World Nuclear Association

Miguel Arias Cañete
Commissioner for Climate Action and Energy
European Commission
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28 November 2014

Dear Commissioner Cañete,

Re: Interim Report of Ecofys to the European Commission, Directorate-General for Energy, on *Subsidies and Costs of EU Energy* (issued October 2014)

World Nuclear Association (WNA) shares the concerns notified to the European Commission by FORATOM (in its letter to former Commissioner for Energy Oettinger on 29 October 2014) regarding the very detailed interim report prepared by Ecofys and its partners KPMG, CASE and CE Delft "Subsidies and cost of EU Energy". As per the Commission's invitation, WNA would like to submit comment on the report's methodology and results.

It is our strong opinion that the interim report has overstated the costs, interventions and subsidies related to nuclear power over the studied time frame and therefore it should not be used to inform EU policy in its current form. We would like to expand on six points in particular that stand out as shortcomings in the current document:

Market interventions for nuclear

1. **Current support – the waste 'subsidy'.** The €7 billion estimated for current support to nuclear energy is opaque and contentious. It seems to primarily relate to the decommissioning of legacy nuclear facilities and makes no distinction for military wastes. This cannot meaningfully be considered as a 'support to production'.
2. **Nuclear taxes.** The cost to operators of nuclear-specific taxes levied by several EU Member States has not been acknowledged, let alone included in the report. This omission should be rectified for all energy sources, but we provide details for 'nuclear taxes'.

External costs of nuclear

3. **Resource depletion.** The authors do not seem to understand the nature of the uranium resource and have not taken account of the historic exploration and price movements. The chosen methodology has yielded a spurious result for this externality.
4. **Nuclear accidents.** The valuation of the external cost of nuclear accidents is too high and including it as an external cost introduces consistency problems in the list of externalities.

Nuclear costs

5. **Nuclear LCOE.** The Levelised Cost of Electricity (LCOE) quoted for nuclear in the report is somewhat higher than that of other recent work commissioned by the EC. Some of the assumptions used (especially WACC, decommissioning and full-load hours) are questionable.
6. **System costs.** These have not been included, but are very much needed if the report is to prove truly informative to European policy-makers.

These points are all expanded upon in the following pages along with recommendations on how the methodology should be altered. Lastly, WNA notes with concern a persistent trend towards nuclear exceptionalism, and a slant in favour of other low-carbon technologies and efficiency. Several such incidences are highlighted.

Yours sincerely,

Agneta Rising
Director General

Market interventions for nuclear

Interventions for nuclear energy have been inflated under the current Ecofys methodology in two main ways. Firstly the subsidy has been overstated by including interventions for legacy nuclear facilities as a form of current 'support to production' and secondly there has been no allowance made for nuclear-specific taxes placed upon operators of nuclear power plants. If these were to be corrected then there is a distinct possibility that the current balance of intervention EU-wide to nuclear production for 2012 would turn out to be negative.

1. Value of interventions for nuclear

The total 'subsidy' representing current interventions from Member States for nuclear amounted to €6,960 million in 2012, according to Ecofys. However nowhere in the report and annexes is this amount clearly broken down according to support type (categories for which include 'support to investment', 'support to energy', 'support to energy savings', 'support to production' and 'R&D') and sub-interventions. This is true for all energy technologies – the monetary amount of interventions are not listed according to technology. If this were done it would likely become clear that a very significant portion of the current nuclear subsidy would be better classified as form of historic support.

The build-up of the current support provided to nuclear power and other technologies is shown graphically in Figures S-2 and 3-1 and listed in Table 3-1 and A2-2. Table 3-3 and A2-3 break down the total amount according to interventions, but how this relates to each generating technology is for the most part unclear. The report states:

- the nuclear industry received €4,330 million in support to decommissioning and waste disposal as a form of 'support to production'. (In fact nuclear was not mentioned explicitly here but in other parts of the text it is noted that nuclear was the only technology with substantial decommissioning charges so it is assumed this intervention applies purely to nuclear).
- €1,590 million in direct support to *fossil or nuclear* electricity production. The nuclear and fossil components have not been separated out.
- €10 million in underwriting insurance for nuclear production.

This does not sum to €6,960 million meaning some nuclear components are not accounted for. It would be useful to know what these are.

