Energy Fair

NUCLEAR SUBSIDIES

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1 Introduction[1]

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.[2] Bearing in mind that there are now several reports showing how to decarbonise the world's economies without nuclear power,[3] that nuclear power is far from being zero carbon,[4] that there are more than enough alternatives,[5] and that those alternatives are quicker to build and have none of the headaches of nuclear power,[6] there is absolutely no case for new nuclear power plants anywhere in the world. In terms of the fight against climate change, money spent on nuclear power is a mis-allocation of resources. The alternatives are quicker and cheaper.

The purpose of this report, prepared by the Energy Fair group,[7] is to highlight the several subsidies for nuclear power, many of which are hidden from view. According to calculations in Section 2.11, withdrawal of just one of those subsidies (limitations on liabilities) would mean that power from new nuclear power stations would cost about 20 US cents per kWh, a level that would make it deeply unattractive to investors. Without the other subsidies identified in this report, it would be even more expensive.

The existence of these subsidies—for an industry that has been established for many years, has already received a large amount of support, and should now be commercially viable without the need for subsidies—is a clear breach of the principle of fair competition.

Although the nuclear industry is now pressing for even more subsidies (see Section 2.9), there is no case for providing them. There is certainly no case for such things as adding a tariff to consumer bills to pay the excess costs of nuclear power, or new tax breaks, as has been called for by the industry.[8] Instead, we should be aiming to *wind down the arms race of subsidies, reserving them for where they are really needed* (see Section 6).

In Section 2, next, we review the main subsidies that are enjoyed by the nuclear industry, focussing mainly on the situation in the UK. Section 3 examines possible justifications for subsidising nuclear power and concludes that none of them are valid. Section 4 considers how subsidies for nuclear power may be withdrawn. Section 5 reviews some of the evidence showing that there are more than enough alternatives to meet the UK's current and anticipated future needs for energy, not just electricity. Section 6 describes distortions in energy markets and how they may be corrected.

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[1] An electronic version of this document, with live links, may be downloaded from http://www.mng.org.uk/gh/resources/nuclear_subsidies1.pdf.
[2] Information on that point, with links to relevant sources, may be seen at www.mng.org.uk/gh/nn.htm#subsidies.
[3] See Section 0 and http://www.mng.org.uk/gh/scenarios.htm.
[4] See http://www.mng.org.uk/gh/nn.htm#CO2.
[5] See Section 0 and http://www.mng.org.uk/gh/energy.htm.
[6] See http://www.mng.org.uk/gh/nn.htm.
[7] See http://www.nonukes.org.uk.
[8] "Energy firms in secret talks on nuclear 'levy'" (Sunday Times, 2009-08-16, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6797809.ece) and "Nuclear power industry may benefit from climate change levy exemption", The Times, 2009-11-12, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6913118.ece.

2 The subsidies

Most of the subsidies described in this section take the form of exemptions from costs that businesses are normally required to cover. The exemptions have the effect of pushing costs on to taxpayers, or the public at large, including people in other countries or people who are not yet born. Although they may be disguised, the subsidies are real.

2.1 Limitations on liabilities

Nuclear power is only required to pay a small fraction of the cost of insuring fully against claims from a Chernobyl-style disaster, or worse.[9,10,11] For example, "... in the United States, the Price-Anderson Act limits the nuclear industry's liability in the event of a catastrophic accident to $9.1 billion, which is less than 2% of the $600 billion guaranteed by the Congress. In any case, $600 billion is considered to be a gross underestimate ..."[12] and "In France, if Electricité de France had to insure for the full cost of a meltdown, the price of nuclear electricity would increase by about 300%. Hence, as opposed to conventional wisdom, the price of French nuclear electricity is artificially low."[13,14]

Elsewhere, there are provisions which are similar to the Price-Anderson Act. In the UK, for example, the Energy Act 1983 brought legislation into line with earlier revisions to the Paris/Brussels Conventions and set a new limit of liability for particular installations. In 1994 this limit was increased again to £140 million for each major installation, so that the operator is liable for claims up to this amount and must insure accordingly. The UK government is now proposing to increase the limit to €1.2 billion[15] but this still falls far short of the potential cost of a Chernobyl-style accident or worse.

The majority of the insurance is provided by a pool of UK insurers comprising 8 insurance companies and 16 Lloyds syndicates—Nuclear Risk Insurers.[16] Beyond £140 million, the current Paris/Brussels system applies, with government contribution to Special Drawing Rights 300 million (about €360 million).[17] As with the limitations on nuclear liabilities in the USA, these sums—which are measured in millions of €—are very much less than the potential cost of a Chernobyl-style accident or worse—which is measured in hundreds of

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[9] See "Government delays nuclear power insurance plans", Building, 2009-03-06, http://www.building.co.uk/story.asp?storycode=3135466.

[10] There is relevant information in *Nuclear costs and finance*, which may be downloaded from http://www.mng.org.uk/gh/resources/Nuclear_Costs_and_Finances.pdf. The most relevant section is "What every investor wants" and the following section.

[11] Other sources include: http://www.neimagazine.com/story.asp?storyCode=2052512, http://www.iaea.org/Publications/Documents/Conventions/liability.html, http://www.nea.fr/html/law/paris-convention-protocol.html.

[12] Helen Caldicott, *Nuclear power is not the answer*, New York and London: The New Press, 2006, ISBN-13 978-1-59558-067-2, page 32.

[13] Nuclear power is not the answer, page 32.

[14] Regarding the 300% figure, 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).

[15] See "Seven-fold increase in liability for nuclear sites announced", DECC press release, 2011-01-24, http://www.decc.gov.uk/en/content/cms/news/pn11_007/pn11_007.aspx.

[16] See http://www.nuclear-risk.com/.

[17] This information comes from "Civil liability for nuclear damage" from the World Nuclear Association, http://www.world-nuclear.org/info/inf67.html.

billions. They are also much less than the $41 billion that BP has set aside to cover claims arising from the Gulf of Mexico disaster.[18]

In addition to the limitations on the sums of money that may be paid out, compensation rights are extinguished under both the Paris and Brussels Conventions if an action is not brought within ten years. Since it can take at least that long for radiation-induced cancers to develop, that limitation on liabilities represents yet another subsidy for the industry.[19]

Since nuclear operators are paying much less than the true cost of insuring against nuclear disasters, they are enjoying a large subsidy, without which they would not be commercially viable (see Section 2.11). This is true although it is sometimes said that the insurance industry would probably not be willing to take on the full risk (see Section 4.2).[20] There is also a direct subsidy for nuclear operators because, when claims have exceeded the cap on a nuclear operator's liabilities, the home state must step in, and when that cap has been exceeded, all the parties to the conventions must contribute, up to the very low overall cap on liabilities.

