A NOTE ON TREC AND CSP

Comment: Comments by Gerry Wolff

Mark Barrett, March 2007

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Comments by Gerry Wolff

I have made some comments on what Mark has said using the 'track changes' feature of MS Word.

We are in the fortunate position that there is more than one scenario in which renewable sources of electricity can meet our needs. Since there are uncertainties about how things will develop in the future, it is probably not sensible to try to decide *a priori* which of these alternative scenarios is 'right'. Rather, government policies should provide support and encouragement for **all** kinds of renewable energy. And governments should **not** be wasting large sums of money chasing the ever-receding mirage of fusion nuclear power, always 40 years into the future. *This is where we should be directing our fire!*

Here is a summary of the main points that Mark has made, with a summary of my responses alongside them:

1. *CSP is too expensive*.
    a. In a report from Business Week (2006-02-14), the CEO of Solel is quoted as saying "Our [CSP] technology is already competitive with electricity produced at natural-gas power plants in California".
    b. John S. O'Donnell, President of Tsugino Co., speaking before the Public Utilities Commission of the State of Colorado on the 29th of September, 2006, said "Concentrating Solar Power can be provided as firm dispatchable power using thermal storage at a cost per kWh under $0.10 for deployments over 50MW in plant size, and under $0.09 for deployments over 200MW in size. I have just returned from meetings in Australia with Solar Heat and Power which confirm these costs."
    c. Speaking about CSP at the Solar Power 2006 conference in California, US venture capitalist Vinod Khosla said "... we are poised for breakaway growth—for explosive growth—not

because we are cleaner [than coal-fired electricity] but because we are cheaper. We happen to be cleaner incidentally."

2. *CSP has been around for a long time and is not likely to become cheaper in the future*.

    a. Early experiments with CSP have not, until recently, led to further developments, largely because fossil fuels have been too cheap. The US government and other governments where CSP can be used have not given it the kind of support that has been provided for wind power in Denmark, Germany and elsewhere. So although CSP has been around for a long time, it has not yet achieved the economies of scale or economies from refinements in the technology that have been achieved with wind power.

    b. In connection with points 1 and 2, the 'DESERTEC' concept developed by TREC does not require that CSP should be the only way in which one might capture 'power from deserts'. If PV were to tumble in price, and if flow batteries or similar technologies for the storage of electricity became cheap, then it might make more sense to use those technologies in desert regions, instead of CSP.

3. *The TREC scenario will cause unacceptable damage to the environment*.

    a. One of Mark's concerns is with the effect of building long-distance power lines over land. But with the HVDC 'Supergrid' concept proposed by Airtricity, power cables would all be laid under the sea. Of course, environmental impacts would need to be assessed but they are likely to be small, and visual intrusion which is an issue with overhead lines, would largely disappear.

    b. Another concern is that CSP plants would cause unacceptable damage to desert ecosystems. CSP plants will certainly change the ecology in areas where they are set up. But since less than 1% of the world's hot deserts could produce as much electricity as the world currently consumes, plenty of untouched desert would be left.

c. There are no pollution problems associated with CSP that are comparable with the kinds of problems that are sometimes associated with oil extraction or ship breaking.

d. There are substantial potential benefits for local people described on http://www.trec-uk.org.uk/csp_sections/csp_bonuses.htm .

4. *The import of CSP electricity is a security risk for the UK*.

   a. In the scenario described in the TRANS-CSP report, there would be an overall *reduction* of imports of energy into Europe compared with the situation now and there would be an increase in the diversity of sources of energy. These two things would mean an overall *increase* in the the resilience and security of electricity supplies. Up to 2050, it is envisaged that CSP imports would constitute no more than 15% of Europe's electricity supplies.

   b. Hot deserts and other areas with high levels of direct sunlight are very widely distributed in the world—which means that *no country need be overly-dependent on a few sources*.

   c. Like the internet, HVDC transmission grids can be designed to be robust in the face of damage or attack. Submarine cables, as proposed by Airtricity for the Supergrid, would be relatively safe from attack.

   d. There are several other reasons why security is much less of an issue than it may superficially appear. These are described on http://www.trec-uk.org.uk/csp_sections/csp_security.htm .

5. *Building long-distance HVDC transmission lines would be too expensive*.

   a. Quite apart from the import of CSP electricity into Europe, there are other good reasons for building large-scale HVDC transmission grids: wind energy is much less variable over a wide area than it is in any one spot; surplus electricity in any one area can be transmitted to areas where it is needed, thus avoiding much of the wastage of energy that would otherwise occur.

b. Since it is likely that, for those kinds of reasons, large scale HVDC grids will be built anyway (see http://www.trec-uk.org.uk/transmission/HVDC_grids.htm), the marginal cost of connecting CSP plants into those grids will be relatively small.

c. The TRANS-CSP report calculates that CSP electricity is likely to become one of the cheapest sources of electricity in Europe, **including the cost of transmission**.

