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Supergrids for Balancing Variable Renewables

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Abstract

The development of a pan-EU HVDC supergrid network could help reduce the grid balancing problems created by the local variability of some renewable sources, by widening the geographical footprint, thus allowing a range of renewable sources across a wide area to be used. In addition to the large resources within the EU, including the major north sea offshore wind resource, there is a significant potential for renewable energy generation in areas on or near the periphery of the EU, and also beyond, such as wind in the East (e.g. in Kazakhstan and Turkmenistan), South (e.g. in Morocco), and North (e.g. in Siberia). In addition there is the solar resource on N Africa and the Middle East, and there are plans for exploitation it, using Concentrating Solar Power technology. Power from all of these sources could also be fed into the supergrid. The paper explores the technological and geographical options and their political and strategic implications.

Keywords: *Supergrid, intermittency, windpower, Concentrating Solar Power.*

1. Introduction

A recent study by Dr Gregor Czisch, from the University of Kassel in Germany, has suggested that the EU should develop a High Voltage Direct Current (HVDC) super transmission grid across Europe, which would make it possible to distribute and share wind derived power from wind farms in windy areas, this, along with hydro and some solar and biomass inputs, helping to provide a stable supply system (1).

There is over 65GW of on-land wind generation capacity already in place in the EU, and a major potential for expansion in and around the EU, including in several of the new EU countries (Bulgaria, Romania and Poland in particular) as well as in some countries which may yet join the EU (e.g. Turkey and the Ukraine).

With HVDC, energy transmission losses are very low, even over very long distances (2-3% over 1000 km), so, with suitable extensions, the supergrid could also link to remote but even windier regions well beyond the EU, including Kazakhstan, which Czisch estimates has a wind potential of 210 Giga Watts (GW) and Northern Russia and Western Siberia (350GW). Czisch also looked at the wind potential in Mauritania, which he put at 105 GW, and Southern Morocco, which he quoted as 120 GW.

On land wind is the cheapest of the major new renewables at present, but while offshore wind is more expensive, the resource is very large, perhaps 150GW in the North sea. A recent EWEA report suggested that the EU could get 17% of its electricity form this area by 2030 (2).

However there are also other options. The supergrid could also link into the large hydro resource in Norway, which could help balance variations in wind availability. There could also be links to the large geothermal resources in Iceland. In the longer term there is also the wave and tidal current flow resource in the North Sea.

In addition, the supergrid could link into the very large solar resource available in desert areas of North Africa and the Middle East, harvested using large focused-solar power plants. Several Concentrating Solar Power (CSP) plants have already been built in Spain and the USA, and projects are underway or planned in Egypt, Morocco, Algeria, Jordan and elsewhere. They will deliver some of the power locally, but they will have some available for export, with, in some cases, undersea grid links being developed across the Mediterranean. Molten salt heat stores can be used to allow for continued power generation over night, and solar heat can be used for desalination of sea-water, some of which can be used for cooling the CSP power units (3).

The availability of large renewable resources on the periphery of the EU, coupled with the large renewable resources within the EU, offers the hope that we can move beyond the current energy problems related to diminishing fossil fuel

reserves and on to a sustainable energy future. Moreover, the wider geographical footprint and range of renewable energy source inputs offered by the use of a supergrid system could ensure that the local variability of some renewable energy sources could be better balanced. For example, the 'Trade Wind' study led by the European Wind Energy Association suggested that aggregating wind energy production from multiple countries using supergrid links strongly increases the 'capacity credit' of wind i.e. the availability of wind energy to meet demand. The wider the countries are geographically distributed, the higher the resulting capacity credit (4).

A similar conclusion on the merits of cross boarder inter-connections was reached in a wider study by Greenpeace/ EREC, looking at the integration of inputs from the full range of renewables, including solar CSP (5).

2. The prospects for supergrids

There are several supergrid projects underway, with one focus being on new North Sea grids linking to offshore wind farms.

The European Commission has indicated that a pan -EU supergrid ought to have a high priority to help ensure energy security long term, and to help balance the variable local availability of some renewable sources.