Figure A2-6 breaks the €6,960 million down by Member state and for the EU-level. By far the biggest component is listed as coming from the UK (€2,770 million) and EU-level support (€3,260 million). After detailed reading we believe it to be likely that the bulk of expenditure on public interventions for nuclear energy in 2012 relating to Czech Republic, Italy, Lithuania, Slovakia the UK and the EU comprises support for decommissioning and waste disposal of facilities that are no-longer operating.

We suspect that the UK amount consists of a transfer from the central government to a state agency, the Nuclear Decommissioning Authority (see further comments below) for the UK's legacy nuclear facilities and which includes allowance for the management of wastes from the UK's military nuclear programme. Ecofys notes this in A2.10.6 but in nevertheless still uses the figure and makes no deduction for it. Indeed the financial amounts (£2.3 billion versus €2.7 billion) seem to bear this out.

It is likely that the EU-level expenditure is divided between:

- expenditures to assist Bulgaria, Czech Republic, Lithuania and Slovakia to decommission the reactors they were required to close under the terms of their accession (i.e. direct support to decommissioning and waste disposal); and,
- for upgrading reactors in the Eastern European Member states to meet higher safety and security norm (i.e. support to *fossil or nuclear* electricity production).
- the nuclear R&D framework program. Table A2-7 indicates that €55 million was provided in 2012 at the EU level for nuclear R&D under Framework Programme 7.

The decommissioning interventions seems to almost entirely relate to legacy nuclear facilities shut down before 2008 (the report's threshold for 'current'). This cannot in any meaningful way be considered a form of current 'support to production'. If these are to be included at all they would be much more appropriately included as a form of historic intervention. They do not relate to currently operating facilities.

In the UK, when the electricity supply industry was privatised in 1990, the nuclear power plants were left under government ownership and were divided into two sets of assets: the Magnox reactors and the Advanced Gas-cooled Reactors (AGRs)plus the single Pressurised Water Reactor (PWR). The Magnox reactors have remained under state ownership and were eventually transferred to the Nuclear Decommissioning Authority (NDA). The AGRs and the PWR at Sizewell were sold off are now owned by EDF Energy. It is misleading to consider the funding provided to the NDA by the UK government as a 'support to production', since almost all the Magnox reactors were closed before 2007 and no longer generate power (the Oldbury Magnox stations were shut in 2012). One Magnox reactor continues to operate (Wylfa 1) but its income goes to the NDA, which does not pay any dividend to the central government.

The Soviet-designed reactors closed as part of the new Member states' accession to the EU no longer generate power and they are no longer assets of the public electricity providers in those countries (again prior to 2008). It seems unreasonable to list state intervention towards decommissioning of facilities closed for mainly political reasons when, if not for this decision, the nuclear power plant operators could have paid for their later decommissioning or possibly even still be profitably generating. At the very least such interventions deserves a clear note or a separate category.

Italy too stands out on Figure A2-6. The country closed all its nuclear power following a public referendum in 1987 – over 20 years ago. These are no longer the assets of Italian public electricity providers and surely expenditures here cannot be considered as current support to production.

<u>Recommendations</u>

1. The bulk of interventions for nuclear that the report classes as current 'support to production' (such as the €4.3 billion in 2012 of direct support to decommissioning and waste disposal)

should be re-classified as a form of historic support and appropriately re-labelled. Figures S-2 and 3-1 should be redrawn accordingly.

2. A new set of figures/tables should be produced for the report that lists the financial amounts of interventions according to technology in order to improve clarity and transparency.

2. Nuclear taxes and the effect on net subsidy

The current Ecofys report does not account for the effect of energy-specific taxes in its assessment of direct public intervention. This is an important omission in the methodology, and means that the report calculates a gross subsidy, and not a net one. This gives an unbalanced profile of the different energy technologies. An attempt is made to justify the omission of taxes on page 2:

> *"Apart from the fact that energy services are a critical requirement for virtually all human activities, the benefits include tax revenues raised by Government (in fact there are a number of energy sectors with higher rates of tax than comparable enterprises), employment, and economic activity. These benefits though are already reflected in market prices, are therefore unlike the external impacts we consider, and are not reported."*

However this justification is flawed. Not all energy forms pay the same amount of tax and some taxes are arbitrary, designed to strip out profits and are not related to an externality. Nuclear energy in particular is subject to such discriminatory taxes in several EU member states. We estimate that nuclear operations were taxed approximately €3 billion in 2012, and quite possibly more. These are assumed to be cashflow transfers rather than accounting entries.