Since, for the UK and other countries in Europe, the Paris and Brussels conventions are involved, it may be argued that limitations on liabilities for the nuclear industry cannot be touched. But the principle of fair competition is very well established and should over-ride particular arrangements for a specific industry, especially since the reasons for those arrangements are no longer valid.[21]

2.2 Underwriting of commercial risks

The nuclear industry, like the banking industry, has been very successful at engineering a commercial environment in which risks are socialised but profits are privatised.[22] In the case of nuclear power, it is, for political reasons, necessary for

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[18] See "Court order halts BP talks with Rosneft", The Guardian, 2011-02-01, http://www.guardian.co.uk/business/2011/feb/01/bp-loss-gulf-oil-spill-resumes-dividend.

[19] Under new rules that were supposed to come into effect in 2006 but are not yet in force, nuclear companies will have to increase the amount of cover they have in place, to €700 million (£620 million) per site, while the time frame for claims will be extended from ten to 30 years. New types of cover will also be required, including protection against "economic losses" resulting from an accident, damage to the environment, and loss of use and enjoyment of the environment, as well as the cost of preventing contamination of new areas. However, it is likely that these new limits will still fall far short of the real cost of a nuclear disaster, and it appears that the UK government is making arrangements to take on these additional costs (see "UK taxpayer may be forced to take on nuclear risk after insurers refuse to offer cover.", The Times, 2009-09-09, http://business.timesonline.co.uk/tol/business/industry_sectors/natural_resources/article6826650.ece.

[20] The website of the World Nuclear Association says that, contrary to what is often said, the insurance industry is willing to take on insurance for nuclear disasters, see http://www.world-nuclear.org/info/inf67.html.

[21] Much of the original motivation for establishing the nuclear industry, and for international treaties designed to put limits on the industry's liabilities for nuclear accidents, was because of its role in the creation of nuclear weapons. With the end of the cold war and with growing worries about the proliferation of nuclear weapons, any such justification for protecting the nuclear industry has completely disappeared. See also Section 4.

[22] See, for example, "New capitalism: old capitalism except taxpayer money is at risk", Sunday Herald, 2009-07-06, http://www.sundayherald.com/oped/opinion/display.var.2518209.0.new_capitalism_old_capitalism_except_taxpayer_money_is_at_risk.php. See also "Boiling the frog slowly: nuclear optimism hides the true

national governments to underwrite most of the commercial risks of nuclear power, as evidenced by the way the UK government had to bail out British Energy in 2005 at a cost of about £5 billion.[23,24,25] More specifically, the Nuclear Decommissioning Authority, under the Energy Act, is able to bail out future private nuclear operators if they fail to fund their liabilities fully.[26,27] In the USA, federal loan guarantees for nuclear power represent a substantial subsidy to the industry.[28]

With regard to the bail out of British Energy, Ian Jackson writes: "The government was forced to step in and implement a complex financial restructuring that effectively renationalised British Energy back into majority public ownership. *This included the government underwriting financial responsibility for £14 billion of decommissioning and spent fuel liabilities that it thought it had privatised in 1996.* … British Energy makes payments into a government-backed Nuclear Liabilities Fund—essentially a pension fund for reactor clean-up—and *any future shortfall will be picked up by the taxpayer*."[29]

The way in which the commercial risks of nuclear power are, for political reasons, underwritten by national governments represents a substantial subsidy to the industry even though no actual money may change hands. If the industry were to obtain that kind of underwriting from normal commercial sources, it would cost a lot of money. The subsidy is an unfair subsidy because there is nothing equivalent for renewables.

2.3 Protection against terrorist attack

Nuclear plants are vulnerable to terrorist attack, as are trains and ships carrying nuclear fuel or nuclear waste. Providing protection against such attacks is costly and, in general, national governments pick up at least part of the bill. Since there is no equivalent risk or need for protection with renewable sources of energy, any special measures that are provided for the nuclear industry represents an unfair subsidy for that industry.

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costs till it is too late," Energy Economy Online, 2009-07-24, http://energyeconomyonline.com/Boiling_the_Frog.html.

[23] See "Ministers 'wrote blank cheque' to bail out nuclear power group", The Guardian, 2006-03-17, http://www.guardian.co.uk/business/2006/mar/17/nuclearindustry.politics.

[24] See also "Waste not, want not", John Sauven writing in The Guardian, 2007-08-21, http://www.guardian.co.uk/commentisfree/2007/aug/21/wastenotwantnot.

[25] We believe this example is relevant because it demonstrates the general point that, ultimately, national governments have no choice but to underwrite the commercial risks of nuclear power. However it appears that the state aid for the rescue and restructuring of British Energy and BNFL were allowed by the EC in 2004 and 2006 respectively. The case reference documents are in the Register and here: Register Search page: http://ec.europa.eu/competition/state_aid/register/ . Moreover, the restructuring of Magnox Electric in the early 1990's was similarly approved by the EC. Once the Commission has approved an aid, it is difficult to do anything to overturn this. In high-politics high-stakes state aid cases, the Commission tends to fudge outrageous subsidies. General information about EC State Aid control is here: http://ec.europa.eu/competition/state_aid/overview/index_en.html.

[26] On 15 January 2004 Lord Whitty told the House of Lords (Column GC170) that *"there may again be circumstances in which a private sector operator cannot meet its nuclear obligations … we must retain the possibility of the Government meeting such costs"*.

[27] See "Waste not, want not", The Guardian, 2007-08-21, http://www.guardian.co.uk/commentisfree/2007/aug/21/wastenotwantnot.

[28] See "The real cost of new US nuclear reactors", Bulletin of the Atomic Scientists, 2009-08-21, http://www.thebulletin.org/web-edition/op-eds/the-real-cost-of-new-us-nuclear-reactors.

[29] Ian Jackson, *Nukenomics: the commercialisation of Britain's nuclear industry*, Sidcup: Nuclear Engineering International Special Publications, 2008, ISBN 978-1-903077-55-9, page 10, emphasis added.

However, there is good evidence that the public is *not* being fully protected against the risks of terrorist attack. For example, in 2006, a reporter from the *Daily Mirror* newspaper managed, very easily, to plant a fake bomb on a train carrying nuclear waste.[30] Despite the well-known risks now posed by pirates to international shipping off the coast of Somalia and elsewhere, the protection provided for ships carrying nuclear materials is only partial.[31]

The fact that protection against terrorist attack for nuclear plants and nuclear transports can only ever be partial represents a cost to us all arising from the corresponding risks. Since there is nothing equivalent for renewable sources of energy, these costs represent an unfair subsidy for the nuclear industry.

2.4 The short-to-medium-term costs of disposing of nuclear waste

On a short-to-medium-term perspective, the nuclear industry is not paying nearly enough of the costs of disposing of nuclear waste: [32]

- Dieter Helm, Professor of Energy Policy at New College, Oxford, says about the system proposed for handling nuclear waste: "It's a fixed-price contract for the Government to take the waste. The Government absorbs the final-end risk."[33]
- Irwin Stelzer, writing in *The Spectator*, says "… in what the government calls 'extreme circumstances', it is prepared to help meet the massive decommissioning and waste disposal costs—knowing full well that such extreme circumstances almost always attend decommissioning and waste disposal."[34]
- Writing in *Nuclear Engineering International*, 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.".[35] These points are made with more detail in *Nukenomics*, pp 61-63.

