Commentary

Subsidies & costs of EU energy focusing on the nuclear sector

Initial assessment of the study "Subsidies and costs of EU energy" by Ecofys & partners for DG Energy (Final Report of November 2014)

Requested by the Group of the Greens/European Free Alliance in the European Parliament

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1 Summary

The Group of The Greens | European Free Alliance in the European Parliament requested this first assessment of and commentary of the study "Subsidies and costs of EU Energy", focusing on nuclear power. This commentary is not a detailed or complete critique, nor is it meant to fill gaps. It is to tease out key insights from study results and omissions, and make suggestions for further studies and the further discussion of future EU policy.

The key criticisms of the study are:

- The cost assumptions for nuclear power, in particular, and the estimates of relevant subsidies are too low, with consequences for the assessment of past investment, the current competitive position of nuclear power, and possible but increasingly unlikely future investment.
- One specific issue deserving deeper analysis are the various measures by government to lower the cost of capital for nuclear power plant construction, in part by de-risking the investment (and thereby protecting the investors).
- Overall and importantly, the lack of transparency and the long history of subsidies in the energy sector disproportionately favour nuclear power, which is capital-intensive and has very long investment cycles. Past (hidden) subsidies, that are not all identified and estimated in the study, still result in reduced "visible costs" for nuclear power, to the detriment of other energy technologies and carriers.
- A first step would be to acknowledge the existence and impact of hidden subsidies, past and present, in order to allow for a more rational debate. Part of the problem, resulting in unnecessary polarisation, is that proponents of nuclear power remain in denial of the true costs and risks of nuclear power, and tend to believe their own propaganda. An honest assessment would help, and the study by Ecofys and partners can only be a start in a longer process.
- The external cost of nuclear power in terms of human health, the environment, economic (especially the uninsured and uninsurable risks involved) and the effects on transparency of government and corporate decision-making on democratic culture have not been addressed adequately in the study. The obvious difficulties in mapping historical subsidies should not be used as an excuse not to try to catalogue present subsidies, and avoid future subsidies for nuclear technology, a technology that should have achieved maturity long ago but is unable to do so.
- The future costs of nuclear power, difficult to estimate as they may be, present a similar challenge. They are known, or in principle could be known with some certainty, and yet they are not properly accounted for. The low levels of funds set aside for decommissioning and dismantling nuclear plants and for removing, storing, monitoring and managing, and safeguarding nuclear wastes for millennia proves this point.
- The study, focussing on the economics, leaves other dimensions of energy policy and the measures in support of energy technologies and carriers unaddressed. One is the lack of a legal assessment of Member State and EU-level interventions, including

an assessment of the economic incentives of laws, regulations, and regulatory practice. Another gap is in the use of and accounting for research funds for nuclear fission and fusion.

- In summary, the main conclusions in the summary are misleading in that they paint to positive a picture of the costs of nuclear power and the subsidies and privileges involved. On the whole, they do not reflect the more nuanced but still (necessarily) incomplete treatment of the issues in the body of the study and the annexes, including the data gaps, cost assumptions, hidden interventions in support of nuclear power, or historical subsidies.

As such, the study fails as concerns nuclear to provide a sound basis for the "formulation of sound and concrete future policy guidance based on the principles formulated in the commission‘s Communication Delivering the internal electricity market and making the most of public intervention". The true cost of nuclear power is very likely a lot higher than stated in the study and may be used to misguide EU energy policy, and impose unnecessary risks and costs on future generations.

The EU should admit errors concerning nuclear power – and the proliferation of nuclear expertise, materials, equipment and technology – making it explicit that they are mistakes that impose high costs and risks on current future generations. The European Commission should refrain from granting further support to nuclear power and commit to investing in renewable energies and smart grids, phase out nuclear power.

The Ecofys study does however make a more robust first assessment of fossil fuel subsidies and costs and should therefore still be considered as a first step in the right direction.

2 Introduction, Background and Context

The Group of The Greens | European Free Alliance in the European Parliament requested this first assessment of and commentary of the study "Subsidies and costs of EU Energy" performed by Ecofys in cooperation with KPMG, the Centre for Social and Economic Research (CASE) and CE Delft. The assessment and commentary focuses on the nuclear power sector, as a political priority and in response to the most surprising provisional finding, namely the relatively low cost of nuclear power if compared with other assessments of true costs, subsidies and privileges for the sector.

Originally designed to be a short commentary "on three pages in three days" it grew longer to do justice to the complexity of the points raised and to improve readability. It is not meant to be a detailed and complete critique or fill gaps left by the Ecofys study. It is to tease out key insights, both from study results and omissions, and present theses on what this might mean for further studies in the field or, more importantly, the further discussion on the development of EU policy on energy, climate, competition and the internal market, or Energy Union.

2.1 Background

A number of developments bear on EU energy policy, dynamics in the allocation of legal competences and political responsibility, political changes and conflicts in energy supply or transit regions, and the changing economics and risks assessments of various forms of energy. At the core of EU policy is the completion of the internal market in the field of energy, the new focus on the Energy Union, and the long-standing but increasingly questioned objectives of the Euratom Treaty, which can be in contradiction to the rules and the spirit of the internal market.

The interconnections between Member States – a physical precondition for the functioning of the internal market – and controversies over persistent state aid in the energy sector are at the top of the agenda. The last-minute decision, now about to be legally challenged, of the previous Commission to allow generous state aid to the proposed new nuclear power station Hinkley Point C in the United Kingdom, add fuel to an already heated controversy about the right balance of policy objectives, and the best way forward towards an EU with a safe, clean, sustainable and affordable energy sector that helps make the EU competitive.

One of the key requirements for a functioning of the internal market is that there are no subsidies or other forms of support that distort competition among businesses in different Member States, nor any barriers to the trans-boundary provision of (energy-related) products, goods and services. Knowledge of subsidies, past, present and planned, is necessary, but not presently given in the field of energy.

According to Tender Specifications, the "European Commission needs a comprehensive analysis for all EU countries and at EU level on production, system and consumption type costs and subsidies for all kinds of energy products and carriers" (p. 10). The Directorate-General Energy therefore commissioned the Ecofys study to gather data on the costs and subsidies to the energy sector, and stated explicitly that "[t]he aim of the study is to provide the European Commission with a complete and consistent set of data on energy (electricity and heating) generation and system costs and the historical and current state of externalities and subsidies in each Member of the EU and for the EU overall" (p. 11).

