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Limits on Wind Power and Global Warming

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Renewable energy sources like wind and solar energy can not solve completely the world's energy problems. Nuclear power is the only alternative especially since there is an urgency in reducing CO_2 emission as fast as we can.

When Jim Hansen, director of Climatology at NASA Goddard Space Center USA, was asked what we can possibly do about global warming, he replied "energy efficiency and renewables". For most people who do not have a close acquaintance with the subject of renewable sources of energy - predominantly wind and solar power, this is a common but incomplete answer. Furthermore, many ardent advocates of renewable energy sources would have you believe that the world can replace all fossil fuel and exist on renewables alone. They give you the false impression that good solutions exist and it is just a question of shifting taxes and restructuring our energy industries. The renewable energy advocates paint a more or less pollution-less world powered by wind mills and solar panels. While their enthusiasm for this utopian vision is infectious, it is far from being realistic for they sweep under the carpet some fundamental issues governed by limits of technology, economics, earth's resources and intermittent nature of wind. As a consequence, these problems will limit the renewable energy sources from ever providing more than 10-20 % share of our total energy needs. In the end, our choice of alternative will be driven by considerations of cost. So long as a non-polluting steady power exists, wind power will remain a small contributor as it is at present.

Here, I would like to point out some simple facts why we cannot rely on renewable energy sources alone to solve the world's energy problems.

I. Capital Cost Of Windmill Installation

Since the energy from a windmill varies as the cube power of wind speed, many installations are looking to off shore locations. Let us take as an example the current proposed project by Cape Wind (www.capewind.org) to build a wind farm in Nantucket Sound, USA. For an installation cost of $800 million, it will provide electricity needs for half the population of Cape Cod, with a wind turbine capacity of 420 Megawatts. Cape wind estimates that the net electricity delivered is 170 megawatts because of lull in the wind. From this, the capital cost for generating wind electricity is $4700/ Kilowatt. In practice the efficiency factor used for wind power is more like 25% of turbine capacity. If we use this figure, then the capital cost for wind electricity is more like $7500/Kilowatt.

For arguments sake, let us use the Capewind figure of $4700/Kilowatt and calculate the amount of wind power needed for providing total electricity demands for USA and EU-16 (European Community) with a combined population of 700 million, assuming 2 KW per person. This comes to a total capital cost of $ 2.8 trillion which is close to the combined GDP of all these countries. Now, of course, this does not solve the problem of all the polluter countries like China and India. One may calculate the capital cost for supplying wind electricity to 2.6 billion people comprising all the population of USA, EU-16, China and India. The total capital cost then becomes: **$10.4 trillion**.

Calculating what the world would need in terms of wind turbines with present day turbine capacity at around 4 MW, we arrive at 5.2 million turbines.
Each wind mill has a steel tower of 80 -100 metres high to mount the generator nacelle and has a rotor with three blades up to 50 metres long. Foundations require hundreds of cubic meters of reinforced concrete 10 metres into the ground. A rough estimate of just the amount of steel necessary for the wind towers and rotor blades gives 5.2 billion tons. Spread the construction over 10 years, then we would need 520 million tons of steel per year. This is comparable to the total world production of steel which is around several hundred million tons per year.

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II. Intermittent Nature Of Wind Power

A windmill has to be designed for maximum expected peak wind, so in practice the energy one gets from a windmill is at best 25% of the nominal design capacity of the turbine because the wind is not blowing all the time. In order to feed a constant power into the grid with no power fluctuations and voltage drops at the consumer end, there has to be a standby steady power supply equal in magnitude to the peak capacity of the turbines to take over when wind is blowing at less than peak speed. Building extensions to the grid is a very expensive business especially since the windmills are often located at remote places not close to the grid.

In Danemark, the most intensely wind-turbined part of the world, the slack in wind power generation is taken up by hydro electric power provided by Norway as all the grids are interconnected in this part of Europe. This, however, cannot be the solution for the rest of the world.

Alternatively, we can forget about connection to the grid and use wind power to make hydrogen. This effectively converts the intermittent mechanical energy of wind into thermal energy of hydrogen which can then be stored and transported for use at any time. This eliminates conversion to electrical energy for the applications where hydrogen energy can be used directly, such as the powering of cars. Our total energy needs can be divided into 3 groups: electricity, industrial and personal and public transportation. Each group accounts for about 1/3 of our total energy needs and contribute equally to CO_2 emission. For our transportation needs, hydrogen production from wind power would make some sense. Each wind farm would have to be equipped with auxiliary installations for electrolysis, - dissociation of water into oxygen and hydrogen - as well as hydrogen compression and storage. Hydrogen may also be shipped by pipeline for local transport needs. The capital cost for this number of auxiliary plants are certain to be very expensive. To convert hydrogen to electricity, one would need a large quantity of fuel cells. There are efficiency factors to contend with at every stage of the process. Let us take an efficiency factor of 80% for both electrolysis

and fuel cells, this means that the total wind power required would have to be upped by 56%.

