Comments on "2050 Pathways Analysis," HM Government, July 2010

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These comments on the *2050 Pathways Analysis* (HM Government, July 2010) are my personal comments although I am Coordinator of Desertec-UK,[1] and I'm a member of the Energy Fair group[2] and the Kyoto2 Support Group (K2S).[3] The comments are not intended to be comprehensive but relate to areas where I have most knowledge.

Foreword (p 1)

Chris Huhne refers to "expected levels of population growth" rather as if this is something that the Government cannot influence. But, while it is prudent in this document to consider worst-case scenarios, it is important to recognise that the Optimum Population Trust and others believe that, for a variety of reasons including food security and degradation of the environment, the Government can and should have policies in place to try to limit and, if possible, reduce the size of the UK population. Press reports suggest that the Prime Minister at least is sensitive to this body of opinion.

The model has a UK focus (p 12)

This makes reasonably good sense for most of the document. But, because of the importance of large-scale supergrids in balancing electricity supply and demand, it will be important in that connection (Section P) to consider a much larger area such as the whole of Europe or the whole of Europe, the Middle East and North Africa (EUMENA).

A growing level of variable renewable generation increases the challenge of balancing the electricity grid (p 34)

There seems to be something of a misunderstanding here:

- All sources of electricity are intermittent because any kind of equipment can fail.
- The demand for electricity is constantly varying.

With regard to the first point, when a conventional power station fails, the effect is normally quite disruptive because that kind of power station is normally quite large and when it fails, the relatively large amount of electricity that it produces is normally lost quite suddenly. By contrast, when the wind dies, it normally does so gradually and there is normally at least a few hours warning. And of course the failure of a few wind turbines amongst many would barely be noticed.

Naturally, a shift towards renewables will make a difference to how supply and demand is balanced on the grid. But the differences may not be as big as is sometimes assumed. In his

[1] http://www.desertec-uk.org.uk.
[2] http://www.energyfair.org.uk/home.
[3] http://www k2support.org/home.

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report, *Managing Variability*,[4] David Milborrow argues that electricity transmission networks in the UK are *already* designed to cope with variability arising from the failure of power stations and from variations in consumer demand, and that, for a small additional cost, wind power could provide up to 40% of the UK's electricity. Further increases in the level of wind penetration are feasible and do not rely on the introduction of new technology.

There is more discussion of these issues below in connection with Section P.

Understanding the cost implications (p 38)

In successors to the *2050 Pathways Analysis* and in new versions of the *2050 Pathways Calculator Excel model*, it is important that information about costs is as accurate as possible. This is especially true of the cost of nuclear power.

Notwithstanding the misleadingly low figures for the cost of nuclear power that are put out by the nuclear industry and repeated, apparently without critical examination, by other organisations, it is now well established that nuclear power is one of the most expensive ways of generating electricity. This is documented in several publications that are listed, with download links, on www.mng.org.uk/gh/nn.htm#subsidies.

For example:

- A report from Citigroup[5] says "Three of the risks faced by developers—Construction, Power Price, and Operational—are so large and variable that individually they could each bring even the largest utility company to its knees financially. This makes new nuclear a unique investment proposition for utility companies." and "Government policy remains that the private sector takes full exposure to the three main risks; Construction, Power Price and Operational. Nowhere in the world have nuclear power stations been built on this basis."
- The cost of nuclear power is disguised by several subsidies described in the *Nuclear Subsidies* report from the Energy Fair group.[6] Here are two examples:
    - The operators of nuclear plants pay much less than the full cost of insuring against a Chernobyl-style accident or worse. It has been calculated that in France, where insurance arrangements are similar to those in the UK, if EDF had to insure for the full cost of a meltdown, the price of nuclear electricity would increase by about 300%.[7] The *Nuclear Subsidies* report calculates that withdrawal of this one subsidy would raise the price of nuclear electricity to more than 20 US cents per kWh. Removal of the other subsidies described in the report would raise the price even higher.
    - The operators of nuclear plants are paying much less than the full commercial cost of disposing of nuclear waste. Writing in *Nuclear Engineering*

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[4] *Managing Variability*, a report by independent consultant David Milborrow commissioned by Greenpeace, WWF, RSPB, Friends of the Earth, July 2009, http://www.trec-uk.org.uk/reports/milborrow_managing_variability_final_July_2009.pdf, PDF, 402 KB.

[5] *New Nuclear – the economics say no; UK green lights new nuclear – or does it?* (PDF, 144 KB, report from Citigroup Global Equities Online, 2009-11-09, https://www.citigroupgeo.com/pdf/SEU27102.pdf).

