2 Current status of renewables

"By developing new low-emission technologies, we can meet the growing demand for energy and at the same time reduce air pollution and greenhouse gas emissions."

George W. Bush, Washington 28 September 2007

What are renewables?

According to the International Energy Agency (IEA), the term renewable energy covers at least three generations of technology, some ultra-modern, others dating back hundreds if not thousands of years.

The first generation of traditional sources of renewable energy includes various types of hydropower, biomass, and geothermal energy. These technologies are already in place and currently producing energy.

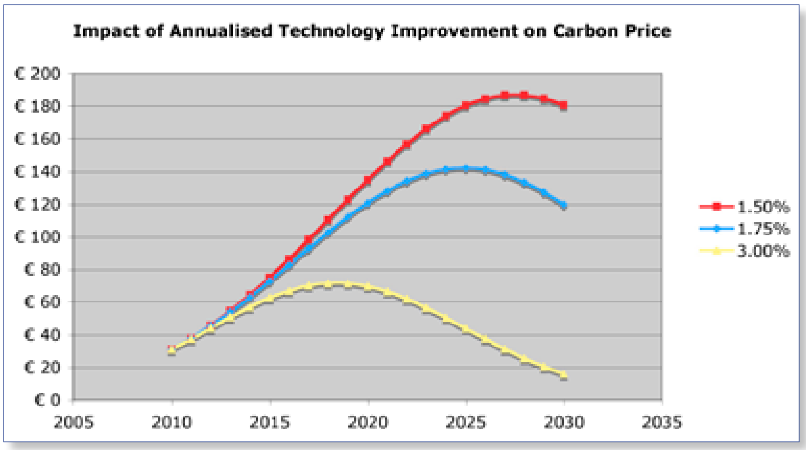
The second generation includes technologies such as wind power, photovoltaics, biofuels, and solar thermal systems. These technologies have been developed and are ready for use but are not yet fully installed/implemented to their maximum extent.

The third generation are those technologies which, while they look promising, still require some development work before they can become commercially available as 'off the shelf' products. Some examples might be biomass gasification, enhanced geothermal systems, and solar hydrogen generation. Carbon capture and storage (a 'clean', but not strictly renewable technology) is clearly still at this stage, while wave power is just moving from development to commercialisation with the advent of systems such as Pelamis.

The global problem

The impetus towards the development and utilisation of renewable energies has varied over the years. Sometimes political factors raise the apparent desirability of renewables. President Carter had the Middle East in mind when advocating 'energy independence for America' even before the Iranian revolution in 1979. Dr Stephen Salter's 'duck' received attention at the time of the 1970s oil price shocks, but official enthusiasm seemed to wane when North Sea oil came on stream (in hindsight a huge missed opportunity). The current driver, however is the increasing consensus on man-made global warming and the need to reduce emissions of carbon dioxide and other greenhouse gases. Quotes such as the one from President Bush at the top of this chapter portray renewables (to use a Texan metaphor) as the 'cavalry coming over the hill' to rescue us.

It seems likely that at next year's post Kyoto conference at Copenhagen there may be multilateral agreement on a system of pricing carbon emissions. This would be intended to encourage efficiency savings and the implementation of technologies such as renewables, with the aim of stopping the growth of



Source: KKI Associates & Z/Yen Group. Carbon Emissions Pricing Model.

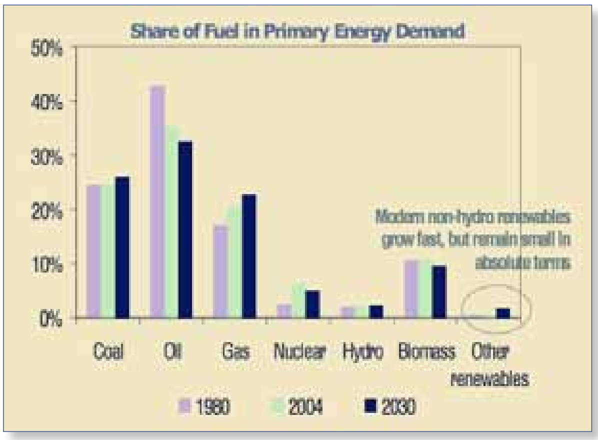
carbon emissions (peak carbon) between 2015 and 2020, and reducing carbon emissions by 60-80% by 2050. In other words, renewables would not simply need to supplement existing conventional sources but to replace significant amounts of them.