6. *Although Mark does not use these non-PC words, there is a sentiment behind what he says which can be expressed crudely as "We can't trust those Arabs."*

   a. As mentioned earlier, there are substantial potential benefits for local people in host countries where CSP plants would be set up. These potential benefits include: desalination of sea water using the waste heat from CSP plants; the creation of shaded areas under CSP mirrors (protected from the harsh tropical sun) with many potential uses including horticulture using desalinated water; jobs and earnings; plentiful supplies of clean electricity. Given these benefits from CSP plants, there is little incentive to disrupt their operation.

   b. The development of a collaboration amongst countries of Europe, the Middle East and North Africa (EUMENA), with substantial benefits for all, is a good way to improve international relations and build mutual understandings. *It is a positive alternative to the confrontational policies of recent years*.

   c. By alleviating shortages of energy and water, CSP can help to reduce tensions or conflicts that may arise over those resources.

7. One other point that is worth mentioning is that, because the amount of carbon-free electricity that can be derived from hot deserts is so enormous, there is potential to use it to displace other more polluting forms of energy in areas where electricity has not been much used. Rail travel throughout EUMENA could be electrified. Plug-in electric hybrid vehicles (PHEVs) could be powered largely by clean electricity. Carbon emissions from the heating of buildings could be

largely eliminated via a combination of improved insulation and ground-source heat pumps powered by carbon-free electricity.

This note results from general knowledge of modelling energy systems, and from some reading of TREC/CSP materials. This note merely raises issues, and doubtless the numbers used here can be challenged; it is not a thorough assessment. Nonetheless, the author concludes that the case for importing CSP electricity large distances into Europe is currently weak because of the economics, environmental impacts and political and security issues relating to long distance (>1000 km) transmission.

Comment: It might be as well to be a little less assertive until such time as the TREC proposals (including the TRANS-CSP and MED-CSP reports) have been examined thoroughly.

However, CSP may presently be appropriate and competitive closer to where it would be deployed, i.e. in low latitude areas. It may be that CSP will compete with indigenous renewable electricity sources in Europe in the longer term, although this depends on the evolution of electricity demand and CSP costs improving relative to other indigenous renewables. The security problem of new energy imports might be difficult to solve.

Comment: Why, then, is it necessary to be so assertive right now in questioning the validity of the TREC proposals?

Comment: This is mere prejudice. Mark has not looked at the issues properly at all.

More investment in to develop and demonsatrate CSP and other renewable technologies on a commercial scale is required.

Comment: CSP has been in operation on a commercial scale since 1985.

Time will tell which technologies are best in which locations.

Comment: Exactly! So why try to pre-judge the issue now?

Objectives and approach

The objective is to securely reduce CO2 emissions and improve energy security at least cost, whilst minimizing other impacts. There is an ethical question of rich countries 'exporting' environmental impacts to other countries, especially poor ones, such as is now a concern with biofuels.

Comment: There are other objectives that have been overlooked. By alleviating shortages of energy and water, CSP can reduce the risk of conflict over those resources. By developing a collaboration amongst countries of EUMENA, with substantial benefits for all concerned, CSP can help to build mutual understanding and improve relations – a positive alternative to the confrontational policies of recent years.

Comment: This is simply a smear. There is no evidence that, with CSP, there would be any export of negative environmental impacts exported from rich countries to poor. There would, in general, be substantial benefits for poor countries (see http://www.trec-uk.org.uk/csp_sections/csp_bonuses.htm).

The question is: what is the least cost combination of demand efficiency and management, renewable generation, storage and transmission that will reach this objective for the UK, for Europe or for a larger region? Demands and renewable energy sources are distributed in space and time in complex ways. Because of this, it is a difficult question to answer for any one country with current demands using present technologies; to provide a solution for an area including Europe and North Africa, decades in the future requires speculation about many developments. On the technology side, the development of cheaper solar PV and electicity storage are examples of

Comment: The word 'speculation' is another smear. It implies that everything is pure guesswork. Of course there is uncertainty about future developments but that is true of all attempts to plan ahead, including Mark's own work!

technologies that would have a profound impact on the optimum supply mix.

Models that simulate the performance of complex energy demand-supply systems are required. Many electricity and other models have an emphasis on the supply side which may lead to sub-optimal mixes. For example; if a substantial fraction of lectricity is used for heating, then this has implications for demand patterns (peak when insolation minimum) and the possbility of cheap heat storage. Will biomass be used for CHP which can provide some load matching? It is not clear that the publishedTREC/CSP modelling accounts adequately for such factors.