The less dangerous categories of nuclear waste can give rise to costs for 100 years or more and there is considerable uncertainty about what those future costs may be. A detailed analysis by Greenpeace of proposals by the UK government for a 'Fixed Unit Price' for the disposal of nuclear waste shows that they have the effect of transferring most of the risk to

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[30] See "We plant 'bomb' on nuke train", Daily Mirror, 2006-07-21, http://www.mng.org.uk/gh/re/daily_mirror_nukes2.htm.
[31] See "Nuclear fuel fleet arms up", The Scotsman, 2009-04-14, http://news.scotsman.com/latestnews/Nuclear-fuel-fleet-arms-up.5166539.jp.
[32] See also Section 1.5 of http://www.no2nuclearpower.org.uk/news/SAFE_ENERGY_No46.pdf and, in particular, http://www.no2nuclearpower.org.uk/news/id_funding.php.
[33] See "Key advisor says that UK's new nuclear policy is flawed", The Times, 2008-01-28, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3261571.ece.
[34] See "Go nuclear, but keep your hand on your wallet", The Spectator, 2008-03-12, http://www.spectator.co.uk/the-magazine/features/553546/part_3/go-nuclear-but-keep-your-hand-on-your-wallet.thtml.
[35] See also "Buried costs", Nuclear Engineering International, April 2008, http://www.greenpeace.org.uk/files/pdfs/nuclear/Nukenomics-Jackson.pdf. See also http://www.greenpeace.org.uk/media/press-releases/taxpayers-facing-nuclear-missile.

taxpayers, making them liable for potentially very large costs in the future.[36] If taxpayers take on a risk that properly belongs to the nuclear industry then they are providing a subsidy for the industry just as surely as if they had provided a grant or a loan guarantee.

2.5 The long-term costs of disposing of nuclear waste

On a long-term perspective, the 'high level' categories of nuclear waste will remain dangerous for thousands of years. The costs arising from the dangers of the waste and the need to manage it will be born by future generations but they will receive no compensating benefit.

Since these are costs that are created by the nuclear industry but are not paid for by the industry, they represent yet another subsidy to the industry, even though no actual money changes hands. The subsidy will be paid by people who are not yet born. Of course, there are no equivalent costs with renewable sources of power.

2.6 The cost of decommissioning nuclear plants

In his book *Nukenomics*, Ian Jackson writes:

> *Perhaps more than any other technology, nuclear power has the habit of making any government the prisoner of past decisions. The economic impact of nuclear energy decisions made in the 1950s and 1960s are still being felt by taxpayers today. … Investing in nuclear technology uniquely captures governments in a lengthy cycle of expenditure that once started, will take a century to exit…. Few other technologies have the capacity to bind government spending for a 100 years. As a result, the long-term costs of nuclear power can only really be estimated and estimates are only as good as the economic assumptions on which they are based.... accurately forecasting the total cost of front end nuclear build and back end nuclear clean-up still remains more of an art than a science.*[37]

Later, he writes:

> *Decommissioning has been described as rather like a Chinese puzzle box in which new problems are revealed the deeper one looks, as successive layers of complexity are revealed. Each year the decommissioning management contractors tend to look a little deeper at what needs to be done and then cost the clean-up tasks accordingly from the bottom up. As a result, the Nuclear Decommissioning Authority's three-year near-term cost projections are reasonably accurate but forecasts of the total lifecycle cost for taxpayers remain highly speculative. It is these difficult long-term cost projections that are rising by 9 per cent annually. In September 2007 the National Audit Office, which formally audits the Nuclear Decommissioning Authority's annual accounts, commented: "It is not possible to quantify reliably the impact on the Nuclear Decommissioning Authority's future financial results of the settlement of these liabilities."*[38]

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[36] See "Greenpeace response to the Consultation on a methodology for determining a Fixed Unit Price for waste disposal and updated cost estimates for nuclear decommissioning, waste management and waste disposal", Greenpeace, June 2010, http://www.mng.org.uk/gpnwaste. See also "Hidden subsidies and new nuclear", Greenpeace, June 2010, http://www.greenpeace.org.uk/files/pdfs/nuclear/gpuk-fup-briefing.pdf.

[37] *Nukenomics*, page 3.

[38] *Nukenomics*, page 25.

In 2006, it was reported that Gordon Brown's estimate of the cost of cleaning up the UK's nuclear legacy would be €132.5bn (£90bn).[39] It may be argued that this huge sum is simply "water under the bridge" and is not relevant now, with the UK government's declared intention that nuclear power should be commercially viable without any subsidies.

The key point here is that it is *impossible* for the UK government, or any other government, to shed its responsibilities for decommissioning of nuclear power stations (and for nuclear waste and other aspects of nuclear power) by passing everything over to the private sector. Given the extreme difficulty of estimating the full costs of decommissioning, as described above, there will *always* be the risk of cost overruns. Since there is also the ever-present risk that nuclear companies will fail, the government will *always* have to underwrite the cost of decommissioning nuclear installations and to pick up the tab when things go wrong.[40][41]

As with the general commercial risks of nuclear power (Section 2.2), this kind of underwriting of decommissioning costs by national governments is a substantial subsidy for the nuclear industry. And it is an unfair subsidy because there is nothing equivalent with renewables.

2.7 Institutional support for the nuclear industry

It appears that various institutions, offices and staff that are needed to support the nuclear industry in the UK are paid for, at least in part, out of public funds. Since, in most cases, there is nothing equivalent for renewables—because renewables are inherently safer, cleaner and less complex—these expenditures are an unfair subsidy for the nuclear industry. Here are the kinds of facilities that have been or are being provided to support the nuclear industry in the UK:

- The National Nuclear Laboratory (NNL).[42]
- A "nuclear academy" in West Cumbria.[43,44]
- The UK government has an Office for Nuclear Development (OND), apparently paid for out of public funds.[45] To be fair, there is now an Office for Renewable Energy Deployment (ORED) but, arguably, there should be an

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[39] See "Nuclear costs to hit £90bn, warns Brown", The Observer, 2006-06-04, http://www.guardian.co.uk/business/2006/jun/04/theobserver.observerbusiness.

[40] None of these problems are solved by the UK government's present proposals that the operators of nuclear plants should put forward plans for decommissioning and that those plans should be vetted by a 'Nuclear Liabilities Financing Assurance Board'.

[41] See "Nuclear decommissioning", Nuclear Spin, September 2008, http://www.spinprofiles.org/images/b/ba/Nuclear_Decomm.pdf.

[42] See "Appointments to the National Nuclear Laboratory", DECC press release, 2009-08-19, http://nds.coi.gov.uk/Content/Detail.aspx?NewsAreaId=2&ReleaseID=405971&SubjectId=2.

[43] See "Minister Ed Miliband opens West Cumbria's £20m nuclear academy Energus", Times & Star, 2009-06-19, http://www.timesandstar.co.uk/news/politics/minister_ed_miliband_opens_west_cumbria_s_20m_nuclear_academy_energus_1_570178?referrerPath=news/education.