[6] Copies may be downloaded via links from http://www.energyfair.org.uk/home.

[7] Appendix J of the report "Environmentally harmful support measures in EU member states" says "Scenario B, in which all liabilities are covered at the upper damages estimates, results in premiums of 5.0 c€/kWh. This insurance scenario would thus lead to a tripling of current total generating costs." (p 132). The report, which was commissioned by the DG Environment of the European Commission, 2003, can be downloaded from http://www.mng.org.uk/gh/resources/EC_env_subsidies.pdf (PDF, 1.1 MB).

International,[8] Ian Jackson says that a "fully commercial price would make disposal far too expensive, killing the prospects of any new nuclear build programme in Britain …. The bottom line is that nuclear energy utilities probably need fixed waste disposal 'prices' for repository disposal capped somewhere in the range from £12,200 to £24,400/m^3, but the NDA's true marginal 'cost' is nearer to £67,000/m^3, and the commercial 'value' of the repository asset could approach £201,000/m^3 if operated as a fully private sector venture.".

- According to a 2005 report from the New Economics Foundation,[9] a kilowatt-hour of electricity from a nuclear generator would, in 2005 prices, cost as much as 8.3 pence (16.3 US cents) once realistic construction and running costs are factored in, compared with about 3 pence (5.9 US cents) claimed by the nuclear industry at that time—and that's without taking account of the subsidies described in the *Nuclear Subsidies* report.

It appears that figures for the cost of nuclear power that were used in the preliminary analysis of costs in the *2050 Pathways Analysis* are not accurate:

- In "Figure 4: Average gross cost per megawatt-hour of the illustrative pathways in 2050" (p 43), pathway Delta (low renewables, high nuclear) comes out as the cheapest option. With more accurate figures for costs, as indicated above, it would almost certainly be the most expensive option.

- The figures given for the capital costs of nuclear power in "Capital cost assumptions (2009 prices)" (p 245) appear to be too low. A recent analysis by Standard & Poor's suggests that the capital cost of a nuclear plant is about $6500/kW (£4185/kW).[10] This is substantially higher than the 'High' figure of £3125/kW given in the Pathways document, p 245. Correspondingly, the curve for pathway Delta in "Figure 3: Annual capital costs for large scale electricity generation to 2050" (p 42) is almost certainly too low.

Future versions of the Analysis and the Calculator should include estimates of the cost of nuclear power that are as accurate as possible. They are likely to be very much higher than the figures given in, for example, the Government's 2008 white paper on nuclear power.[11]

The costs of imported electricity (p 40)

"It is unclear how much this electricity will cost and for this reason the costs have been excluded from the analysis."

There are detailed, country-by-country projections of the cost of 'desert' imports in Annex 1 of the 'TRANS-CSP' report from the German Aerospace Centre (DLR).[12] Overall, the report projects that electricity from desert regions in the Middle East and North Africa is likely to

[8] "Buried costs", Nuclear Engineering International, April 2008, http://www.greenpeace.org.uk/files/pdfs/nuclear/Nukenomics-Jackson.pdf.

[9] *Mirage and oasis: energy choices in an age of global warming* (PDF, 1.2 MB, New Economics Foundation, June 2005, http://www mng.org.uk/gh/scenarios/nef_energy_june_2005.pdf).

[10] See "New US nuclear projects depend on federal loan guarantees: S&P", Platts, 2010-08-17, http://www.platts.com/RSSFeedDetailedNews.aspx?xmlpath=RSSFeed/HeadlineNews/Nuclear/8907506.xml.

[11] *Meeting the energy challenge: a white paper on nuclear power, Department for Business, Enterprise and Regulatory Reform*, January 2008, http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/nuclear/whitepaper08/file43006.pdf.

[12] The TRANS-CSP report may be downloaded via links from http://www.desertec-uk.org.uk/reports htm.

become one of the cheapest sources of electricity in Europe, and that includes the cost of transmission.

"Including them would increase the relative costs of those pathways which include significant amounts of electricity imports."

The projections just mentioned show, country-by-country, and allowing for the cost of transmission, how imports of desert electricity into Europe would *reduce* the price of electricity in each country compared with what it would be without those imports.

Section G: Nuclear (p 167)

Apart from some brief discussion of the problem of disposing of nuclear waste, there is no mention in this section or elsewhere in the document of the several problems with nuclear power.[13] Those problems are likely to have an impact on decisions about energy supplies in the future and are thus relevant to the *2050 Pathways Analysis*.