It is probable that as the fraction of variable and unpredictable renewable energy inputs to supply systems increases, so will the use of storage and transmission. However, analysis by Barrett indicates that a 95% renewable UK electricity system can predominantly use UK resources and will not require long distance transmission or large increases in energy storage. A report on this work may be found at:

http://www.cbes.ucl.ac.uk/projects/energyreview/Bartlett%20Response%20to%20Energy%20Review%20-%20electricity.pdf

This scenario indicates that CSP imports would not be competitive, though it does assume reductions in solar PV costs.

The solutions in other parts of the EU may be very different, although the renewable resources of wind, wave, tide and solar of Europe are considerable.

CSP technology

Like most renewables, CSP generation is of low intensity (about 0.2 GWe(peak)/km2) and variable. Solar radiation has a maximum 'intensity factor' (average/peak insolation W/m2) of 50%, and in actual conditions can range 10-25% depending on latitude, weather and technology. Even in deserts, there is a possibility that cloud or sandstorm will severely reduce CSP output over a large area for periods of many hours and back-up is needed for this eventuality.

Unlike biomass, hydro, and geothermal energy, but like other renewables, CSP has minimal energy storage integral to the basic generation process. However, like other renewables, storage or back-up power for CSP can be provided at additional cost and energy loss to provide reliable generation. In the case of CSP, high temperature thermal storage would facilitate generation when insolation is low or zero.

Comment: Of course this is true but it would have just as much impact on Mark's proposed scenario as it would on any other proposal. There is no reason wny cheap PV and cheap storage of electricity should not be used in desert regions, instead of CSP.

Comment: There is absolutely no mention of CSP in Mark's report! How can he possibly say that the scenario described in his report indicates that CSP would not be competitive? The comparison has not been made!

Comment: There are indeed large renewable resources in Europe. But the quantities of solar energy available in desert regions is very much larger than any of the renewable energy resources in Europe. Diversity of suppy is the key to resilience and security of energy supplies.

Comment: Why make this point here if CSP is similar to other renewable sources of energy? It adds nothing to the discussion except for the rather generalised implication that CSP is problematic.

Comment: One of the slides provided with the TRANS-CSP report shows intensities of different sources of renewable energy in EUMENA in $GWh_{el}/km^2/y$: biomass (1), geothermal energy (1), wind energy (30), hydropower (30), solar energy in hot deserts (250)! It is **other** renewable sources of energy that suffer most from low intensities.

Comment: All sources of electricity, including electricity from coal or nuclear power, have load factors that are less than 100%. There is no source of electricity that is not intermittent. This is especially true of wind power which figures large in the scenario that Mark proposes.

Comment: This is one of the key advantages of CSP over the PV technology that Mark relies on in his proposed scenario. It is possible to store solar heat in melted salts (eg nitrates of sodium or potassium) so that electricity generation may continue through the night and on cloudy days. Because CSP plants are so similar to conventional power stations, it is also possible to use gas as a stop-gap source of heat when there is not enough sun.

Thus, unlike most other renewable sources of energy, CSP can provide base-load power, intermediate power and peaking power, according to need.

Lifetime and operation and maintenance in desert conditions are subject to uncertainty.

Comment: Mark may feel some uncertainty but the people who have been operating CSP plants in California since 1985 will have a rather good understanding of those issues!

Economics

The cost of energy to consumers is basically the sum of generation, storage and transmission costs, although the variability of demand and renewables makes this difficult to calculate.

The more distant demand is from generation, the greater the losses and cost of transmission. Roughly speaking, 2-3000 km transmission loses about 10% of input electricity and costs 1-2 p/kWh. This is about 20-40 % of the current cost of wind generation in the UK and makes it more difficult for CSP, or any remote renewable, to compete.

Comment: This conclusion is quite different from the conclusion of the TRANS-CSP report that CSP electricity is likely to become one of the cheapest sources of electricity in Europe, **including the cost of transmission**.

The experience seems to show that recent actual (not projected) CSP generation costs are perhaps 100-200% greater than actual UK wind costs. Furthermore, there is uncertainty in O&M costs in desert conditions.

Comment: The figures for current costs for CSP electricity that Mark was quoting in Bath are much higher than figures quoted by people working in the industry or planning to invest in it (see http://www.trec-uk.org.uk/csp_sections/csp_costs.htm).

Altogether, the total cost of CSP electricity delivered to the UK might currently be about two to four times the cost of UK wind electricity. Projections can be made of how CSP capital and O&M costs might decrease over the coming decades through innovation and mass production, but these are speculative, just as are the estimates for other technologies. It is to be remembered that CSP is not a very new technology.

Comment: Again, there is now a lot of experience of operating CSP plants in desert conditions so it is not right to make such an issue of supposed uncertainties about these points.

Comment: Mark's back-of-an-envelope calculations are quite different from the figures given in the much more thorough TRANS-CSP report.