2.2 Request for Commentary

The request for this first assessment and commentary focuses on these points:

- Definition of subsidies and costs of EU energy;
- Methodology, data basis and model structure;
- Evaluation of data gaps.

The comments are based mainly on the following:

- Tender Specifications and conceptual and methodological framing of the study;
- Final report, including its annexes;

- Observations from interviews with a small number of experts, inviting them to comment either on the study or on EU policy developments in general.

2.3 Discussion of Context

The study "Subsidies and costs of EU energy" is a practically impossible undertaking, a fact that must previously have been known to the European Commission, DG Energy, as the client, and Ecofys as the contractor undertaking the study. The current state of public knowledge about the true costs and subsidies as well as other factors simply do not allow for a "complete and consistent set of data on energy (electricity and heating) generation and system costs and historical and current state of externalities and subsidies in each Member State of the EU and the EU overall" to be provided.

The contractor had to make a number of assumptions and use simplifications and work-arounds to establish the best possible result given the circumstances and the time and budget allowed. The contractor has been partially diligent in reporting such measure and other shortcomings, so that the study points to a number of data gaps and inconsistencies that remain to be addressed. However, the large gaps and inconsistencies in the data should have been highlighted more, and should have been taken into account in the analysis to avoid the misinterpretation that the summary in particularly may be inviting.

While this is true for all forms of energy products, carriers and services, there are significant differences in the effects. For instance, comparative assessments using standardised methodologies in the framework of EU policies aiming at approximation or harmonisation in fuel taxes have resulted in a fairly satisfactory understanding of that sector. The greatest lack of clarity, the highest density of probably very large and often hidden subsidies and other privileges are associated with the nuclear power sector, where the study falls short of what is needed for the "formulation of sound and concrete future policy guidance based on the principles formulated in the Commission‘s Communication Delivering the internal electricity market and making the most of public intervention" (Tender Specifications, p. 9).

This shortcoming is so important that the conclusion of the study should be that, in its present form and on the basis of the data obtained so far, it cannot provide a basis for decision making on future EU energy policy.

In particular, the study significantly underrepresents the true cost of the nuclear power sector, the subsidies received, and the value of privileges and immunities accorded to the industry.[1] The true cost of nuclear power is very likely very much higher than stated in the

[1] Such support starts with public funding for research, development, demonstration and deployment (RDDD) and education and training for the industry, exists throughout the "value chain", from uranium mining, processing along the whole fuel cycle, fuel stock management, the development, design, construction, operation and maintenance of nuclear installations to their decommissioning and dismantling to the processing and long-term storage, monitoring, management and safeguarding of nuclear wastes. The forms of support are ingenious and

study. Without clear and unequivocal qualifications, the study risks misguiding EU energy policy, especially if the results are simplified and reported without context.

Misrepresentations may be invited by the tone and some detail of the study summary, which are difficult to reconcile with the data presented in the study, including the gaps, and the analysis. Overall, the summary suffers from distorting the presentation of recent and current levels of overt subsidies (2008-2012) for renewable energy and energy efficiency, as compared to the largely "historic" (pre-2008) and hidden subsidies for nuclear power and fossil energy infrastructure. In this context, no attempt is made to include the future and legacy costs that should be assigned to the different energy technologies and carriers. This would show a much higher level of public support for nuclear power in particular. The summary of the study is thus at variance to a number of recent (and earlier) studies that not only show opposite results concerning recent and current levels of support, but also focus on the likely evolution of costs in the foreseeable future.

An important shortcoming of the study by Ecofys and partners is that the data collected and analysed are of little use for the political decisions to be taken at this time. Key questions address the level of subsidies and special privileges required now and in future to finance different options of energy supply and their mix. This needs to be assessed with a view not only to current and future costs, including legacy costs already caused and that now are inescapable but often not adequately funded, but also the social and environmental risks associated with the various options.

Different energy technology options have very different profiles in their distribution of costs and risks, benefits and opportunities, among stakeholder or "constituencies" and over time. For instance, a feed-in-tariff for renewable energy, degressive over time, today puts short-term costs to households and small enterprises but creates benefits for large industry and the public treasury (through increased tax revenue from additional value-adding economic activity) while helping finance power generating assets that will produce power at very low marginal cost and without significant environmental or other social cost for decades to come. Contrast this with the contract-for-difference support schemes proposed for new nuclear power plants, which are not only progressive over time and therefore put an ever increasing burden on household and small enterprises while benefitting large industry in a similar way to feed-in-tariffs, but also put a (contingent) risk on the public purse and create new path dependencies on a technology that has risks too large and uncertain to be insured, and creates legacy costs that will be a burden on hundreds of generations after the present.

A debate about subsidies cannot be dissociated from the wider economic, social, environment, governance and ethical considerations, but these are not included in the Terms of

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varied and range from (overt) direct funding for investment, for instance, via less detectable forms of financial support, including the de-risking of investment, the lowering of capital cost or the granting of liability caps and waivers, all the way to opaque forms of support such as lax or non-enforcement of rules, whether technical rules (affecting safety) or financial rules, such as reporting and auditing obligations.

Reference for the study. In the context of the EU‘s internal market for energy and the Energy Union, the impact of different choices on the functioning of the internal market and the EU‘s competition policy and state-aid disciplines must be assessed. If there are overriding environmental or – in a geo-political or military sense – "strategic" considerations, so important that the EU‘s internal market and state aid rules should be set aside, then such considerations must be made explicit and subject to contestation in political debate involving all EU and Member States‘ citizens and institutions.

3 Terms of Reference of Ecofys Study for DG Energy

The Tender Specifications for "A study on energy costs and subsidies in the European Union" conducted by Ecofys for the European Commission, Directorate-General for Energy, create a framework that induces the contractor to provide data, analysis and conclusions that overstate the reliability of the results and create a bias in the findings.

The specifications begin (on p. 9) by acknowledging a general lack of reliable data and information for policy formulation, and uncertainties created by observed prices not accurately reflecting costs, and where the size and nature of subsidies and cross-subsidisation is not transparent. The complexity of policy designs and policy-instrument choices as well as the lasting effects of historical subsidies add to the lack of clarity and make rigorous comparative assessments and the creation of a unified data set for the EU as a whole a present impossibility.