The Euro Commission's Second Strategic Energy Review in 2008 included proposals for supporting schemes to encourage international co-operation, starting in the North Sea, and to push transmission organisations and energy regulators to enable offshore grid developments.

In Feb 2009 the Commission published more detailed plans with proposals, within the new 5bn euro EU Economic Recovery Plan, for funding for the supergrid- 150m euros (£139m) for work to help integrate more offshore wind energy through a North Sea grid between the UK, the Netherlands, Germany, Ireland and Denmark.

It also earmarked 1.75 bn euros (£1.62 bn) for work on gas and electricity networks, including 100 m euros (£93 m) for a link between the Ireland and Wales to help renewables generators in Ireland access the UK energy market.(6)

Industrial interest has emerged. Airtricity had already made proposals for a 10GW offshore wind farm grid network in the North Sea, as a first step (7). Mainstream Renewables has made similar proposals (8)

In Feb 2009, Norwegian transmission company Imera Power announced plans to build undersea grids in both the Atlantic and the North Sea, which it said could become the "foundation" for a EuropaGrid network. Imera has already received approval from European competition authorities for two transmission links between Wales and Ireland, and it is also working on new links between the UK and France and Belgium, which it said would form the starting point for the EuropaGrid (9).

CSP is also developing rapidly globally. A SolarPACES/ ESTELA/Greenpeace review in 2009 noted that, by the end of 2008, around 560MW of CSP was in operation globally, 984MW in construction and 7,463MW planned.

It claimed that, on the basis of moderate assumptions for future market development, 'the world would have a combined solar power capacity of over 830 GW by 2050, with annual deployments of 41GW. This would represent 3.0 to 3.6% of global demand in 2030 and 8.5 to 11.8% in 2050'. Moreover 'under an advanced industry development scenario, with high levels of energy efficiency, CSP could meet up to 7% of the world's projected power needs in 2030 and a full quarter by 2050' (10). Much of this could be in desert areas in North Africa and the Middle East.

The UAE's ambitious Masdar initiative in Abu Dhabi is supporting CSP. And a German 'Desertec' consortium has proposed a major 400bn grid-linked CSP programme in North Africa, involving Deutsche Bank, Munich Re, Siemens, RWE and E.ON.

That will take time, but more immediately, there are plans a 3,000km under-sea power link from the Algerian town of Adrar, via the island of Sardinia, to mainland Italy, across Switzerland and then to the German city of Aachen, linked to a 150MW hybrid solar-gas CSP plant at Hassi R'Mel in central M'Zab province, with expansion subsequently expected to 500MW.

In July 2009, a Mediterranean Union (U Med) was formally endorsed, promoting regional cooperation between the EU and developing nations bordering the Mediterranean, including North Africa. U Med’s Solar Plan aims to have in place up to 20GW of grid-linked CSP, wind and PV solar in North Africa and the Middle East by 2020, with cross-Mediterranean grid links being established.(12)

As indicated above, PV is being seen as another emerging option for desert areas, in particular concentrated photovoltaic solar (CPV), with solar focusing helping to com-pensate for the current relatively high cost of PV cells- since mirrors are cheaper than PV cells (11).

Overall, some real progress is being made with supergrid systems around the EU and the Mediterranean area. More projects are likely to follow, possibly using the Kyoto Joint Implementation and Clean Development Mechanism, with some of this energy being exported to the EU, for example under the EU's new Guarantee of Origin trading/offset system.

3. Problems and options

Clearly the supergrid would take a major effort politically, not least in terms of getting way-leave across national boundaries and negotiating power management and system control arrangements. It would also open up some new geopolitical

issues. The EU would still be partly reliant on imported energy, but fair trade arrangements could be negotiated to avoid exploitation and reduce the risk of being cut off.

There is the risk that a supergrid programme, utilizing energy from remote sources, might provide EU countries with an excuse for not dealing with their emission problems and developing their own renewable sources.