III. Nuclear Energy

Just the mention of peaceful uses of nuclear energy brings on the spectre of its military use and the related problems of proliferation and terrorism. But let us not throw away the baby with the bath water. If we are not going to use fossil fuels for the standby steady power supply then the only option open to us is nuclear energy. All renewables and nuclear energy have much higher capital costs than fossil fuel installations. The 'overnight' cost for the construction of a nuclear reactor is, according to Spurgeon, assistant secretary foe nuclear energy at US Dept of Energy is $1.5-2.0 billion for a 1000 megawatt plant, which works out to be ~$2000/kilowatt. If one were to include interest on the capital during construction phase
then it would be $2200/kilowtt. Waste disposal and decommissioning will come out of the operating budget. This is much less than the $4700 - $7500 cost of wind power.

From the practical point of view, nuclear reactors are much more compact. Instead of one standard nuclear power station generating 1500 MW which occupies around 100 acres and is weather proof, one would have 1500 wind mills of 4 MW peak capacity each over a much larger area of up to 1500 acres. Furthermore the most important asset of nuclear power is that it has some 10,000 reactor years of experience and its technology has been proven. In principle, a nuclear reactor can be built in 5 years. While starting a new global wind power industry is likely to take at least 10 years or more.

In opting for nuclear reactors one has to consider the availability of fuel. Present day nuclear reactors running on the less abundant Uranium235 fission have probably enough fuel for a couple of hundred years, However, breeder reactors using Uranium238, which subsequently produces Plutonium 239, would give us enough fuel for tens of thousands years. Uranium238, being the more abundant isotope, may be obtained from low grade uranium ore.

IV. Conclusions

So far, we have envisaged a combination of nuclear power and wind power with nuclear reactors providing the standby when wind is down. Since nuclear reactors are not cost effective unless they operate as base load with long time constants for variations in power output, it is essentially replacing the national grid currently supplied by fossil fuel power, i.e. coal, oil and gas. Therefore one can dispense with windmills altogether. However, existing local wind farms could be useful, just by feeding directly into the national grid, the way they do at the moment.

While we wholeheartedly applaud the successes of the Greens in their efforts to preserving our environment, we find their position morally inconsistent on two scores:

First, though wind and solar power are an inexhaustible source of energy, the Greens then go too far from realism by have you believe that the world can be run on renewable energy alone. when any child can conceive of the question: “ Papa, what happens when the wind is not blowing or the sun is not shining? “

Second, if we are serious about reducing CO_2 emission to the atmosphere, which should be our foremost concern, then should we not examine all other energy sources which also satisfy the criterion on being CO_2 non-emitting?

We all agree on the need for urgent action. Recently, this has been abruptly brought home to us by new data from satellite observations that the Greenland ice cap is melting much faster than scientists had anticipated - twice as much ice is going into the sea as it did 5 years ago. Hence it has forced us to reassess, in addition to other effects of global warming, the real possibility of sea level rise of over 8 metres if all of the Greenland ice cap were to disappear, Though scientists are wary about predicting a date for this to happen, there is a general consensus that the next 10 years are critical. If we do not stop massive emission of CO_2 into the atmosphere by then, it would be too late to reverse the present trend - towards a planet becoming a hostile place for humans to live on. So the clock is ticking and we need to replace the present usage of fossil fuel energy as soon as possible. Perhaps the greatest merit of nuclear power in this context is the fact that we can build a nuclear reactor from the blue print of an existing one and have it up and running in 5 years. Both major renewables, wind and solar, cannot be commissioned on a global scale within 10 years, not to mention the problem that a steady standby power source is needed, - a role which can only be filled by nuclear power.

According to 'Annual Energy Outlook'(AEO) of US Dept of Energy, the US energy consumption in 2030 is predicted to rise by 28% from 2004 levels. Just the consumption from coal powered plants will rise by 50% from the consumption in 2004. If we were to replace all the fossil fuel generated electricity in the USA today by nuclear reactors, It would cost around $1 trillion. This is obviously not going to happen. In fact, AEO projects that by 2030, the percentage of energy produced by petroleum will be 41%, coal 26 %, natural gas 20%, nuclear 6.3 %, non-hydro renewables 3.9% and hydro 2%.

Similarly, CO_2 emission in US will grow from 5919 million metric tons in 2004 to 7587 tons in 2025. This does not include the CO_2 from huge polluter countries like China and India. WETO ("World Energy, Technology And Climate Policy Outlook", study for European Commission 2003) predicts that by 2030 the world's emission of CO_2 will increase by 70%. There is no way we can meet these demands without resorting to fossil fuel plants unless we have a crash program of building nuclear reactors.

Many scientists say that drastic action is required if we want to reduce the trend of global warming. The saddest fact is - there are no crash programs to install a large number of nuclear reactors or wind mills in the UK or US. Instead, we just carry on 'business as usual', producing ever more CO_2 as our energy requirements increase from year to year. However, there has been some good news lately, Prime Minister Tony Blair has indicated that Britain will build a number of nuclear reactors. It is a good start.