Section P: Electricity balancing (p 227)

As indicated earlier, the problem of balancing supply and demand on the grid is probably not as great as it may at first sight appear. There is a range of techniques for keeping supplies in balance with demand, either available now or likely to be available well before 2050.[14]

A potent means of keeping supply and demand in balance is the provision of a large-scale HVDC supergrid—so that a shortfall in any area may be met from one or more other areas. For that reason, and several others, there is now a considerable momentum towards the creation of such a grid spanning Europe, the Middle East and North Africa (EUMENA).[15]

Given the importance of integrating supply and demand over a large area, it is important that computer models of supply, demand and techniques for keeping them in balance, should be for the whole of EUMENA, or at least the whole of Europe, and should not focus purely on the UK.

Apart from the supergrid, it is very useful if there can be supplies of electricity that can be increased or decreased quickly according to need. In that connection, three types of supply stand out:

- *Geothermal power*. As the Pathways document recognises, there is useful potential in the UK. But there is additional large potential in Europe.[16]
- *Hydropower*. There is some hydropower in the UK but, as the Pathways document recognises, there is substantially more in the Alps and in Norway.
- *Concentrating solar power (CSP)*. With heat storage and backup sources of heat, CSP plants can provide power on demand, day and night.

Section R: Electricity imports (p 241)

"The 2050 electricity import levels used in this analysis assume that the UK participates with other European and Mediterranean countries in a common project for large scale concentrated

[13] See http://www mng.org.uk/gh/nn htm.
[14] See, for example, http://www.desertec-uk.org.uk/elec_eng/supply_demand html.
[15] Reasons for developing a supergrid are described on http://www.desertec-uk.org.uk/elec_eng/grid htm. Information about moves to develop an HVDC supergrid may be found under the heading "Large-scale HVDC transmission grids" on the same page.
[16] See http://www.egs-energy.com/resource/uk-and-europe html.

solar power stations. Depending on the level of engagement of the UK in this international project, a 'fair share' of the generated electricity would become UK imports." (p 241).

It is unlikely that the Desertec scenario would be realised in this way. Already, two consortia have been set up to develop the Desertec vision: the Desertec Industrial Initiative,[17] led by Munich Re, and Transgreen,[18] led by EDF. When 'desert' electricity comes on stream and is available for export from host countries, it may be offered for sale in the anticipated EU single market for electricity[19] so that any customer in the EU, including customers in the UK, may buy it.

There is no need for any centralised project and no need for any direct involvement by the UK government—although the Government can help smooth the path for these developments by encouraging appropriate policies at the EU level. The idea that Desertec "would need substantial international cooperation" is not really accurate. The main requirement is the provision of an appropriate framework of laws and regulations and appropriate agreements with countries that have the sunshine. With those things in place, the cooperation that will be required will be mainly amongst the companies doing the work.

It appears that the assessments in this part of the Pathways document are too pessimistic:

- eSolar[20] and other CSP companies are rationalising the designs of CSP plants to facilitate mass production and, perhaps more importantly, rapid installation using a minimum of skilled labour. eSolar has already established partnerships with Penglai in China and the ACME group in India for the mass production of CSP equipment.

- Although PV is not the same as CSP, it can give us an indication of what can be achieved. In 2009, Germany installed 3.8 GWp of PV. Given a capacity factor of 9.7%, it would at this rate of installation take just under 22 years to install enough capacity (just under 83 GWp) to generate 70 TWh/yr.

- With the kinds of rationalisation of designs mentioned in the first bullet, above, it seems reasonable to assume that, with a similar effort, and the relative simplicity of installing CSP equipment in bulk in the desert compared with many small installations on rooftops in Germany, it would be feasible to install at least 2 GWp of CSP capacity each year. Given a capacity factor of 60%[21] (which can be achieved with heat storage and backup sources of heat), it would take just under 7 years to install enough capacity (a little over 13 GWp) to generate 70 TWh/yr and just under 14 years to install enough capacity (just under 27 GWp) to generate 140 TWh/yr.

On the strength of this evidence, it appears that the scenario for Level 4 in Section R of the Pathways document should be rated at Level 2. As a general point, CSP systems, like PV and wind turbines, are composed of relatively small, independent modules. For that reason, the rate at which they can be manufactured and installed is a relatively direct function of the human and financial resources that are applied but with benefits from economies of scale. As noted below, the world is well able to produce things fast.