In a new study for the think-tank Tomorrow's Company, KKI Associates and Z/Yen have modelled the impact of public policy, price elasticity and technology on the future price of carbon emission permits. The model deflates carbon prices by a 'pessimistic' 1% pa to an 'optimistic' 3% pa to reflect the total impact of new technologies and energy efficiency savings. Between 2020 and 2030 there are huge differences (over 300%) between the pessimistic and optimistic cases. How optimistic can we be that renewables technology will indeed 'rescue' us?

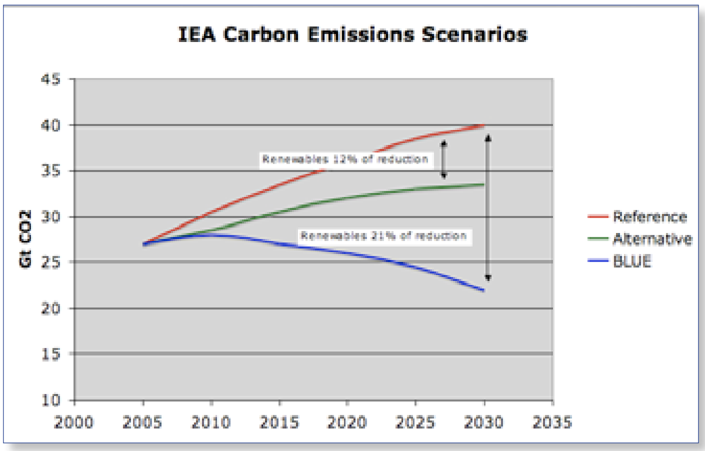
The scale of the problem

The US Energy Information Administration quotes world installed electricity capacity as being 4,000 GW at 2006 (last available statistics) of which first generation renewables comprise just over 22%. This capacity could theoretically produce some 24 trillion kilowatt hours of electricity, but in practice produces about 17.3 trillion. US EIA expects world electricity consumption to double by 2030, which implies the need to double the installed generation capacity to around 8,000 GW. So, with about 160 GW of new electricity capacity being installed each year up to 2030, the world needs to install about 36 GW of renewables just to keep the current ratio of renewables to non-renewables.

Source: IEA report Energy Technology Perspectives 2008



Furthermore, a number of other green technologies require incremental electrical power. For example the widespread adoption of electric vehicles in the United States might require anything from 8 to 160 extra power stations according to Oak Ridge Laboratories. On a worldwide scale, the liquid fuel energy required by the transport sector equates to about 20-40 trillion kilowatt hours. Even allowing for the increased efficiency of electric motors (about 5 times better than IC engines) significant conversion to electric vehicles might require an incremental 1,000 GW. The IEA has generated a series of scenarios reflecting forecast energy requirements and balancing them against CO_2 emissions. The IEA 'business as usual' or 'reference scenario' sees CO_2 increasing beyond 2030, with a very small contribution from non first generation renewables.



Source: IEA report Energy Technology Perspectives 2008

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The IEA's 'alternative policy scenario', combining first and second generation renewables with increased efficiency, sees CO2 peaking around 2030.

Status of some key renewable technologies

First generation Hydroelectric power (HEP) provides over 20% of world electricity capacity (776 GW in 2006). Massive hydropower installation is going ahead particularly in China, which is already the world's largest producer and user of HEP. The NGO International Rivers lists over 20 major projects in China alone with a capacity of 133 GW, scheduled between 2009 and 2020. The world's feasible hydro potential is around 2-3,000 GW according to Hydropower and Dams, with the largest proportion being in Asia. Chinese companies have become the major constructors of HEP schemes in other countries around the world. Overall, hydropower looks set to maintain its share of world electricity production. There are concerns that large schemes damage ecosystems, and also that rotting vegetation is a major source of methane – a more potent greenhouse gas than carbon dioxide.