[44] See "National skills academy for nuclear launches flagship centre for skills training", PersonnelToday.com, 2009-07-01, http://www.personneltoday.com/articles/2009/07/01/51220/national-skills-academy-for-nuclear-launches-flagship-centre-for-skills-training.html.

[45] See Office for Nuclear Development (OND), http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/office/office.aspx.

office equivalent in size to the OND for each of wind power, wave power, tidal power, the DESERTEC concept, and so on.

- The newly-established Nuclear Institute is likely to be in receipt of public money.[46] As with the OND, there appears to be nothing equivalent for any of the several renewable sources of power and the same remarks apply.
- According to a report in *The Times*,[47] the Nuclear Decommissioning Authority,[48] "consumes around half of the Department of Energy and Climate Change's £3 billion budget" and that "58 per cent of [the NDA's] £2.78 billion budget comes from taxpayers".
- The planned Nuclear Advanced Manufacturing Research Centre (NAMRC) will £15 million from taxpayers and the Manufacturing Advisory Service (MAS) will receive £4 million.[49]
- Other nuclear bodies that appear to depend, at least in part, on public funds include the Nuclear Legacy Advisory Forum,[50] the Nuclear Directorate of the Health and Safety Executive,[51] the UK Safeguards Office,[52] the Office for Civil Nuclear Security (OCNS),[53] and the International Atomic Energy Agency.[54]

It should be possible to obtain information about public funding of these various bodies under the UK's Freedom of Information Act 2000.[55]

For comparison, it would be very useful to obtain information about institutional support that may (or may not) be provided for renewable sources of power and the amount of public money that is devoted to it. In case anyone objects that renewables are receiving subsidies via feed-in tariffs and the Renewable Obligations scheme, there are good reasons for this which do not apply to nuclear power (See Section 3.3).

It appears that the UK government is keen to provide yet more institutional support for the nuclear industry, witness its recent statement that it "will provide capital investment of up to £15 million in order to establish a Nuclear Advanced Manufacturing Research Centre consisting of a consortium of manufacturers from the UK nuclear supply chain and universities."[56]

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[46] See "Nuclear Institute launched", The Whitehaven News, 2009-03-18, http://www.whitehaven-news.co.uk/news/nuclear_institute_launched_1_528306?referrerPath=news/.
[47] See "Nuclear Decommissioning Authority pledges action on million-pound bonuses", The Times, 2009-07-17, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6717198.ece.
[48] See http://www.nda.gov.uk/.
[49] See "£19m pledge for nuclear updates", Professional Engineering, 2009-07-29, http://www.profeng.com/archive/archive+2009/2213/22130004.htm.
[50] See http://www.nuleaf.org.uk/nuleaf/home.asp?r=4483&NavPosition170=0&NavInUse170=1&LastSelectedItem=2.
[51] See http://www.hse.gov.uk/nuclear/nsd1.htm.
[52] See http://www.hse.gov.uk/nuclear/safeguards/index.htm.
[53] See http://www.hse.gov.uk/nuclear/ocns/.
[54] See http://www.iaea.org/.
[55] See http://www.opsi.gov.uk/Acts/acts2000/ukpga_20000036_en_1.
[56] See "UK Low Carbon Industrial Strategy", July 2009, page 7. The document may be downloaded from http://interactive.bis.gov.uk/lowcarbon/.

2.8 Other subsidies for nuclear power

Taxpayer support for nuclear power comes in many forms. Here is a selection of other subsidies:

- When a nuclear power station fails, a relatively large capacity is lost and the loss is normally quite sudden and without much warning.[57] The expected increase in the number of nuclear power stations in the UK will mean that the annual cost of providing so-called Large Loss Response will rise from £160m a year to £319m. But the costs will be shared equally across all electricity providers. This is a cross-subsidy to nuclear power from renewable sources of power.[58]
- The following forms of support for the nuclear industry have been recorded in Hansard as answers by the UK government to parliamentary questions in June 2010:
    - **£11 million** on research expenditure to the Nuclear Decommissioning Authority (NDA) in 2010-11.
    - **£10.2 million** for the Engineering and Physical Sciences Research Council's (EPSRC) current nuclear research portfolio since 2008-09 on eight projects directly relevant to long-term nuclear waste management and facility decommissioning.
    - **£3.553 million** for the Natural Environment Research Council (NERC) for nuclear decommissioning and radioactive waste management research covering 2009-11.
    - **£180,000** for the Environment Agency for grant in aid on regulatory research relevant to nuclear waste and decommissioning in 2009-10 (approximately 25% of the research costs in that year).
    - **£0.95 million** annual subscription to the OECD Nuclear Energy Agency (NEA) & the NEA's Databank, which contains technical information from other NEA members.
    - **£5 million** provided by the NDA in 2007-08 million to support the establishment of Energus (formerly referred to as The Nuclear Academy) as a centre of excellence for skills, training and business support.
    - **US$ 9.3 million** and **€16.4 million** respectively to the United Nations' atomic watchdog, International Atomic Energy Agency (IAEA) for 2010, with a similar sum, but allowing for inflation, exchange rate differences, and the likely outcome of current ongoing budget negotiations among member states and the agency, has been set aside for 2011.
    - **€116.95 million** and **US$ 84.42 million** paid by UK to the IAEA over the past 10 years.

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[57] By contrast, variations in wind power are much more gradual and there is normally several hours warning.

[58] See "Exclusive: Will wind farms pick up the tab for new nuclear?" (Business Green, 2010-08-24, http://www.businessgreen.com/business-green/news/2268599/exclusive-wind-farms-pick-tab).

- **£3 million**, DECC's Office for Nuclear Development, total budget for 2010-11. This does not include the cost of DECC's wider work on policy associated with nuclear security, safety and non-proliferation.

- OECD export credits for nuclear power.[59]
- "Sweetners" for companies taking over the management of Sellafield.[60]
- The cost of bribing people to accept a dump for nuclear waste in their area.[61]
- Taxpayers exposed to unlimited liabilities for the costs of accidents at Sellafield.[62,63]
- Taxpayers paying nuclear consultancy fees.[64]
- Payments by taxpayers to directors of BNFL.[65]
- Subsidies provided to support the sale of British Energy.[66]
- Bonuses paid to civil servants.[67]
- Direct financial support for the nuclear industry.[68]

2.9 New subsidies?

As if these subsidies were not enough, the nuclear industry has called for more support for the industry in the UK.[69]