In spite of this, the contractor is tasked with a study of vast scope. For practical reasons, the contractor and the client need to agree on limitations in data sources, scope of the analysis, and methodological simplifications. These measures can have an impact on the study results, not only in their reliability but also in the overall direction; they can create a bias in the research, which can skew results, and ultimately misguide policy. Such is the case here with respect to nuclear energy, where subsidies are underreported, and renewable energies, where support is over-reported, especially with respect to risks and future costs.

On the one hand, the definition of subsidies (in sections 3.4.1 and 3.4.2 on pp. 11-13) is quite broad and includes not only current and historical subsidies in the narrow sense (of direct payments from public budgets) but also other, indirect subsidies and privileges as well as the non-internalisation of external costs and "legacy costs".

On the other hand, in particular in relation to nuclear power, the information and data sources to be considered and explicitly stated in the Tender Specifications as an "Indicative List of Relevant Material" (on p. 10) represent a relatively narrow sample of studies from institutions, namely the OECD Nuclear Energy Agency (OECD NEA) with a known bias in favour of incumbent technologies and industry structures. Furthermore, the "Description of Tasks" (on p. 11) contains what reads like an exclusive list of governmental and financial media

organisations "active in energy market analysis". Inadvertently or by design, the Description of Tasks excludes critical studies and assessments from academic institutions or independent studies sponsored by civil-society or public-interest advocacy organisations. In doing so, the Tender Specifications narrow the analysis to micro- or firm-level economic considerations where assessments of macro-level or total public costs and risks is necessary.

This narrowing of the evidence base is significant, as there are a number of recent and current studies with broader scope and perspective and results that are at variance with those seeded for the Ecofys study.[2] To their credit, Ecofys and partners went beyond the evidence presented in documents originating from governmental, inter-governmental or financial media organisations.

One example is the recent (September 2012) study of External Cost of Nuclear Energy and Proposals for Reforming Nuclear Liability Law "Externe Kosten der Atomenergie und Reformvorschläge zum Atomhaftungsrecht" conducted by Green Budget Germany for Greenpeace Energy and the German Federal Association for Wind Energy[3]. Based on a survey, the external costs of nuclear energy vary by a factor 3.200 and range between 0.1 and 320 ct/kWh, with a "best guess range" of 10.7 to 34 ct/kWh. This study also states method logical difficulties and makes important qualifications to its findings.

4 Observations on Ecofys Report (November 2014)

4.1 Definition of subsidies and costs of EU energy

Overall, the requirement to use a broad definition of subsidies and other forms of support, has been fulfilled in the Ecofys study, as has the requirement to include all costs in the assessment. There are gaps that remain in spite of the efforts of Ecofys and their partners', and they provide good explanations (in the annexes) or arguments (to challenges from stakeholders, for instance).

Here are some observations and commentary:

- **Broad but not Comprehensive Definition of Subsidies**
  The study is based, as is requested by Tender Specifications, on a broad definition of subsidies, and makes good attempts to cover all energy forms, products, carriers and services, all Member States, and all forms of subsidies and other forms of support,

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2 Some such studies are listed at the end of this commentary.

3 http://www.foes.de/pdf/2012-09-Externe_Kosten_Atomenergie.pdf

current and historical. However, the approach is not and cannot be comprehensive, and – given the costs and risks involved – omitting one direct or indirect type of subsidy or privilege can change the results of the economic assessment by orders of magnitude. In view of the data gaps and hidden subsidies, and until more detailed and complete data and analytical studies are available, the study results should be treated with caution. In particular, the true cost of nuclear (and fossil) energy should be deemed to be much higher than currently appears.

- **Satisfactory Overview of "Current" Subsidies**
  The overview of "current" subsidies and other forms of support (from 2008 to 2012) can be called satisfactory. It is good enough to get a reasonable understanding of types and levels of subsidies and support to see if there are unjustified distortions of competition in the internal market.[4]

- **700 Subsidy and Support "Interventions" in 2012**
  The study identifies and presents annual economic values of over 700 "interventions" – meaning policy or regulatory action in support of (parts of) the energy sector – in 2012. The number alone indicates the heterogeneity of policy and the complexity of creating a unified framework for analysis. The aggregate value of these state interventions underlines the economic importance of the sector.

- **No Legal Assessment Yet**
  However, in addition to tabulating economic values, a legal assessment of these interventions is needed for a more detailed understanding of the design and character of individual interventions. Assessing the legality of interventions with EU competition law or state aid rules is a matter of technical design and details. While the Member States and the European Commission may deal with these matters case by case, the aggregate effect of all interventions, even if deemed legal each on their own, can counter the objectives of the internal market or of the Energy Union. Absent trustworthy information about the true level and value of subsidies and privileges, and thus the costs and risks of nuclear power, and absent a comprehensive legal assess-

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[4] There are, of course, justifications for but also strict disciplines for limited distortions in competition in and obstacles to the functioning of the EU‘s internal market. The examples of subsidies for nuclear power on the one hand and renewable energy on the other provide pertinent cases for comparison. In the case of renewable energy, there are clear environmental objectives and transparency of the subsidies, which are designed to be and in practice are diminishing over time and thus temporary in a sector that is maturing and shows all the benefits of a technological and economic "learning curve"; it is thus very likely that the subsidies can be phased out over time. In the case of nuclear power, in a technology that is not maturing, there is no such learning curve – on the contrary, the technology and the sector exhibit a "negative learning curve" where costs rise over time – and many of the subsidies and privileges are not transparent and increase over time. With such differences, support for renewables should be judged to be legitimate where support for nuclear should not be.

ment, the legitimacy of new nuclear and even extensions in the running time of existing plants lack legitimacy.

4.2 Methodology, data basis and model structure

The overall framework is chosen as a rational response to the Tender Specifications and adapted to the practical difficulties of working in a field with inconsistent and incomplete data. However, the choice does not and cannot do justice to the complexity and context. The data used are those held in generally well-regarded and established (governmental or inter-governmental) organisations. That does not mean that they are correct. They have the advantage of being fairly consistent, at least for most recent and current data, and that they are presumed to have effective procedures for maintaining data quality. They can be criticised for relying too much on data provided by incumbent industry operators or their regulators, and that there is too little contestation and validation of data, information and assumptions. This general finding points to the need for a deeper analysis, particularly in relation to the nuclear sector.