Conventional geothermal power is smaller scale compared with HEP, and limited to specific parts of the world. The IEA suggests that an incremental 85 GW may be implemented over the next 30 years.

Combustible biomass and combustible waste account for about 6% of renewable energy electricity generation according to the IEA. This would suggest a capacity of about 50 GW total, although the IEA also states that "countries have difficulty monitoring the supply and consumption of biomass" and that "the quality and reliability of the data may be limited". Unless specific action is taken to encourage biomass use, IEA scenarios expect its share of production will fall as countries shift to more modern forms of energy.

Although not used for electricity production, biofuels could also be regarded as a first or second generation renewable. The IEA expects biofuels to grow about ten times by 2030, to around 150 millions tonnes of oil equivalent. Biofuels have been criticised for removing agricultural land from food production at a time of population increase and food shortage. Biomass gasification, where the material is converted to carbon monoxide and hydrogen at high temperatures, is still at the development stage.

Second generation Wind power is the most widely implemented of the second generation technologies. Its installed capacity at the end of 2008 was 120 GW, growing at around 29% pa according to the global wind energy council. Again, China, often quoted as relying on coal power stations, has doubled its wind capacity and is expected to become the second largest wind power user by 2010. Other major users of wind power are Denmark, Spain, and Portugal.

Photovoltaics (solar cells), which convert light into electricity, are the fastest growing renewables technology. Historically used for local supply in remote areas, photovoltaics are now being assembled into power stations. Australia is planning the largest of this type (154 MW) in Victoria. At the end of 2007, total production had reached 12 GW, with nearly 4 GW added that year. Annual production is increasing by nearly 50% per year, doubling every two years.

Solar thermal plants differ from photovoltaics in that they concentrate the sun's rays to provide a source of heat. At the moment there are three such plants in the USA, two in Spain and one in Australia with a combined capacity of less than 0.5

GW. From a small base the industry looks set to grow rapidly, with 40 projects (typically 50 MW each) announced in Spain, 17 larger projects in the US, and another 8-10 around the world. The total capacity of the announced projects is around 8 GW.

Fuel cells are sometimes counted as a renewable technology, but are correctly regarded as a conversion device. They can allow transport to be effectively non-polluting (only water is produced from hydrogen oxygen cells), but ultimately the hydrogen (or other fuel) has to be prepared by processes such as the electrolysis of water. So the 'renewability' depends on that of the electricity used to produce the fuel. Mass acceptance of fuel cell vehicles also depends on engineering solutions to the storage of hydrogen, the lightest element and one which is correspondingly difficult to liquefy.

Third generation Although the IEA classifies wave and tidal power as third generation there are a number of schemes already in place. The longest established is the tidal barrage power station (approx 70 MW) at the Rance estuary in Brittany, which opened in 1966. Tidal barrage schemes have not been widely implemented, due to their high capital cost, and the potential for interference with marine ecosystems. The country that seems most interested in tidal barrage systems is Russia, which is investigating two 10 GW (!) schemes in the White Sea and the Sea of Okhotsk, according to the Washington Post.

Novel approaches to tidal energy involve tidal stream generators. These are analogous to underwater wind turbines, set on either a vertical or horizontal axis (with an intriguing helical Russian design being mooted for South Korea). Although they avoid the problem of barrage schemes, most are still at the pilot/development stage. The University of Strathclyde's Baseload Strategy website lists a dozen different development concepts.

The first small full-size marine current propeller prototype rated at 1.2 MW has been installed at Strangford Lough in Northern Ireland in 2008. Other small projects will be in Norway, the US, Australia and Canada. Such schemes are site specific, requiring strong local currents but some sites have great potential. For example Alderney Renewable Energy estimates a potential to extract 3 GW from the waters around that island. A scheme is being evaluated for the Pentland Firth, between Scotland and the Orkney Islands, which could be rated at 1.7 GW.

