



# Wind and Solar Power

## Vision or Mirage?

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## Introduction

Wind and solar power are the two main renewable energy technologies being deployed at present. The main facts and issues on them are summarised in this document. For a fuller discussion of these and other renewable technologies, see *Renewable Energy: Vision or Mirage*, published jointly by the Adam Smith Institute and the Scientific Alliance.<sup>1</sup>

### Low energy density

Both wind and solar energy are very abundant, but the problem comes in harvesting them economically. They are diffuse (weak) forms of energy which require large installations to generate a significant amount of power. Both wind farms and solar panel arrays take up considerable areas.

This diffuseness also means that installations have to be put in where they are most likely to generate power. For wind, this means in the windiest regions, which tend to be in the north and west. Also, wind speeds are generally higher offshore, and siting turbines there meets lower public resistance. These factors mean that considerable investment is needed in transmission networks to take the power from where it is generated to where it is needed.

## Wind power

Wind power is the main source of renewable electricity in the UK, and a technology for which both the UK and Scottish governments have ambitious plans. For an island nation in the path of prevailing winds, this seems like a

reasonable starting point, but wind is intrinsically variable and only predictable to a certain extent.

A certain minimum wind speed is needed for turbines to operate and produce power. The output then rises steeply, as power is proportional to the wind speed cubed. However, turbines cannot operate when wind speed is too high, and must be shut down at times when the potential power output is very high. Although high output may coincide with periods of high demand, stationary areas of low pressure in winter will not infrequently mean that wind contributes very little power when it is most needed.

At the end of 2010, the nominal wind power capacity was 5GW, of which just over 1.5GW was offshore. Averaged out, the capacity factor for UK wind energy from 2003 until 2010 comes to 25.8%, or approximately one quarter of the rated output. In 2002, government expectations were for capacity factors of 30% for onshore and 35% for offshore. Inner Dowsing has achieved 34% and Danish offshore wind farms over 40%.

### The need for backup

The focus of the government on CO2 emission reduction by the introduction of renewable energy has resulted in all the large generators taking large stakes in the highly subsidised wind industry, where their returns on sites with good wind characteristics can be spectacular. However, the amount of wind power available will always be dependent on the weather. Back-up, dispatchable power plants must always be available to supply demand and balance the grid for the demand for power that the wind is not producing. Winter peak power often coincides with very large, slow-moving

<sup>1</sup> <http://www.adamsmith.org/sites/default/files/research/files/renewableenergy2011.pdf>

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anti-cyclones, which bring extremely cold weather and almost no wind; therefore little or no wind power output is possible.

Not only does wind power need under-utilised backup generators for continuity of supply, but their operators also receive constraint payments to switch them off when their output is not needed.

The backup generation – often in the form of relatively inefficient open-cycle gas turbines – has to be held in a state of readiness so that it can be rapidly ramped up when needed. This is inefficient, since fuel is being used when no power is needed, means the plant is only operating for a proportion of its available time and ramping up and down tends to increase wear. Currently, the additional costs, which are incurred only because backup power is needed when renewables fail to deliver, are not allocated to the renewable energy generator, making the costs appear lower than they should be.

#### **Contribution to carbon dioxide emissions reduction**

Analysis of data from Ireland, which has a considerably higher proportion of wind generating capacity than the UK, shows that, as wind power increases, fuel savings per MW decrease, levelling off at around 330 kg of CO<sub>2</sub> per system MWh, indicating that as wind power output rises past (say) 1400MW, there will be little if any further fossil fuel savings. This can be confirmed by looking at the specific CO<sub>2</sub> emissions of the non-wind (mainly thermal) output. There is a huge scatter of results across a wide range, but there is undoubtedly a trend of rising specific fuel consumption as the output from the roughly 1400MW of installed wind capacity increases.

1400MW in Ireland is equivalent to what will be (very roughly) 14-15GW of wind power in the UK, which it is reasonable to assume would be the level beyond which no more fossil fuel savings would be made.

#### **Public resistance**

Those wishing to drive the construction of more wind capacity in the UK should take note that public opposition is widespread, with the great majority of proposals spawning local groups objecting on grounds of visual intrusion, noise, flicker, reduced house value and wildlife destruction. Despite wind power only delivering 3% of UK electricity in 2010, there is already a high and rising rate of local resistance, as illustrated by refusals of local (democratically elected) councils to provide building permits for new, mostly very large, onshore wind turbines.