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[59] See "OECD lays out nuclear export credits", Nuclear Engineering International, 2009-06-29, http://www.neimagazine.com/story.asp?sectionCode=132&storyCode=2053426.
[60] See "IoS investigation: official plotted Sellafield cover-up", The Independent, 2009-01-04, http://www.independent.co.uk/news/uk/politics/ios-investigation-officials-plotted-sellafield-coverup-1224473.html.
[61] See "Windfall for nuclear waste site", BBC News, 2008-12-22, http://news.bbc.co.uk/1/hi/england/cumbria/7795162.stm.
[62] See "MP's anger as state bears cost of any Sellafield disaster", The Guardian, 2008-10-27, http://www.guardian.co.uk/environment/2008/oct/27/sellafield-deal-nuclear-economy.
[63] See "Why did government use emergency procedure over Sellafield clean-up bill?", The Guardian, 2009-03-10, http://www.guardian.co.uk/politics/blog/2009/mar/10/sellafield-emergency-procedure.
[64] See "Taxpayer foots the bill for nuclear bonuses", The Times, 2009-04-22, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6144016.ece.
[65] See "BNFL's 'expensive failures' earn £1m payoffs from taxpayer", The Guardian, 20080-12-11, http://www.guardian.co.uk/world/2008/dec/11/nuclear-executive-salaries.
[66] See "Could nuclear sell-off be another taxpayer bail-out?" The Guardian, 2008-11-11, http://www.guardian.co.uk/environment/2008/nov/19/edf-nuclear-energy-sellafield-drigg.
[67] See "Cumbria nuclear workers handed £11k bonus by NDA", Carlisle News & Star, 2009-04-23, http://www.newsandstar.co.uk/news/cumbria_nuclear_workers_handed_11k_bonus_by_nda_1_544942?referrerPath=/1.50001.
[68] See "£19m pledge for nuclear updates", *Professional Engineering*, 2009-07-29, http://www.profeng.com/archive/archive+2009/2213/22130004.htm.
[69] See "EDF Energy wants Britain to fix the market if it builds nuclear plants", The Times, 2009-11-07, http://business.timesonline.co.uk/tol/business/related_reports/the_future_of_energy/article6907099.ece, "Families face nuclear tax on power bills" (The Guardian, 2009-10-19, http://www.guardian.co.uk/environment/2009/oct/19/nuclear-tax-on-power-bills), "Consumers to pay for new nuclear power plants" (Daily Telegraph, 2009-08-18, http://www.telegraph.co.uk/news/newstopics/politics/6044394/Consumers-to-pay-for-new-nuclear-power-plants.html), "Energy firms in secret talks on nuclear 'levy'" (Sunday Times, 2009-08-16, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6797809.ece) , "UPDATE: UK nuclear indus seeks equal terms with renewables" (Easy Bourse, 2009-06-10, http://www.easybourse.com/bourse-actualite/marches/update-uk-nuclear-indus-seeks-equal-terms-with-

The UK government has indicated in April 2009 that it may give an explicit subsidy to the nuclear industry (which would be on top of the many hidden subsidies),[70] although they have later denied that any subsidies will be provided.[71] However, it appears that the government has indeed been looking at ways of forcing taxpayers to contribute towards nuclear costs.[72] And, although we have not yet examined them in detail, it appears that recent proposals by the UK government for reform of the electricity market are likely to contain hidden subsidies for nuclear power.

2.10 Other sources of information

There is more information about subsidies for nuclear power in the following sources:

- Other hidden subsidies identified by Dr David Lowry.[73]
- Subsidies identified in Pete Roche's *NuclearSpin* briefing: *Nuclear costs and financing*, October 2008.[74]
- Subsidies identified in Pete Roche's *No2NuclearPower.org.uk* briefing, *Nuclear Subsidies – how the market is rigged in favour of dangerous nuclear electricity*, January 2007.[75]
- Subsidies identified in *The Economics of Nuclear Power*, by P. Bradford, A. Froggatt, D. Milborrow and S. Thomas, Greenpeace International, May 2007.[76]
- Subsidies for nuclear power in the USA described in *Nuclear power as taxpayer patronage: a case study of subsidies to Calvert Cliffs Unit 3* (PDF, 285 KB, Doug Koplow, Earth Track Inc., July 2009) [77] and other reports from Earth Track.[78]

2.11 What is the real cost of nuclear power?

Because subsidies for nuclear power are, for most part, not transparent, estimating the sizes of the several subsidies is not straightforward. However, as is suggested in Section 4.2, it should be possible to calculate the sizes of the several subsidies using well-established actuarial and accounting methods.

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renewables-682055), "EDF calls for support for nuclear industry" (Financial Times, 2009-05-25, http://www.ft.com/cms/s/0/1369ae48-4972-11de-9e19-00144feabdc0.html?ftcamp=rss), "Slash renewables target to protect nuclear, says EDF" (ENDS Report Bulletin, 2009-03-12, http://www.mng.org.uk/gh/resources/ends_report_bulletin_2009-03-12.html).

[70] See "Budget 2009: Darling gives renewables a £5bn shot in the arm", The Guardian, 2009-04-22, http://www.guardian.co.uk/environment/2009/apr/22/wind-renewables.

[71] See "Energy firms in secret talks on nuclear 'levy'", Sunday Times, 2009-08-16, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6797809.ece.

[72] See "UK taxpayer may be forced to take on nuclear risk after insurers refuse to offer cover", The Times, 2009-09-09, http://business.timesonline.co.uk/tol/business/industry_sectors/natural_resources/article6826650.ece.

[73] See "The nuclear industry's secret subsidies", The Guardian, 2008-09-04, http://www.guardian.co.uk/commentisfree/2008/sep/04/nuclear.nuclearpower.

[74] See http://www.mng.org.uk/gh/resources/Nuclear_Costs_and_Finances.pdf.

[75] See http://www.no2nuclearpower.org.uk/reports/Nuclear_Subsidies.pdf.

[76] See http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear_economics_report.pdf.

[77] See http://www.mng.org.uk/gh/resources/Koplow_CalvertCliffs3_july_2009.pdf

[78] See http://www.earthtrack.net/earthtrack/index.asp?page_id=151&catid=74.

Although the full results of such calculations are not available now, we can make a start:

- According to a report from the New Economics Foundation,[79] a kilowatt-hour of electricity from a nuclear generator will cost as much as 8.3 pence (13.7 US cents) once realistic construction and running costs are factored in, compared with about 3 pence (4.9 US cents) claimed by the nuclear industry—*and that's without including the cost of managing pollution, insuring against catastrophic accidents, or protecting nuclear power plants and nuclear transports from attack by terrorists.*
- In Section 2.1, we saw that "if Electricité de France had to insure for the full cost of a meltdown, the price of nuclear electricity would increase by about 300%.", with that 300% figure backed up with evidence from Appendix J of the European Commission report "Environmentally harmful support measures in EU member states".[80] The latter source suggests that the premium required would be 5.0 c€/kW (about 7.2 US cents/kWh).
- On the strength of this evidence, we may conclude that, if the nuclear industry had to pay the full cost of insuring against a meltdown, the cost of power from new nuclear power stations would be 13.7 + 7.2 = 20.9 US cents per kWh—*higher than most other sources of power*.
- The cost of nuclear power would be even higher if the industry had to pay all the other costs that have been identified in Section 2: the cost of underwriting the commercial risks of the industry, the cost of protection against terrorist attacks, the short-, medium- and long-term costs of disposing of nuclear waste, the cost of decommissioning nuclear plants, institutional support for the nuclear industry, and a range of other subsidies.

Without the subsidies that the nuclear industry enjoys now, it would certainly not be commercially viable. Notwithstanding the existence of all those subsidies, the industry says that it needs even more subsidies in order to go ahead with the building of new nuclear plants (Section 2.9).