It is not possible in this short commentary to assess the model structure in detail, which requires additional expert knowledge. At a general level and with some regret, however, it may be said that the models are standard for the kind of assessment undertaken by Ecofys and partners. As such, they come to conclusions that fit with the mainstream of other studies generally in support of incumbent energy technologies and carriers. There can be very important effects generated by some "standard assumptions" embedded in models, and it would have been very important to critique assumptions more than has been done. Examples are discount rates (used to give a present-day value to future costs or benefits), cost of capital or interest rates, assumptions about the development of sector-specific costs. A deeper analysis is required before making an assessment of the suitability of all such assumptions for the study purpose.

- **Cost Assumptions for Nuclear Power Plants**
  Ecofys and partners were forced, mainly for reasons of data availability and the number of plants, to use older nuclear power plants of Generation II (which dominate generation of the nuclear reactors currently in operation) in their assessment of the costs of generating nuclear power. This choice may have resulted in lowering the estimation of generating costs because the investment costs of nuclear power have historically gone up (in constant dollars, i.e. controlled for inflation) from each generation to the next, and from almost each plant to the next that has been built within each generation. In addition, there are sharp increases in operating cost as the average age of the nuclear power plants currently in operation increases – their average age in the EU is now around 30 years – and it become increasingly difficult and costly to maintain the reactors as they reach or exceed the operating time they were designed for. This historical experience and the delays and cost overruns in current construction point to accelerating increases in the cost of nuclear power, in

spite of subsidies and "de-risking interventions" being undertaken.

- **Cost of Capital and "De-Risking" Investment**
  Investment in electricity generation (and the grid) is characterised by relatively high capital costs (and comparatively low operating costs) and a long investment horizon reflecting the long technical life of the installations. Ecofys and partners use essentially the same "Weighted Average Cost of Capital" for all energy technologies (and countries). This assumes that all investments have similar risk attached to them, which is evidently not the case. Public policy interventions are often designed to reduce the investment risk of investment[5]. This can be either directly for individual investments (through project-specific loan guarantees, for instance) or classes of investments (such as through feed-in tariffs or access to market guarantees for small projects in distributed renewable power generation). Or it can be indirectly through changing the general cost of borrowing for certain sectors or companies (see section 5.2 Reducing the Cost of Capital for Nuclear Power Companies on p. 13 for more detail). Without such "de-risking", new nuclear power projects would not be "bankable", meaning that they could not be financed through the commercial capital market, an astonishing situation in an industry over 65 years old and in sharp contrast to the renewable energy sector where some subsidies are being faded out and an increasing investment volume succeeds in market conditions and does not require support any more.[6]

- **Historic investment support**
  In the study, historic investment support is only taken into account if the depreciation period has not ended by 2012. Although that is a defensible methodological choice, it distorts the overall picture presented by the analysis. It would have been equally or more plausible to distribute the support over the whole period of operation (or power production) in order to balance the costs and benefits of the subsidies.

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5 Investment risk comes in various guises: "Market risk" refers to uncertainties of future power prices and thus revenue; "cost risks" refers to the risk of cost overruns during construction, including due to delays or new safety measures (especially likely after Fukushima), "subsidy risk" refers to the risk that current – overt and covert – subsidies may be denied, perhaps following legal challenges, "political risk" may arise from changing electoral majorities or shifts in public opinion, for instance after the next nuclear catastrophe, and "construction risk" is the project management risk of building nuclear power plants as very complex installations. See Energy Fair (ed.) (2012): "The Financial Risks of Investing in New Nuclear Power Plants", URL: http://www.mng.org.uk/gh/private/risks_of_nuclear_investment.pdf

6 Citibank issued a report in November 2009, saying "New Nuclear – The Economics Say No", URL: https://www.citigroupgeo.com/pdf/SEU27102.pdf;
The argument is summarised and put in context by Julio Godoy in his "Nuclear Does Not Make Economic Sense Say Studies", URL: http://ipsnews.net/news.asp?idnews=50308;
See also this article in Forbes: http://www.forbes.com/sites/energysource/2014/02/20/why-the-economics-dont-favor-nuclear-power-in-america and this in the Bulletin of the Atomic Scientist: http://thebulletin.org/nuclear-aging-not-so-graceful
In 2011, Reuters reports Citigroup as saying: "UK nuclear investment environment 'dire'" http://uk.reuters.com/article/2011/07/06/nuclear-citigroup-idUKL6E7I618X20110706

4.3 Evaluation of data gaps

- **What about Hidden "Interventions"?**
  In spite of the large number of observed interventions, it is still doubtful that all relevant interventions were identified. As is stated in the Tender Specifications, there is a lack of transparency and clarity, which hides the true competitive position or efficiency of producers. Governments and the recipients of subsidies and other forms of support often have an interest in shielding them from public and sometimes even parliamentary scrutiny. This may be especially true for subsidies to the nuclear industry with its close ties to the military, especially in the EU's Nuclear Weapons States, a point that merits deeper analysis.[7]

- **Estimates with Reference to a Hypothetical "Liberalised Market"**
  Where subsidies, especially historical ones, are not known, reasonable estimates must be used in order to provide a "complete and consistent set of data". In the study, this is done by estimating (or guessing) the costs and prices under the hypothetical (and historically counterfactual) condition of a liberalised market for energy. Because of the uncertainty around the hypothetical condition and the hidden nature of the support mechanisms, any estimation will be highly uncertain.

- **Estimates Invite Controversy, which then Lower the Estimate**
  In the context, any estimate will invite controversy from the government agency that granted it and the industry that benefited. As a result of the asymmetries in access to data as well as economic and political power, such controversies are likely to result in a lowering of estimates. (The convention among economists to assign a value of zero to data that cannot be observed or estimated reliably has the same effect.)