#### **Practical considerations**

To deliver 18GW of offshore turbines, each, say, with a capacity of 3.6MW, will require the construction of 5,000 turbines during the roughly 3000 days left until 2020. Optimistically, there will be roughly 120 days per year, 1080 days in total, that will be suitable for offshore construction. So with nine years remaining to 2020, almost 5 turbines must be installed each working day, starting now, and then all the way through to 2020, in order to achieve the target. At 630MW, the London Array will be the largest offshore wind farm ever constructed. The project started in 2001 and aims for commissioning in 2013. It stretches credulity to believe that between 2011 and 2020, 28 more projects equivalent to the now ten year-old London Array, can be conceived, planned, financed and constructed.

Wind turbines are also subject to considerable stress, which can lead to failure of blades or other components. Gearbox failure is also not uncommon, and replacing this (or undertaking other maintenance) requires appropriate weather conditions. For offshore turbines, of course, the problem is made much worse. Overall installation life is around 20 years, much shorter than for conventional plant, and equipment cannot be refurbished at the end of life.

#### **Solar power**

Photovoltaic power, generated from sunlight shining on panels containing an array of silicon-based cells is the most expensive of currently commercialised technologies, despite the cost of PV panels having fallen considerably in recent years. Although power output in sunny areas nearer the equator may be quite high, in northern Europe capacity factors are around 10%.

Solar power is more predictable than wind – even on cloudy days, some electricity is generated – but it produces its peak output in the middle of the day, when demand is relatively low. At times of peak demand, on winter evenings, solar cells produce no power at all.

There are only modest ambitions for the use of solar power in the UK, which seems appropriate given its high cost and low efficiency at such a high latitude. The current worldwide installed solar capacity is about 40,000MW of photovoltaic power and about 1,170MW of concentrated solar power.

One financial disincentive to solar power is the large land area required. A 1000MW Concentrated Solar Power facility requires 6000 acres of land, enough for about ten

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coal-fired plants with the same rated output. Producing 1000MW from photovoltaics requires over 12,000 acres of land. Nuclear power stations need much less land than even coal-fired ones; their land use is minuscule compared with renewables.

### **Subsidies**

The development of solar power is driven entirely by subsidies, since the costs are significantly higher than those for conventional sources. Because the costs imposed by net metering are left with the electricity distributor rather than being paid by taxpayers, the metering finishes up being a subsidy from poor consumers who cannot afford solar panels to rich consumers who can.

Without these subsidies, it is safe to say that the grid-connected solar energy industry would not exist. As a result of them, solar power is being developed in countries in northern latitudes where the sunshine is less intense and skies are often cloudy. Typical capacity factors in desert areas are about 21%, but in high latitudes they can be 10% or less. This leads to the absurd situation where Germany is the world's leading market for photovoltaic systems, with a total installed capacity of 17GW at the end of 2010. However, despite the current high cost of PV cells and their low output at times of high demand at high latitudes, greater manufacturing efficiencies and economies of scale have brought prices down significantly. For example, data from Germany shows that the installation cost per kW has halved in the last five years.

The policy specifically favours small-scale, often domestic, installations which are intrinsically less cost-effective. Many householders, not surprisingly, are putting their money into such schemes, which offer payback periods of less

than ten years, and a considerably higher rate of return (government guaranteed) than offered by bank savings accounts. However, this boom is likely to be short-lived: the government has already announced cuts in the subsidies available for installations registered after 11 December 2011.

It is difficult to understand this discriminatory policy. If the objective is to reduce emissions of carbon dioxide, and if (against all the evidence) it is decided that massive subsidies for solar power are an effective way of doing it, then all the subsidies should be the same.

In the UK, the capacity factor would not be above 9%, and could be significantly less. To generate the same amount of energy as a nuclear station with a capacity factor of 90%, 10,000MW of solar power would be needed to be equivalent to 1000MW of nuclear power. Based on these figures, the equivalent installation cost of a large PV farm is \$19,000/kW. This is more than three times the cost of nuclear power, and even more when an allowance is made for backup generation. In contrast to the price calculated above, home installers typically offer to install a 2.5 kW unit for £12,500. This works out at £5,000/kW of nominal capacity (\$8000/kW). The price is then more than \$50,000/kW of actual output, or more than eight times the cost of nuclear.

*This paper contains extracts from Renewable Energy: Vision or Mirage, published jointly by the Adam Smith Institute and the Scientific Alliance. The full report is available for download at [www.adamsmith.org](http://www.adamsmith.org).*