3 Justifications for nuclear subsidies?

Some people may acknowledge the existence of subsidies for nuclear power but argue that those subsidies are justified. This section examines arguments of this sort and concludes that none of them are valid.

3.1 The 'public benefit' argument

From time to time, right up to the present, people have attempted to justify nuclear power as a public benefit for the following reasons:

- The original justifications for the limitation of liabilities for nuclear power, and other forms of support, were two-fold:
  - Nuclear power was considered to be necessary because of its role in the production of nuclear weapons.

[79] 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).
[80] See http://www.mng.org.uk/gh/resources/EC_env_subsidies.pdf (PDF, 1.1 MB).

- As a means of generating electricity, it was one of the few alternatives to coal or other fossil fuels.

- Today, nuclear power is promoted as part of the answer to the problems of CO_2 emissions and climate change.
- Extraordinary as it may sound, nuclear power has sometimes been promoted as a 'home grown' source of power that enhances the UK's energy security.
- Nuclear power may be justified as a public benefit because it can be used to destroy some of the unwanted stockpiles of plutonium.
- It may be argued that nuclear power helps to improve the workings of the transmission grid.

As described in the following subsections, none of those arguments are sound.

3.1.1 Military and diversity justifications

Although nuclear power was seen as necessary for the production of materials needed in nuclear weapons, the cold war is now over and many people would like nuclear weapons to be phased out.[81]

At the time of the miners' strike in 1984-5, Mrs Thatcher saw nuclear power as a useful alternative to coal as a means of keeping the lights on. Now, as described in Section 5, there are more than enough alternatives that are cheaper and better than nuclear power.

3.1.2 Climate change

Far from being an answer to the problem of CO_2 emissions and climate change, *nuclear power would be a mis-allocation of resources*, making things worse by diverting funds away from better and cheaper alternatives:

- When environmental and hidden costs are factored in, nuclear power is one of the most expensive ways of generating electricity.[82]
- Several reports show how it is possible to cut CO_2 emissions and enhance energy security, without using nuclear power.[83] There are more than enough alternatives that have none of the headaches of nuclear power.[84]
- Bearing in mind that the nuclear cycle is far from being zero-carbon,[85] we get bigger cuts in CO_2 for a given amount of money, and we get them sooner, if we choose renewables with energy conservation—and without using nuclear power. We certainly don't need both.

3.1.3 Security

Nuclear power is not a 'home grown' source of power in the UK since all uranium is imported. It is true that stockpiles of plutonium may be processed into MOX fuel, with depleted uranium. But although MOX core loadings up to 100% are theoretically possible,

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[81] See, for example, "US and Russia to scrap 2000 nuclear weapons", The Scotsman, 2009-07-07, http://news.scotsman.com/latestnews/US-and-Russia-to-scrap.5433732.jp.
[82] See Section 2.11 and http://www.mng.org.uk/gh/nn.htm#subsidies.
[83] See www.mng.org.uk/gh/scenarios.htm.
[84] See Section 0 and www.mng.org.uk/gh/energy.htm.
[85] As is described in some detail in *Nuclear power is not the answer*.

no commercial nuclear reactor has ever been licensed to operate at that level. Where MOX is used, it normally provides only about 30% to 50% of the fuel of a nuclear power station, with the rest provided by Low Enriched Uranium (LEU).[86]

Most of the decarbonisation scenarios mentioned above[87] provide for greater security of energy supplies than with nuclear power, with its associated worries about all aspects of security, including the security of supplies of uranium, terrorist attacks on nuclear plants or nuclear materials in transit, the creation and detonation of 'dirty' bombs, and the proliferation of nuclear weapons.

3.1.4 Destruction of plutonium

It is clear that at least some of the UK's unwanted stockpile of plutonium may be destroyed by processing it into MOX fuel and then 'burning' that fuel in appropriately-designed or adapted nuclear plants.

If we set aside the several practical problems associated with this course of action,[88] it looks like an attractive option: we reduce a storage-and-pollution problem and we get some electricity as well.

How does this relate to the issue of subsidies for nuclear power? According to Ian Jackson,[89] MOX fuel is nearly 50% more expensive than LEU. If the argument were to be accepted that nuclear power has a role in "plutonium disposition", then it would be legitimate for the government to pay the *additional* cost of the MOX, without those payments being classified as subsidies.

But the plutonium disposition argument does ***not*** justify all the other subsidies that have been described in Section 2 or all the other headaches with nuclear power.[90]

Since some kind of solution must eventually be found to the problem of storing or disposing of the UK's legacy of nuclear waste and, since plutonium stockpiles can participate in that solution, there is no case at all for building new nuclear power stations *purely* as a means of reducing the quantities of stored plutonium. Any new nuclear power stations must be commercially viable as power generators, *without* the subsidies that have been identified.

3.1.5 Improving the workings of the grid?

Nuclear power is sometimes promoted as 'base load' power with the implication that it can be relied on 24/7. But all sources of power are liable to fail and nuclear power is no exception. Failure of a nuclear power station is normally quite disruptive because, normally, it means a relatively sudden loss of a relatively large amount of power.[91]

The inflexibility of nuclear power is an embarrassment. The output cannot be increased quickly to meet peaks in demand and the output cannot easily be reduced when supplies

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[86] *Nukenomics*, page 89.
[87] See http://www.mng.org.uk/gh/scenarios.htm.
[88] *Nukenomics*, Chapter 4.
[89] *Nukenomics*, page 84.
[90] See http://www.mng.org.uk/gh/nn.htm.
[91] See, for example, "Exclusive: Will wind farms pick up the tab for new nuclear?" (Business Green, 2010-08-24, http://www.businessgreen.com/business-green/news/2268599/exclusive-wind-farms-pick-tab). The expected increase in the number of nuclear power stations in the UK will mean that the annual cost of providing so-called Large Loss Response will rise from £160m a year to £319m. But the costs will be shared equally across all electricity providers.

exceed demand. In general, the most valuable sources of power are those that can respond quickly to changes in demand, as for example, hydropower, geothermal power, tidal lagoons, and concentrating solar power with heat storage and backup sources of heat.

3.2 Detriments to health and 'justification' for nuclear power

On the website of the UK's Department for Business, Innovation and Skills (BIS)[92] it says:

> *The concept of Justification is based on the internationally accepted principle of radiological protection that no practice involving exposure to ionising radiation should be adopted unless it produces sufficient net benefits to the exposed individuals, or society, to offset any radiation detriment it may cause.*

and on the website of the UK's Department of Energy and Climate Change (DECC),[93] it says:

> *Justification is a requirement of EU law under which before any new class or type of practice involving ionising radiation can be introduced it must first undergo a high-level, generic assessment to determine whether its overall benefit outweighs any associated health detriment.*

Here, the concept of 'justification' is narrower than it is in the 'public benefit' considerations discussed above. Even if one were to conclude that the net benefits of nuclear power outweigh "radiation detriment," this would fall a long way short of demonstrating that the several subsidies for nuclear power are justified.