Country	**tax detail (for 2012)**	**2012 paid (estimate)**
Belgium	Nuclear tax of 0.5 Euro cents/kWh	€479 million*
France	Tax on basic nuclear installations	€350 million**
Germany	€145 per gram of fissile uranium or plutonium fuel loaded into reactor. This translates to 1.4 Euro cents/kWh (2012 nuclear generation of 100 billion kWh)	€1400 million***
Sweden	Nuclear tax of 0.67 Euro cents/kWh. (63.5 billion nuclear kWh generated in 2012)	€424 million***
UK	0.61 Euro cents /kWh† Climate Change Levy (70 billion kWh 2012 generation)	€427 million***

* known exactly. Source: https://www.electrabel.com/assets/be/corporate/documents/activity-report-2012_EN.pdf

** Estimate based on NEA report https://www.oecd-nea.org/law/legislation/france.pdf , which cites 2006 values. It may be slightly over as not all such facilities relate to power production

*** estimated by multiplying tax rate by 2012 generation levels

† 0.51 p/kWh used. http://www.hmrc.gov.uk/rates/ccl.htm conversion rate of 1.2 euro per pound used. The UK climate change levy affects nuclear plants despite the fact that these emit zero greenhouse-gas emissions during operation

Several other countries have enacted similar taxes initiatives (e.g. Spain), but were outside the time period in question and therefore have not been listed. Legal challenges have been brought against the taxes in Belgium and Germany, with results pending as of writing.

Recommendation

1. Net subsidy must be the subject of this assessment. Where energy specific taxes exist and are not related to an externality (as is the case in the nuclear-taxes mentioned) these should be subtracted from the current intervention in all relevant figures (e.g. Figure S-2)
2. A description of energy-specific taxes, including nuclear taxes, should be included in the main body of the report.

External costs

The external costs of nuclear are estimated at approximately €22/MWh, as shown in Figure 3-8. The two major contributors to this estimate, resource depletion and cost of nuclear accidents, are based on faulty reasoning. This results in a misleading impression that nuclear energy's externalities are greater than those attributable to solar power.

3. Resource depletion

Depletion of resources makes up the largest part of the perceived nuclear externality, but the method used to estimate this for uranium is highly flawed. The two most problematic underlying assumptions of the 'Resource Scarcity Adjustment' method are that,

- the quantum of reserves and resources are fixed; and,
- the cost of extracting these resources will rise.

Historical and geological evidence suggests that there is almost no foundation to these assumptions. Firstly, the quantum of uranium in the earth's crust (and oceans) is perhaps the only really fixed limit and this quantum is a very high multiple of the 9800EJ (energy content) assumed in the report. The technology of finding these resources continues to improve and more resources are identified regularly. Secondly, the history of uranium extraction has been one of trend cost reduction due to improvements in extraction technology and there is no reason to believe that these reductions will not continue into the future. A final point is that the report fails to recognise the potential to recycle nuclear fuel and an eventual long-term transition to a fast reactor closed fuel cycle increases the available energy resource from extracted uranium by approaching 100-fold.

This flawed conclusion is even hinted at by Ecofys who note an alternative methodology for valuing resource scarcity that attributes a zero cost to uranium energy resource depletion. The authors have chosen to ignore this method in the calculation of the cost of uranium depletion for nuclear power without justification.

Recommendations

1. The assumptions underlying the resource depletion calculation are unfounded. No resource depletion estimate (for uranium at least[1]) should be included in the study.

[1] We are not informed enough to necessarily expand this to include fossil resources – although we believe similar points may apply.

4. The cost of nuclear accidents

There are several points to be made on the valuation of the externality for nuclear accidents, which appears on Figure 3-8 as a bar to the value of €4/MWh. Firstly, the European Union has never experienced a nuclear power accident leading to serious off-site impacts. How then can a real monetary value be recorded in the figure? This externality is of a completely different nature to all the others listed in Table 2-3. It is potential rather than an on-going and actual hazard. Neither Box 3-1 nor section A3.3 explain the inclusion of this number satisfactorily.