- **Hidden Interventions More Likely in Favour of Nuclear Power**
  There are likely to be more hidden subsidies for nuclear power than for other energy technologies, especially in contrast to renewable energy technologies that have often been supported not by subsidies (from government budgets) but by market-based

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[7] It may be worth remembering what Jonathan Schell wrote in "From Hiroshima to Fukushima" in The Nation: http://www.thenation.com/article/159238/hiroshima-fukushima
"As Ira Chernus has chronicled in his book Atoms for Peace, the proposal paradoxically grew out of Eisenhower's distaste for arms control. He had launched a nuclear build-up that would increase the US arsenal from 1,436 warheads at the beginning of his two terms to 20,464 by the end. His strategic nuclear policy was one of "massive retaliation," which relied more heavily on nuclear threats than Truman's policy had. Arms control would have obstructed these policies. Yet Eisenhower needed some proposal to temper his growing reputation as a reckless nuclear hawk. Atoms for Peace met this need. The solution to nuclear danger, he said, was "to take this weapon out of the hands of the soldiers" and put it "into the hands of those who will know how to strip its military casing and adapt it to the arts of peace"—chiefly, those who would use it to build nuclear power plants. Of course, the weapon never was taken out of the hands of soldiers, but the basic power of the universe was indeed handed over to nuclear power engineers, including Japanese engineers."

and highly visible charges or levies on electricity bills. The importance of this asymmetry is difficult to assess, but good attempts were made in recent studies from Austria[8] and Germany[9].

- **Impossibility to Map Historical Subsidies**
  While current subsidies and other forms of support could be documented, analysed and tabulated in a satisfactory manner, the same cannot be said about historical subsidies. Many of those subsidies are documented, if they are publicly available at all, in forms not accessible to modern IT equipment; they are still only on paper and in locations often physically difficult to reach. A thorough analysis of such subsidies and other forms of support is the painstaking work of historians and clearly beyond the scope of the study performed by Ecofys and partners.

- **Historical Subsidies Tend to be Shrouded in Secrecy**
  Such historical subsidies, which can have an effect on competitive positions today especially in industries with physical assets that have a very long economic and technical life (or a very slow turn-over of capital stock), are found more in the "conventional" fossil energy sector and, in particular, in the nuclear industry. (This can be explained at least in part by a) the close links between military and "civilian" nuclear technology, facilities and materials, and b) the economic and geostrategic urgency of building up the nuclear industry during the cold war and in response to the OPEC-induced oil crises of the 1970s and early 1980s.)

- **Ignorance of Historical Subsidies Favours Nuclear Power**
  The difficulties in accessing information and data about historical subsidies creates a bias in favour of the nuclear sector, again especially in contrast to renewable energy technologies which developed in parallel to modern information technology, including the "smart grid" and now battery storage.

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8 Mraz, Gabriele, et alii (2014): "Renewable Energies versus Nuclear Power – Comparing Financial Support". Report by the Austrian Institute of Ecology and e-think to the Vienna Ombuds-Office for Environmental Protection. Vienna, November 2014, 100 p. Download via www.ecology.at/wua_erneuerbarevskernenergie.htm

9 Küchler, Swantje, and Rupert Wronski (with Jonas Haas) (2015): "Was Strom wirklich kostet – Vergleich der staatlichen Förderung und gesamtgesellschaftlichen Kosten von konventionellen und erneuerbaren Energien" [The True Cost of Electricity – Comparison of State Aid and Macroeconomic Costs of Conventional and Renewable Energies]. Report by Green Budget Germany for Greenpeace Energy. Berlin, January 2015, 132 pages. Download via http://www.greenpeace-energy.de/engagement/energiepolitik/das-kostet-strom-wirklich.html
A summary can be found at http://energytransition.de/2015/02/what-electricity-really-costs

5 General Commentary & Suggestions for Discussion

Responding to the request for additional commentary beyond the Tender Specifications and the Final Report of the Ecofys study, the following points are submitted:

5.1 Potential use of Research Budgets to Subsidise Nuclear Power

This appears to be an important point where the Ecofys study leaves gaps, but it is difficult to find good evidence. In general terms, the problem is that money meant for research, development, demonstration and (pilot) deployment can find its way into "normal" (commercial) operation and thus become a de-facto subsidy. While this is tolerable, perhaps even desired, in the initial phases of technology and business development, it should be considered a particular form of hidden subsidisation if it persists. Normal procedures for monitoring, auditing and reporting on the use of research budgets seem to have failed consistently for years in relation to nuclear technology. The funds appear to involve Euratom expenditure that is spent without proper controls or audits, or even reporting from Member States. In such cases, it can be assumed that the unaccounted-for sums are channelled to military research, for which they were not intended, or as subsidies into nuclear power plants.

5.2 Reducing the Cost of Capital for Nuclear Power Companies

There are explicit ways for government to lower the cost of capital, an important form of support in an industry that has high capital cost and long investment lead times. Explicit ways are loan guarantees, which effectively and directly reduce borrowing costs by lowering interest that banks (and other creditors) would charge. An important but implicit way is to create expectations of government support at times of distress for the nuclear company. Such expectation are created by ownership, for instance, as governments are generally not presumed to allow their emanations to go bankrupt but are expected to recapitalise them (i.e. to inject additional capital to increase the capital available for the business) or even to bail them out in times of need. Expectations are not legal in form, and yet they have their effect on the credit risk ratings of nuclear companies, which lower the cost of capital.

Here are a few illustrations of how the effect works in the practical decisions and communications of rating agencies (such as Standard & Poor‘s (S&P), Moody's, Fitch):

- **S&P downgrades French nuclear-uranium giant AREVA (29 June 2010)**[10]
  "[S&P] are [...] lowering the long and short-term credit ratings on AREVA to BBB+/A-2 from A/A-1" […]. The downgrade stopped there, and avoided increasing AREVA's cost of borrowing considerably, because the "outlook reflects [S&P's] view that AREVA is likely to be able to successfully execute the […] proposed capital increase, thus strengthening its balance sheet. [...] S&P also suggested the French government 'would provide timely and sufficient extraordinary support to AREVA in the event of financial distress.'" AREVA bond ratings were eventually cut to junk by S&P on 20 November 2014 when it became clear that the company would require a (further) capital injection from the French government, sooner or later.[11]

- **Moody's assigns A3 rating to hybrid notes of EDF (22 January 2014)**[12]
  "Moody's Investors Service has today assigned a definitive A3 long-term rating to" […] 'hybrid' debenture notes of Electricité de France (EDF) […] This reflects […] that the Aa3 senior unsecured rating benefits from two notches of uplift based on our expectations for potential extraordinary support from the French state […]."