Most of what has been said about possible justifications in terms of public benefit applies to 'justification' in this relatively narrow sense: there are no good reasons for exposing people to the undoubted risks from radiation, including risks from a Chernobyl-style accident or worse.

3.3 Subsidies for renewables

If may be argued that subsidies for nuclear power are justified because renewables are receiving subsidies, either directly via grants or tax breaks or indirectly via Renewable Obligation Certificates (ROCs) or feed-in tariffs.

At present, renewables need protection or support mainly because of distortions in the energy market summarised in Section 6. If those distortions were to be corrected then, as described in that section, support for renewables may be reduced or removed.

4 Withdrawal of subsidies

As was indicated in the introduction, the subsidies that are enjoyed by nuclear power are a clear breach of the principle of fair competition. They invite legal challenge or direct action by politicians to remove these distortions in the market place.

Several of the subsidies for nuclear power are quite subtle and removing them is not simply a matter of forbidding the payment of certain sums of money. For example:

- With regard to the limitations on liabilities for nuclear power (Section 2), it may not be possible to find any insurance company or consortium of companies that

[92] See http://www.berr.gov.uk/.
[93] See http://www.decc.gov.uk/.

would be willing to take on the risk.[94] However, that in itself does not provide a reason for exempting the industry from relevant costs.

- The way in which national governments must necessarily underwrite the commercial risks of nuclear power (Section 2.2) and the costs of cleaning up after the nuclear industry (Section 2.6), is a subsidy for the nuclear industry even though there may be no direct payment from the government to any nuclear company. But that does not mean that the subsidy should not or cannot be withdrawn.
- Again, the fact that people who are not yet born are providing a subsidy for the nuclear industry (Section 2.5), does not exempt the industry from paying relevant costs.

In broad terms, the subsidies we have identified provide support for nuclear power in either or both of two ways:

- The operators of nuclear plants are exempted from paying costs that businesses of a similar kind would normally be required to pay.
- Risks and corresponding costs are transferred from the operators of nuclear plants to taxpayers and members of the public.

Thus, in general, these subsidies may be stopped in the following way:

- Operators of nuclear plants should be required to pay the full costs of running their businesses.
- Where there are risks that may result in costs falling on taxpayers or members of the public, the operators of nuclear plants should be required to take out full insurance from commercial insurers.

With regard to the second point, we wish to emphasise that 'full insurance' means insurance against claims for damage, *without any cap or ceiling*. Otherwise, bankruptcy may be used as a way of denying compensation to the victims of a nuclear disaster.

If commercial insurers are unwilling to provide the necessary insurance, the operators of nuclear plants should pay an appropriate insurance premium to the government (the insurer of last resort), *calculated by two or more independent actuarial experts*.

With regard to limitations of liability (Section 2.1), it is sometimes argued that, with careful engineering, the risk of disaster can be reduced to a level where it can be ignored. Our response is that the question of whether or not the risk is small enough to be ignored is not for the nuclear industry to judge. The best way of assessing that risk is to require the operators of nuclear plants to obtain full insurance against disaster or, if that is not possible, for the operators of nuclear plants to pay premiums to the government calculated by two or more independent actuarial experts.

[94] Although, as mentioned earlier, the website of the World Nuclear Association says that, contrary to what is often said, the insurance industry is willing to take on insurance for nuclear disasters, see http://www.world-nuclear.org/info/inf67.html.

5 There are more than enough renewables to meet our needs

There is no question that renewable sources of power can meet the UK's present demands for energy (not just electricity), and anticipated future demands as outlined in Section 5.1 below. Renewable power sources are in general quicker to build than nuclear power stations. And, without distortions in energy prices (Section 6), renewables are in general cheaper than nuclear power.[95]

Here is some of the evidence that renewables can meet our needs:

- **A network of land-based 2.5-megawatt (MW) turbines restricted to nonforested, ice-free, nonurban areas operating at as little as 20% of their rated capacity could supply more than 40 times current worldwide consumption of electricity and more than 5 times total global use of energy in all forms. There is additional potential in offshore wind farms.** See "Global potential for wind-generated electricity", Xi Lua, Michael B. McElroya, and Juha Kiviluomac, *Proceedings of the National Academy of Sciences of the United States of America*, June 22, 2009, doi: 10.1073/pnas.0904101106.[96]
- **The "economically competitive potential" of wind power in Europe is 3 times the projected demand for electricity in 2020 and 7 times the projected demand in 2030. Offshore wind power alone could meet between 60% and 70% of projected European demand for electricity in 2020 and about 80% of projected demand in 2030.** See "Europe's onshore and offshore wind energy potential", European Environment Agency, 2009.[97] The UK is one of the windiest parts of Europe.
- **For five offshore electricity generating technologies—wind with fixed and floating foundations; wave; tidal range; and tidal stream—the full practical resource, estimated to be 2,131 TWh/year, exceeds current UK electricity demand six times over.** See "The Offshore Valuation: A valuation of the UK's offshore renewable energy resource", The Offshore Valuation Group, May 2010.[98]
- **Renewable sources of power can provide 100 percent of the world's energy (not just electricity) and it is technically feasible to make the transition by 2030.** See "A path to sustainable energy by 2030", Mark Z. Jacobson and Mark A. Delucchi, *Scientific American*, November 2009, pp 58-65,[99]This article reviews research showing that there are more than enough renewable sources of energy to meet all of the world's energy needs, not just electricity. In the scenario described in the Scientific American article, wind supplies 51 percent of the demand worldwide, provided by 3.8 million large wind turbines (each rated at five megawatts). Although that quantity may

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[95] See Section 2.11 and http://www.mng.org.uk/gh/nn.htm#subsidies.
[96] Download via http://www.pnas.org/content/early/2009/06/19/0904101106.full.pdf+html.
[97] Download via http://www.mng.org.uk/gh/resources/Europes_onshore_and_offshore_wind_energy_potential.pdf.
[98] Download via http://www.mng.org.uk/gh/scenarios/offshore_vaulation_full.pdf.
[99] See http://www.stanford.edu/group/efmh/jacobson/sad1109Jaco5p.indd.pdf. An interactive online presentation about this research may be viewed via http://www.scientificamerican.com/article.cfm?id=powering-a-green-planet.

sound enormous, it is interesting to note that the world manufactures 73 million cars and light trucks every year. An interesting conclusion of this research is that, 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.