But the imports would only meet part of the EU's requirement for electricity, the bulk would still come from local/national renewable sources, backed up in the interim with gas and coal (with CCS). In practice the two areas, imports and national/local generation, could be expanded in parallel, reinforcing each other.

It is sometimes argued that it is foolish to transmit solar and wind derived electricity thousands of miles when these sources are available everywhere to some extent, but it is also the case that it makes sense to collect them where they are most intense. And these two approaches are not mutually exclusive.

It is also noted that the supergrid just deals with electricity, whereas heat and transport are also important. Some electricity could of course power plug in battery-electric cars, as well as electric trains and trams, and also be used in heat pumps. But there is also a range of direct renewable heat supply options, including domestic solar collectors, biomass CHP, and biogas from Anaerobic Digestion of wastes, which can be run in parallel. Once again, the two approaches are not mutually exclusive.

So as it all develops together, we could move to a mixed system, with local heat supplies and local, regional and continental electricity supplies, linked in at various levels, and with the supergrid being developed piecemeal, as suitable supplies became available.

Given that wind power is the cheapest at present, that is likely to be the first, along possibly with hydro, to feed into the supergrid. But CSP could catch up, followed perhaps by CPV. So it could be an evolving system.

Conclusions

There is a significant potential for renewable energy generation in areas on or near the periphery of the EU, and also beyond, such as wind in the East (e.g. in Kazakhstan and Turkmenistan), South (e.g. in Morocco), and North (e.g..in Siberia). In addition there is the solar resource on North Africa and the Middle East.

The main problem facing the supergird idea is politics- for example getting agreement for cross-national grid links. It has certainly sometimes proven hard to get agreement about new grid lines in parts of the EU. For example, parts of the new interconnector between the French and Spanish grids across the eastern Pyrenees, have had to be run underground at very large extra cost, due to environmental objections. However, it is sometimes argued that HVDC grids can carry more power and so may have less impacts than conventional AC grids. It has been suggested that some existing grid lines could be replaced and that only about a 15% expansion in new grid lines would be needed. Moreover, although expensive, it is easier to have underground installation with DC than AC, with the lower HVDC transmission losses basically meaning less heat loss to be dissipated (13)

Clearly there would have to be fair trade arrangements to avoid exploitation, and also protection for the EU against being cut off. But with a dedicated grid system linked to the EU, unlike with oil, which can be stored and shipped elsewhere, it is hard to see how there would be much opportunity for supply blackmail or major price speculation. Moreover, the EU would also presumably be trading in excess wind and hydro-power from the north, so it could be a two way, hopefully co-operative, arrangement.

There will of course be a need for negotiation over prices. That has already been an issue in relation to the export of excess power from Danish wind projects and the import, during low wind periods, of hydro power from Sweden and Norway (14). It is vital to capture the advantage of being able to balance variable renewable supplies across wide areas, and conventional competitive market trading may not reflect this.

One way to avoid price conflicts might be to develop an EU-based Cross-Feed Tariff, possibly also providing extra support for a suppliers able to offer stored renewable power.

If a fair balance can be achieved the prize could be a new geopolitics- no longer would Middle East oil or Russian gas dominate EU energy policy. Instead some of the relatively poor countries on or near the periphery of the EU could benefit.

There are of course political issues flowing from the fact that one part of the ECs enthusiasm for such a system is because it could help enhance competition in a pan-EU energy market. The problem is that this might undermine some of the regional

market control enjoyed by the current main energy players. Some of the large utility companies and some countries do seem less than enthusiastic about the single energy market, and also the supergrid. An additional issue might be that the EC and national governments may well look to the large energy companies for at least some of the funding for such a programme, something that the companies may wish to avoid.

This paper has focused on projects in and near the EU, but clearly the concepts have wider implications. It is interesting for example to see that the USA has plans for new grid systems to link up with renewables, with talk of an 'Interstate Transmission Super Highway' (15).

With large inputs from wind, CSP and from other renewables linked in, we could see a move to major supergrids around the world, fed and balanced by a range of sources from a range locations. If we are to respond effectively to climate change and improve energy security, this looks like at least part of way ahead.

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