Energy Strategy Reviews 1 (2013) 233–242

Contents lists available at SciVerse ScienceDirect

Energy Strategy Reviews

journal homepage: www.ees.elsevier.com/esr

ANALYSIS

The trouble with justification — Getting straight on the science and politics of nuclear energy

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ARTICLE INFO

Article history:
Received 11 September 2012
Received in revised form
17 January 2013
Accepted 17 January 2013
Available online 12 February 2013

Keywords:
Risk governance
Deliberative democracy
Transdisciplinarity

ABSTRACT

The way nuclear energy technology 'escapes' a deliberate justification approach as an energy technology on a transnational level is today in sharp contrast with the way fossil fuel energy technologies are subject of global negotiations driven by the doom of climate change. The claim put forward is that this 'denial' is a symptom of a contemporary settled 'comfort of polarisation' around the use of nuclear energy technology that is deeply rooted in the organisational structures of politics, science and informed civil society. The article argues for the need to develop a new rationale that aims to seek societal trust 'by method instead of proof', taking into account that the outcome of such a justification process might as well be an acceptance or a rejection of the technology. It sketches what this 'deliberate-political' approach would be in theory and practice, briefly hits at two contemporary myths that would relativize the need for this approach and concludes with a 'pragmatic' list of elements of an advanced framework for deliberation on nuclear energy technology and on energy in general.

1. Introduction

Due to the specific character of its associated risk, the societal justification of nuclear energy technology is troubled by moral pluralism. That is: even if we would all agree on the scientific knowledge base for the assessment of the risk, opinions could still differ on its acceptability. Science may thus inform us about the technical and societal aspects of options, it cannot instruct or clarify the choice to make. The matter becomes even more complex if we take into account the fact that science can only deliver evidence to a certain extent. Despite the maturity of nuclear science and engineering, the existence of inherent uncertainties, unknowns and unknowables puts fundamental limits to understanding and forecasting technological, biological and social phenomena in the interest of nuclear risk assessment. Last but not least, we have to accept that three important factors remain to a large degree beyond control. These are human behaviour, nature and time.

The resulting room for interpretation and discourse that unavoidably marks any 'political act of justification' puts a heavy responsibility on nuclear technology assessment as a research and policy practice and on the consequent strategies nuclear energy proponents and opponents develop to make their case. Today, the way nuclear energy technology 'escapes' a deliberate justification approach as an energy technology on a transnational level is in sharp contrast with the way fossil fuel energy technologies are, for more than two decades now, subject of global negotiations driven by the doom of climate change.

The reasoning in this article is set out as follows: while one can observe that, after the Fukushima accident, nuclear energy development policies (and their widespread political support) were hardly affected, there remains a consistent denial of the need to treat the nuclear issue in a confrontational energy policy on a transnational level. The claim put forward is that this is nothing but a symptom of a contemporary settled 'comfort of polarisation' that is deeply rooted in the organisational structures of politics, science and informed civil society. The result is not only a discursive deadlock. It also mediates the formal structures of policy-supportive knowledge generation and decision making and hinders the establishment of a deliberate justification process around the use of nuclear energy technology in a broader energy governance context. Last but not least, it maintains

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http://dx.doi.org/10.1016/j.esr.2013.01.004

a power vacuum that allows free play for transnational market forces, and hinders 'dialectic' reflection on a global ethic that would inspire more democratic approaches to risk justification, transgenerational accountability and transnational responsibility for accidents.

Advancing on this claim, the article sketches the complexity of risk perception and justification in the nuclear case and analyses traditional (anti)nuclear argumentation. Taking into account the fact that nuclear rationales are troubled by cognitive perplexity and moral pluralism as suggested above, the conclusion will be that, in making the case for nuclear energy, one would need to accept that good science, a responsible safety culture and clear information are necessary but insufficient conditions for societal trust. In other words: if nothing has been learnt from decades of nuclear discourse in terms of developing better technical arguments pro/contra, then what can be learnt today is that technical rationales do not help society to choose side. The article then argues for the need to develop a new rationale that aims to seek societal trust 'by method instead of proof', taking into account that the outcome of such a justification process might as well be an acceptance or a rejection of the technology, given that societal trust would rather be connected to the method of knowledge generation and deliberation and thus only indirectly to the outcome of the decision making itself. Consequently it sketches what this 'deliberate-political' approach would be in theory and practice, briefly hits at two contemporary myths that would relativize the need for this approach and concludes with a 'pragmatic' list of elements of an advanced framework for deliberation on nuclear energy and on energy in general.