- **The variability of sources such as wind power is much less of an issue than is sometimes suggested**. See "Managing Variability", Greenpeace, WWF, RSPB, Friends of the Earth, July 2009.[100] Fluctuations in wind strength can be managed technically and at modest and declining cost, high proportions of wind power are feasible in the UK's energy mix, and new technological developments could allow for a steadily increasing use of wind power and the phasing out of conventional carbon based fuels as a backup technology. See also "Matching variable electricity supplies with variable demands".[101]
- **Photovoltaics (PV) could generate about 266 TWh/yr in the UK—about 66% of the UK's present electricity demand**. See "Renewable Energy and Combined Heat and Power Resources in the UK", Tyndall Centre, 2002.[102] PV is quick and simple to install.
- Using concentrating solar power (CSP), **less than 1% of the world's deserts could produce as much electricity as the world is using. Less than 5% of the world's deserts could produce electricity equivalent to the world's total energy demand.** These calculations, which are quite conservative, are based on research from the German Aerospace Centre (DLR).[103] Although it would be possible to obtain all the world's energy from deserts, **there are several reasons why Europe and the UK** (and other regions and countries) **should use a variety of renewable sources of power**, as described in the TRANS-CSP report from the DLR.[104]
- **It has been estimated that 73% of global energy use could be saved by practically achievable design changes to passive systems and that further savings may be achieved by improvements in the efficiency of conversion devices.** See "Reducing energy demand: what are the practical limits?" (report by Jonathan M. Cullen, Julian M. Allwood, and Edward H. Borgstein ofthe Department of Engineering, University of Cambridge, 2011-01-12).[105]
- **The government's own plans for the growth in renewables and energy conservation can ensure adequate generating capacity in the UK until at least the mid 2020s.** See "Implications of the UK meeting its 2020 renewable energy target", Pöyry Energy (Oxford) Ltd for WWF-UK and Greenpeace-UK, August 2008.[106]

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[100] Download via http://www.trec-uk.org.uk/reports/milborrow_managing_variability_final_July_2009.pdf.
[101] See http://www.trec-uk.org.uk/elec_eng/supply_demand.html.
[102] Download via http://www.tyndall.ac.uk/sites/default/files/wp22.pdf.
[103] Relevant reports may be downloaded via http://www.trec-uk.org.uk/reports.htm.
[104] Download via http://www.trec-uk.org.uk/reports.htm.
[105] Download via http://dx.doi.org/10.1021/es102641n.
[106] Download via http://www.mng.org.uk/gh/resources/Implications_of_UK_renewable_energy_targetv1.0.pdf.

- **There are several other reports on how to decarbonise the world's economies via renewables and the conservation of energy, without using nuclear power**. A more comprehensive list, with notes and download links, is on www.mng.org.uk/gh/scenarios.htm.

5.1 Future developments

Electrification of road and rail transport in the UK would add to the UK's demand for electricity but not as much as one might think:

- In terms of energy, about 50% more electricity would be needed (see Appendix 8 of "Energy UK"[107]). The main reason it is not more is that electric motors are very much more efficient than internal combustion engines. Much of the energy that we are using now for overland transport is simply wasted.
- In practice, any additional amount of generating capacity that may be required is likely to be less than 50%. This is for two reasons:
    - It is likely that much of the charging of electric vehicles will be done at night when there is likely to be a lot of spare capacity from sources such as wind power. To that extent, it does not add to the generating capacity that would be required.
    - The electrification of road transport will facilitate the introduction of grid-to-vehicle technologies allowing two-way flows of electricity between vehicles that are on charge and the transmission grid. This, with other techniques for balancing the grid,[108] will help to keep demands for electricity in balance with supplies, thus helping to minimise the amount of spare capacity that is required.

It seems likely that, in the future, there will be increasing use of electrically-driven heat pumps to provide space heating in buildings. But, with good insulation of buildings and the use of technologies such as inter-seasonal heat transfer,[109] residual needs for the heating of buildings should be small.

As mentioned earlier, a report from the Department of Engineering, University of Cambridge, estimates that 73% of global energy use could be saved by practically achievable design changes to passive systems and that further savings may be achieved by improvements in the efficiency of conversion devices.

With appropriate policies in place, it seems likely that the UK government's suggestion that "electricity use could double by 2050"[110] is unduly pessimistic and that little or no increase in generating capacity may be required.

6 Correcting distortions in the energy market

The reasons that renewables are, at present, needing some kind of protection or support are:

- The commercial 'playing field' is tilted against them:

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[107] Download via http://www.mng.org.uk/gh/resources/energy_UK3.pdf.
[108] See http://www.trec-uk.org.uk/elec_eng/supply_demand.html.
[109] See, for example, http://www.howedell.herts.sch.uk/eco_issues/sustainable_elements.pdf.
[110] See "Chris Huhne speech to the Royal Geographic Society – 'The Perfect Storm'" (DECC press release, 2011-02-17, http://www.decc.gov.uk/en/content/cms/news/RGS_speech/RGS_speech.aspx).

- In a report published in 2004,[111] the New Economics Foundation made a conservative estimate that worldwide subsidies for fossil fuels amounted to about $235bn a year—and there seems not to have been much change since then.
- The continued existence of subsidies for oil, gas and coal, is confirmed by reports that the G20 intend to remove them.[112]
- Nuclear power is heavily subsidised as described in Section 2.
- There is still no global cap on emissions and schemes such as the EU ETS are not working properly. For those kinds of reasons, the price of CO_2 emissions is far too low.

- It is widely accepted that renewables need support until they a properly established. When any particular renewable technology is well established and, *when there is a level playing field for renewables*, then there may be a case for withdrawing subsidies for that particular technology (more below).

More generally, the Stern report said that climate change is the greatest market failure the world has seen,[113] and that actions are needed to compensate for that failure.

Rather that piling subsidy upon subsidy, we should be aiming to *wind down the arms race of subsidies, reserving them for where they are really needed*:

- Ensure that a proper price is paid for CO_2 emissions.[114,115]
- Remove subsidies from oil, gas and coal, as the G20 have indicated they will do.
- Remove subsidies from nuclear power following procedures outlined in Section 4.
- Retain subsidies for renewables that have not yet reached the bottom of their cost-reduction curves.
- Remove subsidies from renewable sources of power that have reached the bottom of their cost-reduction curves and are well established.

7 Conclusion

Greater awareness of the subsidies for nuclear power may pave the way for their reduction or withdrawal. Apart from the savings to the public purse, removal of subsidies for nuclear power will help to level the commercial playing field for renewable sources of power, thus

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[111] See "Fossil fuel subsidies 'must end'", BBC News, 2004-06-21, Hhttp://news.bbc.co.uk/1/hi/sci/tech/3818995.stmH.
[112] See, for example, "G20 fossil fuel subsidy push may aid climate talks", Reuters, 2009-09-25, http://www.reuters.com/article/environmentNews/idUSTRE58O3RN20090925.
[113] See "Stern: climate change a 'market failure'", The Guardian, 2007-11-29, http://www.guardian.co.uk/environment/2007/nov/29/climatechange.carbonemissions.
[114] In this connection, the nuclear cycle is far from being zero carbon, see http://www.mng.org.uk/gh/nn.htm#CO2.
[115] One of the most effective ways of ensuring that a proper price is paid for emissions of industrial greenhouse gases is to control them 'upstream', at or close to their origins. This is described in *'Upstream' reform of the EU Emissions Trading System* from the K2S group (http://www.k2support.org/home) which may be downloaded from http://www.mng.org.uk/euets.

boosting their expansion and speeding the transition to the sustainable low carbon economy that is so urgently needed in the fight against climate change.

There are more than enough renewable sources of power to meet present and anticipated future needs for energy, not just electricity. They are cheaper than nuclear power, they can be built more quickly, and have none of the other headaches of nuclear power.