Next, nuclear operators make provisions for the possibility of a nuclear accident (this is acknowledged in A2.9.1). Every year that a nuclear accident does not occur, maintaining nuclear third party insurance counts as a unique cost to nuclear operators who must maintain this as part of their condition of operation. Nuclear plants are also subjected to a unique safety regulatory system, leading to an additional compliance cost burden which other energy technologies do not bear. The accident externality portrayed in the Ecofys report does not seem to take account of the attempts to internalise these costs.

That said, it may be argued that the cost of nuclear liability insurance in the EU may in the event of a serious accident be insufficient to compensate the victims. The work of D'haeseleer, undertaken for DG Energy, which concluded with a range of €0.3 - 3 /MWh, (for a potential accident) has attempted to take account of this possibility. D'haeseleer's report is noted by Ecofys but his estimates are ignored. A higher range of €0.5 – 4 /MWh is noted and it is the highest value that is selected without further justification for Figure 3.8, rather than, say, the mid-point or mean or lower value.

Finally, while there is a category for nuclear accidents, there is no corresponding category for the accidents of other energy sources. This is noted in A3.3 as being due to the fact that "*In the case of nuclear, the cost and consequences of any accident has the potential to be very much higher than for other energy sources.*" Several objections can be raised to this attempt at a justification. For one, it clearly forgets the fact that the consequences of a serious hydro-electric failure could be very great indeed[2]. There have also been a steady stream of increasingly high impact and high cost energy accidents the world-over usually to do to with the extraction, storage or transport of fossil fuels and biomass. Secondly this does not seem to recognise the fact that overwhelmingly the costs of a nuclear accident are driven by the social response rather than the impact categories included in Table A3.2 (human health, ecosystem and resource depletion). They are to a certain degree therefore within society's ability to influence.

<u>Recommendation</u>

1. The current nuclear accident externality estimate of €4/MWh should be removed from Figure 3.8. This figure should be reserved for real externalities and not potential ones.
2. For completeness, a category for energy accidents could be added but this should be based on actual energy accidents which have taken place in the EU and ended up requiring

[2] The worst energy accident on record is the Banqiao dam failure which led to the near-term deaths of some 171,000 people.

government assistance. Alternatively, the issues should be discussed in an appendix with reference to relevant studies of this topic.

Energy costs

5. Levelised Cost Of Energy for nuclear

We are puzzled by the levelised cost range for nuclear in the EU (€79-110/MWh) that appears in the report, and question why it is somewhat higher than the range of (€69-111/MWh) that is presented in the study conducted recently for DG Energy by Professor D'haeseleer. Moreover, the D'hasesleer study was focused on first-of-a-kind Generation III nuclear reactors rather than the Generation II reactors analysed in the Ecofys report (see Table A4-1), which should have lower costs[3]. Given that the D'hasesleer study was conducted with the express purpose of informing the Commission on the costs of nuclear the differences in the results deserved to be addressed directly by this report since it serves the same purpose.

We find the levelised costs presented for different energy sources somewhat unfamiliar and suspects that in part this arises as a result of some of the assumptions made in the levelised cost modeling. For example, decommissioning costs have been included for nuclear but not for any other technology. The authors seem to take the view that decommissioning costs for other technologies are not significant and can therefore be ignored. However, for some technologies this is simply not the case. Offshore wind in UK waters is expected to have decommissioning costs often in excess of the 15% of capital costs that are assumed for nuclear and the life of the structures is not expected to exceed 25 years; a much shorter period of time to accumulate the funds than the 60 years expected for new nuclear plants.

Another example is the Weighted Average Cost of Capital (WACC) used for nuclear of about 10% is somewhat on the high side, especially given that the utilities expected to build new nuclear plants are generally public sector companies. In contrast, the renewables WACCs of between 5-8%, which are predominantly for private sector companies, are modeled as very low risk. The renewables policy risk of 3% is hard to justify for future generation projects given the revisions to subsidised tariffs that have already been enacted in countries such as Spain. A final point regards the decision to use statistically measured rather than 'technical' full load hours. The statistical load hour average is brought down for the EU nuclear fleet by the French performance as indicated in table A4-7; however French nuclear reactors operate in load-following mode in order to help balance supply and demand in the country (i.e. they reduce a system cost). This is not typical for any country outside of France at the moment. Germany, too, shows some rather atypical full load hours in the period in question (2008-2012) which also happens to cover the time frame of the Fukushima accident and Germany's political response to that event. German nuclear capacity factors are typically much