Comment: Although CSP is not new, it has not yet benefitted from the economies of scale and refinements of the technology that have brought down the price of wind power. Wind power was brought on stream via support from the Danish government and other governments. For a variety of reasons, CSP has had much less support in the USA and other places where CSP might be used. As before, the word 'speculative' is simply a smear and adds nothing to the debate. Projections of all kinds suffer from uncertainty, including the projections that Mark has made.

Environment

The environmental impacts of transmission and generation have to be thoroughly accounted for.

It seems that, very approximately, a 3000 km HVDC transmission line would require, per GW, some 5-10000 pylons stretching across several countries; in contrast, 500 wind turbines produce a GW – a tenth of the number of large structures. 3000 km of transmission might require 100 kt tonnes of steel and cement and 70 kt of aluminium.

Comment: None of these points are relevant to the 'Supergrid' concept proposed by Airtricity in which all the HVDC transmission lines would be laid under the sea!

Each GW of CSP covers about 5 km2 or more of land. Desert ecosystems can be fragile. There are questions such as how mirrors would be kept clean in a dusty, arid environment.

Apart from the physical impacts of these technologies on ecosystems, the visual impacts of these technologies and consequent public opposition can strongly inhibit their development; especially if the energy is not being used within the country where the impacts occur.

Politics and energy security

First, it may be argued that the UK or any country should show what it can do in its own country, and not export impacts elsewhere, such as is happening with biofuels.

It is clear that the dependence on importing fossil fuels undermines national or European security, and increases the possiblity of international conflict over energy resoures. Importing any energy resource causes this problem, whether finite or renewable. Furthermore, whereas most countries have long term stores of fossil or nuclear fuels providing strategic security, this is not possible for electricity. Therefore, reliance on substantial distant CSP (or any) generation, poses a security problem which can only be relieved with alternative energy supplies. In addition, the nature of CSP and transmission technologies makes them difficult to protect.

Given current concerns about energy imports into Europe, it is difficult to imagine convincing politicans to have an energy policy that relies on a 2000 km cable across several countries to a CSP installation in a region with which the UK and parts of Europe currently have some political disagreements, rather than relying on North Sea wind turbines on other indigenous generation, even if there were an additional cost to reliance on indigenous or EU resources.

Political security can be enhanced by economic cooperation and exchange, but this is possible without bulk energy trade. A strong case could be made for investing in demonstration commercial scale CSP.

Summary

It is difficult to predict what may be best in the distant future, and so it is pragmatic to pursue the least cost, least impact path at step by step in each country and region provided this does not prevent cost-effective final systems being developed. To invest in CSP and transmission to Europe at present would not be the best next step. For the UK, the next most cost-effective low carbon electricity supply steps might be wind and CHP. However, R&D and demonstration expenditure on renewable, storage and transmission technologies should be increased now and maintained.

If CSP is the best option, then it can be deployed to replace the nearest fossil fuel generation in high solar regions– this will result in the greatest global CO2 reduction per Euro. This could be done through such devcies as the Clean Development Mechanism, aid programmes, or straight investment.

Comment: As mentioned before, the impacts of CSP in host countries would be very positive, not negative as he implies. Desalination of sea water and the creation of shaded areas with many uses, including horticulture are substantial benefits for local people, in addition to the jobs, earnings and plentiful supplies of clean electricity.

Comment: There is a range of reasons why security of electricity supplies will be significantly greater in the scenario described in the TRANS-CSP report than are current energy supplies. These reasons are summarised on http://www.trec-uk.org.uk/csp_sections/csp_security.htm .

Comment: There are already very good reasons for developing for a Europe-wide HVDC transmission grid and there is even a proposal for a world-wide HVDC transmission grid (see http://www.trec-uk.org.uk/transmission/HVDC_grids.htm). The main reasons are that large-scale HVDC grids can greatly reduce the variability of sources such as wind power and, perhaps, more importantly, they have an important role in allowing electricity to be moved from anywhere that has a temporary surplus to other areas where the electricity is needed – thus reducing the large amounts of wastage that would otherwise occur.

Since it is likely that large-scale HVDC grids will be built for those kinds of reasons, it would obviously be sensible to ensure that CSP plants in North Africa and the Middle East were connected in to those grids. Little England might choose to do its own thing, but that would not be wise!

Comment: HVDC transmission technologies are already mature. They have been in use for over 50 years.

If, after installing and improving CSP on a large scale and obtaining operating experience over the coming decades, it becomes clear that the CSP electricity can compete on cost and environment and security grounds with indigenous European options, then CSP can take its place in the mix through free economic competition.

Comment: Development of CSP plants will obviously begin in the areas that have plenty of sunshine and the first market for their electricity will obviously be people living nearby. But when large-scale HVDC transmission grids have been built (for the reasons given above), it would be natural to connect CSP plants in to them. It would also make sense for the UK to be connected into the same supergrid.