Wave power utilises the motion of waves rather than tidal currents to generate power and has the advantage of being rather less site specific than tidal power. The energy is rather less concentrated so wave power farms may be smaller than some of the large tidal systems. The first commercial wave farm in Portugal uses machines from the young Scottish company Pelamis. Current capacity is 2.25 MW eventually increasing to 21 MW.

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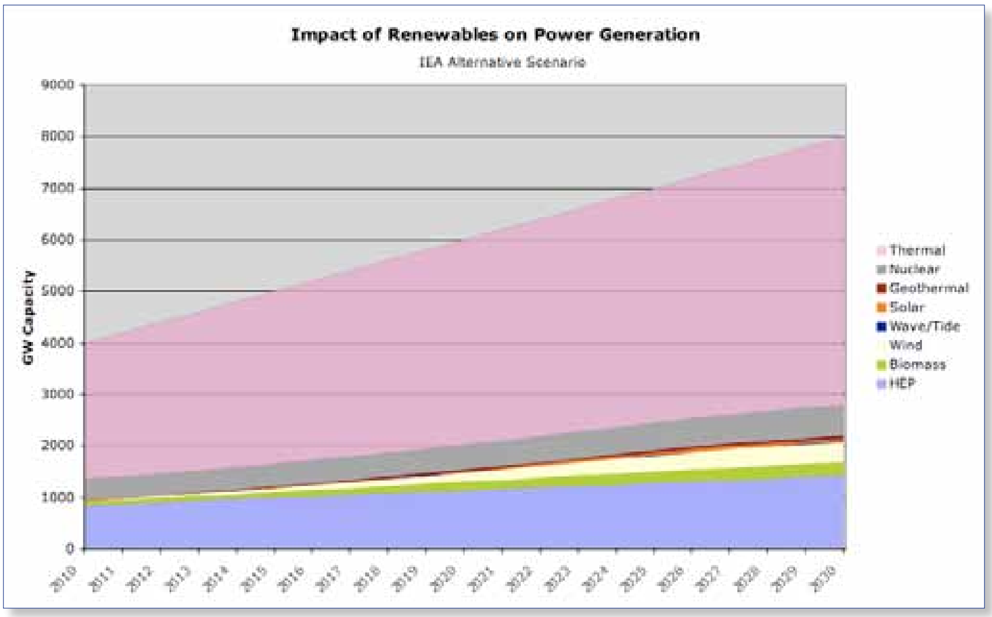
The IEA expects tide and wave power together to grow nearly 50 times by 2030, but starting from a very small base to total perhaps 7 GW.

Other third generation technologies are further from the market. In 2006 MIT reported on the prospects for energy from enhanced geothermal systems (sometimes termed 'hot dry rock'). Water or other fluids, (possibly supercritical carbon dioxide) is pumped into deep subsurface fractured rocks. The fluid can return to the surface at temperatures approaching 300°C and be used directly for heat or to power turbine generators. MIT estimated that 100 GW could be installed in the United States by 2050 following a 15 year R&D programme. Small commercial developments (below 20 MW) are underway in France, Germany and the US, and a larger 250 MW site in Australia is currently being drilled.

Conclusion – 'where is the cavalry?'

The IEA, in their 2006 'alternative policy scenario' projections, forecast that world governments do invest in renewables for electricity generation. In this scenario, hydropower capacity doubles between 2004 and 2030, biomass increases four times, geothermal three times, wind 18 times, tide and wave 46 times and solar 60 times. However, these increases from a low base are barely enough to maintain the current proportion of demand met by renewables (roughly from 24% to 28%). Assuming a growth in nuclear capacity at 2% pa (again, an IEA forecast), the proportion of electricity met by thermal power shifts from about 66% to about 65%. It does not look like renewables will produce the annualised technology deflator of 1-3% in the Tomorrow's Company carbon price model mentioned above.