- **S&P lowers Vattenfall ratings to 'A-/A-2' (9 December 2011)**[13]
  "As [S&P] do not believe that Vattenfall's financial risk profile and credit measures will improve to a level commensurate with an 'a-' stand-alone credit profile (SACP) in the near to medium term, we have consequently revised the SACP to 'bbb+' from 'a-'. Our 'A-' long-term rating on Vattenfall is one notch above the SACP, based on our expectation that there is a "moderate" likelihood that the company would receive support from its owner, the Kingdom of Sweden […] in a financial stress scenario.

More such examples can be found to demonstrate the practical relevance of expectations of contingent state support for nuclear power companies. The financial value of these expectations for the companies depends on circumstances and changes over time, but it is considerable. The expectations are reinforced by repeated experience in countries where nuclear companies were in need of recapitalisation, such as during restructuring processes in the United Kingdom, or in acute distress, such as TEPCO after the tragedy at Fukushima.

Perversely, from a macro-economic perspective, the financial markets have learned they can trust governments to bail out nuclear companies, and that their investments are safe (unless they invest in subordinate notes which may not benefit from government largess in the same

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10 http://www.mineweb.com/archive/sp-downgrades-french-nuclear-uranium-giant-areva-on-weakened-profitability

11 http://www.ft.com/intl/fastft/239772/areva-cut-junk-sandp and http://www.bloomberg.com/news/articles/2014-11-26/areva-says-it-may-consider-recapitalization-to-reduce-debt-load

12 https://www.moodys.com/research/Moodys-assigns-A3-rating-to-hybrid-notes-of-Electricit-de--PR_290961

13 http://www.reuters.com/article/2011/12/09/idUSWLA986520111209

way as senior debt). This is all the more serious as the practice of repeated bail-outs for nuclear utilities is self-reinforcing through a political process. Because these companies achieve or maintain investment-grade status, institutional investors with high standards of fiduciary duty, such as government-supervised pension funds, continue to invest in their stock and bonds. If then the company is threatened by insolvency, concerns for the security of those investments exert a strong pressure on governments to provide another bail-out. This vicious circle will be broken at some point, most likely with significant social and political consequences especially in those EU Member States with – relative to their population and size of economy and tax take – large investments in the nuclear sector and unfunded nuclear legacy costs. France, Belgium, and the United Kingdom come first to mind.

5.3 External Cost of Accidents, Liability Caps & Waivers, Insurance

This subject is address at length in the Ecofys study. But a number of problems remain:

- The figures stated for external cost of accidents appear to be low. A recent study by the French nuclear safety institute IRSN estimated the cost of a major nuclear accident in France at 430bn Euros, a figure that does not include the likely economic and other damages in downwind or downstream countries, such as Belgium, Germany, Luxemburg, the Netherlands or Switzerland. A major nuclear catastrophe has the potential to cause damages on a continental scale, as was seen with Chernobyl.
- The probability of accidents appears to be based on the methodology also applied by the calculations of William d'Haeseleer.[14] This can be questioned, for instance, by:
  a) Charles Perrow's critique of the assumption that the probabilities of events contributing to an accident are not independent of one another, leading to the insight that the chances of large nuclear accidents are much higher than the statistical probabilities under the conventions used by the nuclear industry (which are not accepted by the insurance industry),[15]
  b) a hypothetical statistical analysis of the observed distribution of actual accidents, for which the dataset would have to be corrected for underreporting and non-reporting, and
  c) c) consideration of the frequency of (partial) core-melt accidents in civilian nuclear power plants (of every 5 to 7 years).

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[14] The study by William d'Haeseleer (2013) "Synthesis on the Economics of Nuclear Energy" Report to the European Commission) cannot currently be found on the web; for a summary see: http://www.energypolicyblog.com/2014/02/10/the-costs-of-nuclear-energy-in-europe

[15] Perrow, Charles (1994): *Normal Accidents: Living With High-Risk Technologies*. New York, NY: Basic Books. 386 pages.
See also Amory Lovins (2011): "With Nuclear Power, 'No Acts of God Can Be Permitted'."
URL: http://www.huffingtonpost.com/amory-lovins/with-nuclear-power-no-act_b_837708.html

- The liability of builders, owners and operators of nuclear power plants in case of accidents is capped at very low levels (compared to the level of damages that did occur in some accidents, e.g. Kyshtym, Chernobyl, Fukushima), while international agreements not only reinforce liability caps but also deny victims trans-boundary access to compensation.[16] This is not only in violation of the polluter-pays-principle but also potentially incompatible with internal market rules, if citizens of one EU Member States are denied access to full compensation from those responsible for an accident if those are located in another Member State.
- Insurers have stated a willingness to consider insuring nuclear power plants against limited liability for damages from other risks, e.g. terrorist attack. This has not been done so far, partly for economic reasons – such insurance would add to the cost of operating nuclear power plants – but also because nuclear operators routinely refuse to give the information insurers need to make their actuarial assessment of risk and premium payable.

5.4 The Lessons of Fukushima and the Cost of Nuclear Power

The tragedy of Fukushima has revealed a number of shortcomings in the management of nuclear power and its risks. The fact that the seismic activity in the region can – in long but apparently regular intervals – generate very large tsunamis, has been known for centuries. Stones with still readable and comprehensible inscriptions saying "Don‘t build below here" have been placed as markers along the high-water line of past tsunamis. Yet the Fukushima plant, and other plants, were built in vulnerable areas. Fukushima is a lesson about learning, not learning and unlearning lessons.

The British government holds the position that everything that can be learned from Fukushima has been taken into account in the design of the planned new nuclear power plant at Hinkley Point C.[17] This position ignores a number of easy-to-grasp lessons that were obvious from media coverage of the catastrophe as it unfolded (and continues to unfold):

- Nuclear reactors should not be placed too close to one another, as an accident in one may affect access to the neighbouring reactors, making emergency intervention difficult or even impossible.
- Fukushima revealed that a melt-down of fissile material can happen not only in reactors but also in spent fuel pools when cooling is interrupted for long. The lesson is that such pools need to be constructed with a more resilient cooling system, and preferably at a distance from reactors.