[3] There have been delays and overruns in Generation III reactor projects within the EU, but these should largely be attributable to their First-Of-A-Kind nature. These projects follow a hiatus of about two decades in which there was no construction of new nuclear designs within EU countries. So-called nth of a kind reactors (NOAK) should achieve substantial cost reductions through learning and as the supply chain is strengthened - particularly where countries build a series of such reactors.

higher, in the range of 90%[4]. The UK figures are also low representing genuine technical difficulties but for a reactor technology (the AGR) that is no longer commercially available for purchase today. It must be said that these assumptions combine to make the nuclear LCOE appear comparatively high.

Recommendations

1. An explanation of the differences between the Ecofys and D'haeseleer LCOE for nuclear should be included in the report.
2. Decommissioning costs should be included in the LCOE assumptions for all generating technologies (and especially offshore wind), not just nuclear.
3. Uncertainty bars should be included in Fig 3-10 reflecting whatever is the most sensitive parameter for each technology (eg WACC, Full-load hours, etc).
4. As drawn, Figure 3-15 indicates the lower bound for nuclear costs as about €90/MWh and the median as about €100/MWh. This figure should be redrawn carefully to reflect the lower bound of €79/MWh for nuclear as given in the text. In fact there appears to be some issue with the drawing of the quoted ranges for all generating technologies.

6. System costs

Given the amount of detailed investigation that has gone onto every other conceivable form of support and externality in the report, the complete exclusion of a system cost analysis stands out starkly. Box 2-4 provides an explanation for why this is not included in the report's methodology. Of relevance is the following text:

> *"Several studies have been carried out to estimate these costs and also discuss the issue of allocation (see below for examples). These studies tend to be for scenarios for higher penetration of supply-driven renewable resources than was the case in the EU in 2012, for example NEA considered penetrations of 10-30% for both wind and solar. Even if system costs might increase in future, the contribution from energy supplied in 2012 is considered to be negligible. In addition, most of these costs should be reflected in the market in future, for example through imbalance costs for plant operators. As such they would not be defined as external costs."*

This justification can only be described as weak. The following points stand against it:

- By not including a system cost analysis (by technology) in the report, the authors are preventing the reader from making up their own mind as to whether system costs are currently significant or not.
- It is not obvious that system costs are currently negligible – especially in certain European countries which already have penetration levels of intermittent renewables of around 20%[5]. Even at 10% penetration levels for wind (predicted to have the lowest system costs), the NEA report mentioned estimated a generalised system costs €14.2/MWh.

[4] See page 11 of http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/REPORT_OptimizCapacity.pdf
[5] 2012 generation figures Spain: wind 16%, solar 4%. Germany: wind 7.4%, solar 4.5%. Denmark: wind 33%. EU wind 11.4%.

- It is not clear that future increases in the system costs will be reflected in the market price for individual technologies. Notably the compression effect, whereby priority dispatch allows renewable energy forms to displace other generators and reduce their load hours, will result in those generators charging more per kWh to cover fixed costs when they do generate.
- As the amount of intermittent generation in interconnected European grids is set to rapidly increases in line with EU targets (e.g. the 2020 and 2030 energy targets), managing system costs will increasingly become a major challenge for all EU countries and an increasing component in electricity consumer tariffs.

There is admittedly a question as to how system costs should be treated by Ecofys. In one sense they may be thought of as an externality but since all technologies give rise to some level of system cost this is not a very helpful categorisation. A more appropriate place to discuss them is within the levelised cost estimates.

<u>Recommendation</u>

1. Estimates for system costs according to technology should be calculated in the report System costs should be introduced and discussed in the levelised cost section (3.3), and represented graphically in Figure 3-15 via a different coloured bar connected to the right-hand side of the LCOE.
2. By far the most comprehensive study on electricity system costs by technology is the NEA's *Nuclear Energy & Renewables: System effects in low carbon electricity systems*. The amounts calculated in that report should form the basis of the Ecofys analysis.
3. For transparency an estimate of system costs by country should also be produced and included in the report.