countries, a significant share – 30 GWp – would be in developing countries. Manufacture and installation would provide around 2.3 million jobs. By 2040 the PV contribution would rise to 21%.

Prices for PV systems vary between countries and according to the level of market development in different regions of the world, but life-cycle running costs for solar electricity range from 25 - 100 Euro-cents/kWh depending on the available insolation and financial assumptions. These costs make PV an economically advantageous choice in a large variety of applications where no mains electricity is available. The grid connected markets still depend on government support, but as with any technology, the development of a learning curve leads to cost reductions. In the case of PV the cost decrease is expected to be around 20% every time the total installed capacity is doubled. By 2020 the cost of solar electricity in the most insolated regions - the Middle East, Asia, South America and Australasia - will have more than halved to as little as 10-13 Euro-cents/kWh in the best conditions. This would make PV power competitive with typical electricity prices paid by end consumer households.

Renewables galore

There are a wide-range of other renewable technologies, which can be economically harnessed to provide heat and electricity. The Greenpeace Energy Scenario shows 70% of electricity and 50% of heat being produced by renewable sources by 2050. (29)

(1) Solar thermal energy can be collected on an individual building-scale using solar thermal collectors. Solar thermal technologies on the market now are efficient and highly reliable, providing solar energy for a wide range of applications, from domestic hot water and space heating in residential and commercial buildings, to swimming pool heating, solar-assisted cooling, industrial process heat and desalination of drinking water. (30)

(2) Biomass – a very broad term used to describe material of recent biological origin. It includes wood, crops, algae and other plants, as well as agricultural and forest residues. Biomass can further be used for a variety of different end-uses: heating, electricity generation or transportation. It could, for example, replace the use of fossil fuels in combined heat and power plants, and help to balance the use of intermittent sources such as wind. Biological power sources are renewable, easily stored, and, if sustainably harvested, CO_2-neutral, which means they are also climate-friendly. (31)

(3) Geothermal energy is heat derived from the earth. It is the thermal energy contained in the rock and the fluid filling the fractures and pores within the rock in the earth's crust. In most areas, this heat reaches the surface in a very diffuse state. However, due to a variety of geological processes, some areas, including the western part of the USA, west and central eastern Europe, Iceland, Asia and New Zealand are underlain by relatively shallow geothermal resources. The highest temperature resources can be used for electricity generation. Current global geothermal electric power generation totals approximately 8,000 MW – about the same as eight large coal or nuclear power plants. As a non-fluctuating renewable energy source geothermal is an important element in the overall generation mix. Ground source heat pumps can also be used to make use of heat stored by the earth. For every unit of electricity used to pump the heat, 3-4 units of heat are produced. (32)

(4) Systems designed to harness energy from waves and tides could provide up to 20% of the UK's current electricity demand, with perhaps 3% installed by 2020. (33) Wave and tidal stream energy has the potential to offer the UK the chance to create a world-class domestic industry developing, manufacturing and installing devices for an emerging global market. The industry is now at a critical stage of development. It faces a number of hurdles that must be overcome for its potential to be realized. (34) Many of the world's leading wave and tidal power companies are based in the UK, but if they don't get the government support required they will move to other countries such as Portugal where support is more enthusiastic. (35)

(5) Today, around one-fifth of the world's electricity is produced from hydro-power. Large hydroelectric power plants with concrete dams and extensive backwater often have very negative effects on nature the environment. However, smaller, 'run-of-the-river' power stations, which are turbines powered by one section of running water in a river, can produce electricity in an environmentally friendly way. (36)

Nuclear vs renewables

Greenpeace France commissioned the French research institute, DÉTENTE, to compare investment in new reactors in the most nuclearised country in the world – France - with investment in wind. DETENTE compared the construction of 1 European Pressurised Water Reactor (EPR) with a wind project of an identical investment, and found that wind gives a much higher job creation and electricity production. Wind generates 2.3 times more electricity. (37)

France gets nearly 80% of its electricity from nuclear reactors, so it has an iconic status amongst nuclear advocates. The US Institute for Energy and Environmental Research (IEER) says France could phase out nuclear power and achieve a CO_2 reduction of up to 40% by 2050. In fact, under a business as usual scenario, CO_2 emissions will rise to 30% above today's level by 2040. IEER makes the point that, if a country as heavily reliant on nuclear power as France can phase it out and still reduce carbon dioxide emissions, then it will be much easier for other countries such as the US to achieve the same thing. (38)

Conclusions

It is feasible to phase out nuclear power around the world, AND reduce carbon emissions at the same time. A sustainable energy path based on energy efficiency and renewable energy can deliver the energy supplies we need. What is more such a path would be cheaper and create more jobs. There is now a growing consensus amongst policy makers that energy is central to reducing poverty around the globe. (39) The rapid expansion of clean and sustainable energy offers a win-win for the poor and the environment. The growth of renewable energy is both necessary to provide energy services to those who currently do without, but to provide the solutions we so urgently need to tackle climate change.

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