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16 See: http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Liability-for-Nuclear-Damage

17 See letter by Andy Hall, First Deputy Chief Inspector, UK Office for Nuclear Regulation (ONR) to The Guardian on 25 November 2013: http://www.theguardian.com/environment/2013/nov/25/nuclear-regulation-post-fukushima

- Post disaster response involves moving large quantities of material and heavy equipment at short notice. The Fukushima lesson is that at least two separate access routes are necessary to provide sufficient capacity and redundancy.
- Managing stricken reactors and those that may still be operating on the same site may become humanly impossible because of high radiation levels. In such cases, back-up control-rooms in distant bunkers are needed, which need to be integrated into the design, built before a reactor is fuelled up, maintained and tested at regular intervals.
- The accident and core-melt at Fukushima may have been better managed with more powerful and resilient back-up power, both on-site and off-site. Resilience implies not only redundancy of emergency equipment but also a much larger stock of fuel for back-up generators.[18]
- Shortly after the accident started, the authorities in Fukushima needed to enlarge the evacuation zone, something that had not been prepared. Effective evacuation plans and preparations for and in a sufficiently large area should be made ahead of building a nuclear power plant; it should be integrated into the design of any new power plant.[19]
- Many of the sensors and surveillance equipment in Fukushima could not operate after the accident started; they could not cope with high levels of radiation. In effect, the crew had to manage the stricken reactors "blind", which delayed actions that may have alleviated the consequences of the event. Only "hardened" sensors, cameras and other such equipment should be used in nuclear reactors, with duplication reducing risk of equipment failure somewhat.

These are just some of the obvious lessons; there are no doubt additional lessons to be learned on the basis of thorough analyses of the events at Fukushima. Such analysis has not yet been completed (and published). The lessons learned need to be incorporated into the design, construction, equipment, management and maintenance, and training within any existing and potential new nuclear power plant, and in the planning and emergency preparedness of the authorities in a large area around nuclear power plants. The unavoidable additional costs for post-Fukushima measures to reduce the dangers of nuclear plants are likely to be considerable, and have not yet been factored into the economics of the proposed new plant at Hinkley Point in England, for instance.

6 Focus of the Debate

Any evidence-based, scientific evaluation is necessarily backward looking and of limited usefulness for making political decisions about the future. The Ecofys study is no exception.

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[18] This lesson was also learned at Forsmark in 2006.

[19] The authorities in Germany learned how badly they are prepared for a serious nuclear accident during an exercise in 2013, see Sebastian Heiser (2014) "Der Super-GAU." In taz.blogs, 24. Oktober 2014. URL: http://blogs.taz.de/rechercheblog/2014/10/24/der-super-gau

The context for the European debate, as is stated in the introduction, concerns the choices that must be made relating to the transformation of the energy system, so as to make it low-cost, low-risk, low-pollution and low-carbon in the context of stronger European cooperation (in the Energy Union) while maintaining the function of the EU's internal market.

As was argued above, historical subsidies can continue to have significant distorting effects on current prices. The subsidies should be acknowledged and calculated or estimated to assess the continued distortions they may cause. This is important in two respects: One is to ensure that perverse subsidies are identified, stopped, and their distortions corrected to create a level playing field. This is more than just an economic consideration, it is also important to challenge the widespread belief (against evidence to the contrary) that nuclear power (or coal power) is cheap and sustainable. The other is to calculate to which extent renewable energies should be entitled to subsidies so that they are not disadvantaged as they compete with nuclear and fossil energies that still benefit from the effects of historic subsidies.

However, given the difficulties involved and that historical facts cannot be changed, it is also important to focus on current and future subsidies, which can be influenced by policy decision and regulatory action today. This would avoid continuation along investment pathways during the potentially long time it might take to fill data gaps and arrive at a consensus concerning the estimation of historical subsidies.

Looking at the current levels and trends in costs of nuclear power and renewables, the following observations, although contestable, provide guidance:

- The cost of renewable energy technologies are going down, roughly along the "learning curve" (of a 15% decrease in cost for every doubling of aggregate output, for instance);[20]
- The same is true for battery storage and some other innovative storage technologies as well as "enabling technologies" from the IT sector that are becoming incorporated into the electricity sector ("smart grid" technologies);[21]
- Nuclear power plants, being large and intermittent in the sense that they can and do quite often go off-grid within seconds without warning (unplanned capability loss), require large, high-capacity, high-voltage transmission lines over long distances that have bi-directional flow capacity and are able to reverse flow at very short notice, and a "spinning reserve" of idling (but running) generators that can ramp up very fast to compensate the sudden and unforeseen loss of the largest power plants feeding into the grid, usually a nuclear power plant. Distributed renewable power plants (and

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20 This Wikipedia entry provides an introduction to the concept, also called experience curve by technologists: http://en.wikipedia.org/wiki/Experience_curve_effects

21 For instance, see Ajaz Shah (2015): "EuPD Research ermittelt Preissenkung für Stromspeicher", 20 February 2015: http://energyload.eu/solar-akku/preissenkung-stromspeicher

small and medium-sized fossil-fired combined heat-and-power plants do not impose similar requirements on the grid, a point often misrepresented in the current debate.[22]

- In contrast, the trend of costs for fossil energies is still more likely to be up than down, notwithstanding the short or medium-term effects of hydraulic fracturing ("fracking"), which entails large environmental and probably also social (health) effects not yet accounted for, and the current situation on the international oil market;
- The cost of nuclear electricity generation also keeps going up; there is a "negative learning curve" meaning that costs tend to rise the more is learned about the risks and the systems necessary to reduce them; the high average age of nuclear plants in the EU (and around the world) and the additional safety requirement after learning the lessons of Fukushima further contribute to rising operating costs;[23]
- In addition, there are significant, and yet largely unfunded future costs and legacy costs of nuclear power, such as the clean-up of historic sites, for the decommissioning and dismantling of nuclear installations and the processing of wastes for long-term storage, monitoring and management, and safeguarding. Such costs, being currently unfunded or severely underfunded in many countries, are an implicit future subsidy for present nuclear power generation;[24]
- The best obvious way to reduce the underfunding and set aside sufficient (cash) reserves to pay for future and legacy cost, would be a surcharge (or levy) on nuclear

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22 As power supply systems around the world graduate from the centralized structures with over-sized plants and low variety in plant size and technologies, to more balanced, distributed generation, demand response and storage with a greater variety, "[l]arge-scale power generation [...] will be the dinosaur of the future energy system: Too big, too inflexible, not even relevant for backup power in the long run", see, for instance: http://www.energypost.eu/ubs-citigroup-warn-investors-massive-revolution-energy-industry