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[17] See http://www.dii-eumena.com/.
[18] See http://www.prysmian.com/communication/news html?newsLink=/archive/news/2010/news025 news.
[19] See, for example, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/836&type=HTML.
[20] See http://www.esolar.com/.
[21] See p 77 of the TRANS-CSP report from the DLR which may be downloaded via links from http://www.desertec-uk.org.uk/reports.htm.

Transmission links to the UK. For Level 4, the Pathways document suggests "A significant grid infrastructure in Europe would need to be constructed with a UK interconnector of an additional 20 GW designated for electricity imports." There are two points here:

- The reference to the required size of the UK interconnector assumes that flows of electricity between mainland Europe and the UK are all in one direction. Given that the UK has some of the best renewable energy resources in Europe, and given that there are more than enough such resources to meet all of Europe's energy needs,[22] it is likely that the UK will be a net exporter of electricity. In that case, the size of the interconnector that would be required is likely to be smaller than suggested in the Pathways document.

- With regard to the capacity of the grid as a whole, an important point is that, in any grid where consumers and producers of electricity are distributed across the geographical area of the grid, a 'cascading' effect operates. This means, for example, that consumers of electricity in the UK may benefit from 'desert' electricity from North Africa without it being necessary for electrons to travel all that distance. This is explained in www.desertec-uk.org.uk/elec_eng/cascade.html. This effect does not eliminate the need for long-distance transmission via low-loss HVDC transmission lines but it means that the amount of such transmission that is required may be less than if the cascading principle were not operating.

If the UK can be a net exporter of renewable electricity, one may ask what, from a UK perspective, is the point of electricity supplies from the Middle East and North Africa? Such supplies are important from a UK perspective because, with other supplies from across EUMENA, they increase the overall robustness of the EUMENA-wide system and reduce the risk of any temporary shortfall in UK supplies. Since, as was noted earlier, CSP with heat stores and backup sources of heat can supply power on demand, it can make a useful contribution to the robustness and security of electricity supplies throughout EUMENA.

There is undoubtedly a lot to be done to decarbonise the UK's economy. But, as an antidote to the somewhat pessimistic tone of the *2050 Pathways Analysis*, here are some reasons for optimism:

- It is clear from several reports that there are, by a wide margin, more than enough renewables to meet all the world's present demands for energy (not just electricity) and anticipated demands in the future.[23]

- An economic model conducted for the *New Scientist* magazine suggests that radical cuts to the UK's emissions would cause barely noticeable increases in the price of food, drink and most other goods by 2050.[24]

- A report from the European Climate Foundation found that in several scenarios, up to and including the generation of electricity from 100% renewable sources, the future

[22] See reports by the European Environment Agency and the Offshore Valuation Group which are referenced on http://www.energyfair.org.uk/pren.
[23] See http://www.energyfair.org.uk/pren and http://www.mng.org.uk/gh/scenarios.htm.
[24] See "Low-carbon future: we can afford to go green", *New Scientist*, 2009-12-02, http://www.newscientist.com/article/mg20427373.400-lowcarbon-future-we-can-afford-to-go-green.html?full=true.

cost of electricity is comparable to the future cost of electricity under the current carbon-intensive infrastructure—and supplies would be at least as reliable.[25]

- There are huge commercial opportunities for 'UK plc' in the new green economy of the future.
- In their article last year in the *Scientific American*,[26] Mark Jacobson and Mark Delucchi make two interesting points:
    - Because there would be much less wastage of energy in a renewables scenario, total world demand for power in 2030 would be 11.5 terawatts, using renewables, compared with 16.9 terawatts if we were to stick with conventional sources of energy.
    - As a measure of how quickly things can be manufactured, the world creates 73 million cars and light trucks every year. Although the tooling would be different, this statistic suggests that, for the world's industries, it would not be a major undertaking to produce the 3.8 million 5 MW wind turbines that would be needed in the Jacobson and Deluchi scenario to produce 51% of the world's electricity.

When the USA entered the second world war, President Roosevelt famously told the car makers to make tanks, not cars, and, despite initial protests, they greatly exceeded their targets. To borrow an inspirational phrase from President Obama, "Yes, we can".

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[25] See *Roadmap 2050*, European Climate Foundation, with others, in 3 volumes, April 2010, http://www roadmap2050.eu/.

[26] "A path to sustainable energy by 2030" Mark Z. Jacobson and Mark A. Delucchi, *Scientific American*, November 2009, http://www.stanford.edu/group/efmh/jacobson/sad1109Jaco5p.indd.pdf.