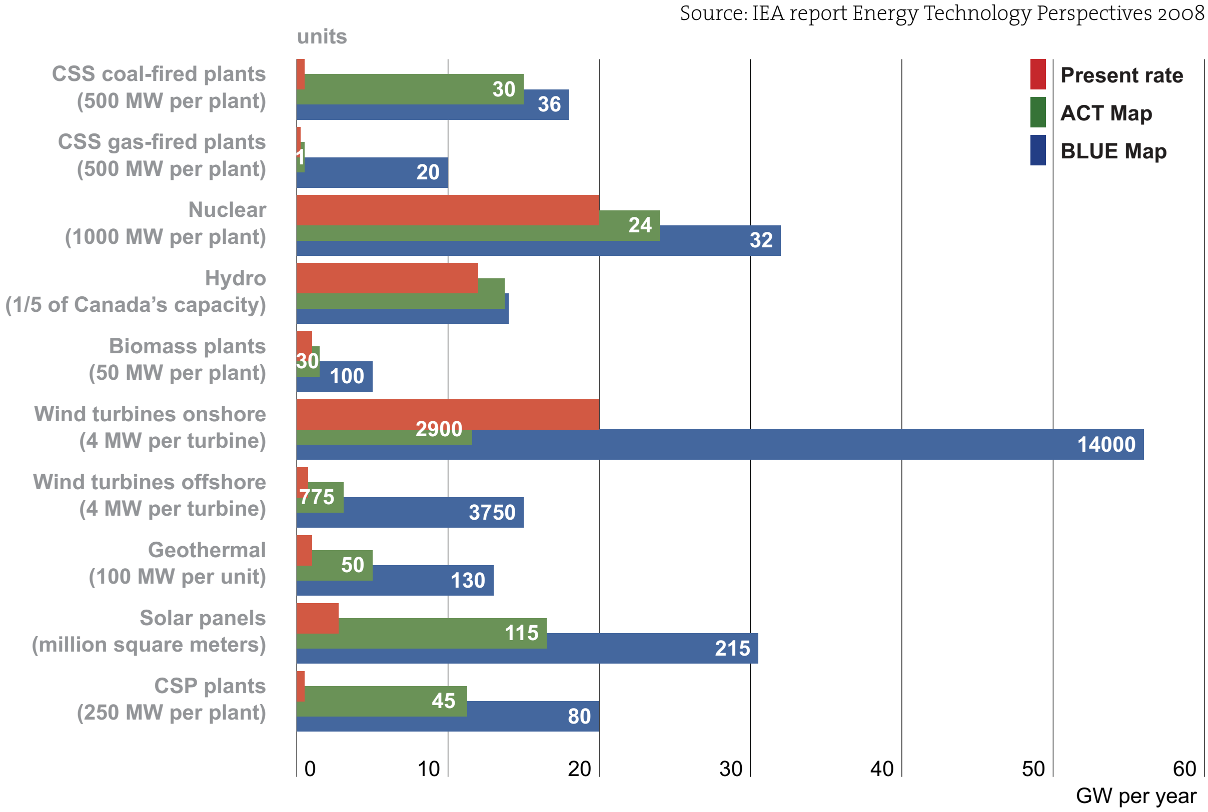
This alternative energy scenario is quite conservative with respect to power from solar, geothermal and wave/tide. It forecasts that together, these sources contribute 120 GW from a world demand of 8,000 GW. In its 'beyond alternative' or 'blue scenario' the IEA begins to map out the investment needed for renewables to really transform the outlook for energy and climate in the mid 21st century. The answer is that we need not hundreds but thousands of gigawatts from these sources. That is the challenge for the 'technological cavalry' (to not quite quote President Bush) – 1,000 GW generating capacity each from solar, wind, geothermal, wave/tide by 2030.



Source: Data interpolation by KKI from IEA 2030 forecasts

The annual rates at which new power generation capacity would need to be added in each scenario.

Source: IEA report Energy Technology Perspectives 2008



Dr Kevin Parker is the principal and founder of KKI Associates, a consultancy which for the last 15 years has worked on around 150 technico-economic assignments, especially in sectors based on chemistry and/or energy. Most recently, he has built an economic model, which allows companies and regulators to predict the price of carbon emissions permits in the EU/ETS scheme.

Kevin trained as a chemist, and worked for 12 years with British Petroleum, including spells in R&D, international sales, and technico-economic corporate planning. He is a Sloan Fellow of London Business School.