23 The nuclear industry is unique in having a negative learning curve both within each generation of nuclear plants and from each generation to the next. The more is learned about this technology, the more it is to be contained with safety margins, and yet it remains unsafe. A good analysis is provided by Gruber (2010) in Energy Policy (subscription required), discussed here: http://thinkprogress.org/climate/2011/04/06/207833/does-nuclear-power-have-a-negative-learning-curve

24 Decommissioning costs have just been estimated by the International Energy Agency at $100bn. This estimate doesn‘t even cover the £70bn cost the UK‘s Sellafield site alone: http://www.telegraph.co.uk/finance/newsbysector/energy/10629219/MPs-attack-Sellafield-decommissioning-as-costs-hit-70bn.html and http://www.economist.com/news/britain/21600135-britain-paying-dearly-neglecting-its-nuclear-waste-glowing-review. Sellafield is a large and complex site, with a mix of military and "civilian" purposes, and a history of accidents. The estimates for other UK sites are generally between £500m and £1bn; EDF in France sets aside 350m Euros per plant. This is low compared to the current $4.4bn estimate for decommissioning California‘s San Onofre plant: http://www.scpr.org/news/2014/09/24/46948/san-onofre-decommission-will-cost-4-4-billion Overall, there is too little experience with commercial decommissioning and dismantling, as this is done mostly as first-of-a-kind research, testing or demonstration exercise (without proper and transparent accounting). Industry insiders told me (under Chatham house Rule) that decommissioning and dismantling costs as much per MW capacity as it costs to build at current(!) prices. Some think the costs will come down, following Moore‘s law, others point to the negative learning curve in the nuclear industry and think that these costs will rise over time.

power, not only as a financing instrument but also to ensure that the observed price of nuclear power reflects actual costs somewhat better;

- The untaxed and non-earmarked reserves or set asides in nuclear utilities‘ balance sheets, meant to ensure that future decommissioning and waste-management costs can be covered, are often misappropriated and invested in unrelated ventures. This is an indirect form of subsidy, as the profits earned from such investment accrue to shareholders. When such funds are badly invested – such in fossil-fired power generating plant that cannot recover investment costs in increasingly competitive electricity markets – and reduced in value or lost, the cost for decommissioning and other legacy costs will fall onto future taxpayers.
- However, it is unlikely that the remaining safe operating time of existing nuclear power plants, under current market conditions, will allow for the accumulation of sufficient reserves to fund the future and legacy costs, so they will fall to future taxpayers (or ratepayers), and essentially become an "externality" to the industry but a burden for society as a whole;
- Another significant externality is the contingent cost represented by the risk of damages following nuclear accidents.

7 Key Conclusions and Discussion

This commentary started from the study of "Subsidies and costs of EU energy" by Ecofys and partners, but moved on address the wider context. The key criticisms of the study are:

- The cost assumptions for nuclear power, in particular, and the estimates of relevant subsidies are too low, with consequences for the assessment of past investment, the current competitive position of nuclear power, and possible but increasingly unlikely future investment.
- One specific issue deserving deeper analysis are the various measures by government to lower the cost of capital for nuclear power plant construction, in part by de-risking the investment (and thereby protecting the investors).
- Overall and importantly, the lack of transparency and the long history of subsidies in the energy sector disproportionately favour nuclear power, which is capital-intensive and has very long investment cycles. Past (hidden) subsidies, that are not all identified and estimated in the study, still result in reduced "visible costs" for nuclear power, to the detriment of other energy technologies and carriers.
- A first step would be to acknowledge the existence and impact of hidden subsidies, past and present, in order to allow for a more rational debate. Part of the problem, resulting in unnecessary polarisation, is that proponents of nuclear power remain in denial of the true costs and risks of nuclear power, and tend to believe their own propaganda. An honest assessment would help, and the study by Ecofys and partners can only be a start in a longer process.

- The external cost of nuclear power in terms of human health, the environment, economic (especially the uninsured and uninsurable risks involved) and the effects on transparency of government and corporate decision-making on democratic culture have not been addressed adequately in the study. The obvious difficulties in mapping historical subsidies should not be used as an excuse not to try to catalogue present subsidies, and avoid future subsidies for nuclear technology, a technology that should have achieved maturity long ago but is unable to do so.
- The future costs of nuclear power, difficult to estimate as they may be, present a similar challenge. They are known, or in principle could be known with some certainty, and yet they are not properly accounted for. The low levels of funds set aside for decommissioning and dismantling nuclear plants and for removing, storing, monitoring and managing, and safeguarding nuclear wastes for millennia proves this point.
- The study, focussing on the economics, leaves other dimensions of energy policy and the measures in support of energy technologies and carriers unaddressed. One is the lack of a legal assessment of Member State and EU-level interventions, including an assessment of the economic incentives of laws, regulations, and regulatory practice. Another gap is in the use of and accounting for research funds for nuclear fission and fusion.
- In summary, the main conclusions in the summary are misleading in that they paint to positive a picture of the costs of nuclear power and the subsidies and privileges involved. On the whole, they do not reflect the more nuanced but still (necessarily) incomplete treatment of the issues in the body of the study and the annexes, including the data gaps, cost assumptions, hidden interventions in support of nuclear power, or historical subsidies.

As such, the study fails, as concerns nuclear, to provide a sound basis for the "formulation of sound and concrete future policy guidance based on the principles formulated in the commission‘s Communication Delivering the internal electricity market and making the most of public intervention". The true cost of nuclear power is very likely a lot higher than stated in the study and may be used to misguide EU energy policy, and impose unnecessary risks and costs on future generations.

The EU should admit errors concerning nuclear power – and the proliferation of nuclear expertise, materials, equipment and technology – making it explicit that they are mistakes that impose high costs and risks on current future generations. The European Commission should refrain from granting further support to nuclear power andcommit to investing in renewable energies and smart grids, phase out nuclear power.[25]

The Ecofys study does however make a more robust first assessment of fossil fuel subsidies and costs and should therefore still be considered as a first step in the right direction.

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[25] Please see http://ecologic.eu/3303 or the summary paper at http://ecologic.eu/download/vortrag/2010/RAK_NuclearGPPI_100305.pdf

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