2. Strategies of presence, strategies of absence

2.1. Post-Fukushima nuclear rationales

On 11 March 2011, the Tohoku-Chihou-Taiheiyo-Oki Earthquake and consequent tsunami led to the nuclear accident at Fukushima Daiichi. While 15 months later, in a press statement announcing the 'Release of the Fukushima Nuclear Accidents Investigation Report' [1], TEPCO officials state that they '[…] *keenly feel the responsibility for the accident and are determined to engage in business operation with safety on the top priority to prevent future recurrence* […]', one can observe that, meanwhile, major voices of the nuclear industry have already rationalised the accident and its consequences into its story of continuing relevance. Already in September 2011, the World Nuclear Association stressed that '… *The future of nuclear energy in most countries is likely to be much the same after the ramifications of the Fukushima accident are fully considered as it was before the accident, though there will be some safety benefits from lessons learned* …' [2]. In its update on their 2050 Roadmap (released in November 2011 to cover the consequences of the Fukushima accident), FORATOM, the Brussels-based trade association for the nuclear energy industry in Europe, writes that '… *Fukushima is likely to have some effect on costs and new build timescales in the shorter-term but not to be a decisive factor affecting the longer term contribution of nuclear energy...*' [3].

At the time of these communications, major nuclear safety review policies to assess the resistance of existing nuclear power plants to Fukushima conditions had only started in Europe and the US. Meanwhile, the stress tests report no major sign for a need to reorient safety strategies or to reconsider plant designs in this respect. The US Nuclear Energy Institute reports that the US "FLEX" strategy addresses the major problems encountered in Japan [4] while the European Commission and the European Nuclear Safety Regulators Group (ENSREG) underlined in a joint statement on 26 April 2012 that '*the stress tests and peer review have been a rigorous review of the safety of NPPs in the light of three main areas of the Fukushima accident*' [5]. It further notes that '*According to the principle of continuous improvement, ENSREG and the European Commission consider that the stress tests have identified* […] *four main areas for improvement to be explored across Europe*: (1) *Issuing the Western European Nuclear Regulators Association (WENRA) guidance with the contribution of the best available EU expertise on assessment of natural hazards and margins taking account of the existing IAEA guidelines*; (2) *Underlining the importance of Periodic Safety Review*; (3) *Implementing the recognised measures to protect containment integrity*; (4) *Minimising accidents resulting from natural hazards and limiting their consequences*'. The stress tests did not result in the need for a particular European reactor to shut down or to undergo major operations. In general, the opposite would have been remarkable of course, as there is no reason why a review that was merely a 'thought exercise on paper' would reveal new insights compared to those from the routine periodic safety reviews. If there is one net positive result, than it can be put on the accounts of civil society rapprochement: although Greenpeace said that '*the tests had exposed some "black holes" in the emergency responses that need to be addressed*', they also stated that '*European regulators deserve praise for carrying out their stress tests in a transparent manner*' [6].

The impact of the Fukushima accident on nuclear policy and political and public discourse will wane faster than the one of Chernobyl, and the reason is not the lower accidental release of radioactivity or the fact that there is no directly related death toll. While Chernobyl shocked the nuclear sector and the wider world, this time, reactions from that wider world (that is: outside Japan) seem to be much more — and I weigh my words — 'pragmatic'. While the accident will remain to inspire academics and activists for years to come, mid-2012, the nuclear industry seems to have returned to pre-Fukushima business. State-owned Czech utility CEZ considers bids to develop and deliver two nuclear reactor units for the Temelín nuclear power plant [7], Belarus is 'on its way to being prepared for a first nuclear plant' [8] and other recent nuclear business activities have been reported in, among others, China, the United Arab Emirates, the US, the UK, South Korea and Argentina. While, motivated by the Fukushima accident, Italy has abandoned plans for re-introducing nuclear energy and Germany, Belgium and Switzerland have reconfirmed their phase-out plans, the Nuclear Energy Agency of the OECD reports that '… *Many more countries on the other hand have confirmed their intention to continue with new build plans, albeit at a somewhat slower pace than initially planned. This is the case for China, the Czech Republic, India, Poland, the Republic of Korea, the Russian Federation, Turkey, the United Kingdom, the United States and Vietnam*' [9]. With respect to the United Kingdom, World Nuclear News reported that '*the appetite of UK business leaders for new nuclear generating capacity has not diminished, despite the F. accident*' [10]. And on 26 June 2012, energy ministers from the 21 Asia-Pacific Economic Cooperation (Apec) member countries released a statement wherein they stress that '*Asia-Pacific countries must work together to ensure that nuclear power can continue its important role in the region's energy mix despite the experiences of Fukushima*' [11]. They further '*recognise the importance of the safe and secure use of nuclear energy in the region and its potential to diversify the regional energy mix while meeting growing energy demand and reducing greenhouse gas emissions despite the tragic accident at the Fukushima Daiichi power station*'.

After Fukushima, the basic rationale provided by nuclear energy supporters remains unchanged, 'although there will be some safety benefits from lessons learnt'. Energy demand will continue to rise, consistent with further industrial development and ('green') economic growth. Climate change is a serious problem and, according to the nuclear proponents, nuclear energy is part of the solution. According to the opponents however, climate change is a problem and nuclear energy remains just another problem. Positions over nuclear energy technology with respect to its potential to tackle climate change and support sustainable development remain polarised, but when it comes to defend them in the global formal arenas around these issues, the discussion falls silent.

2.2. The future(s) we want

Focus shift from Fukushima 11 March 2011 to Rio de Janeiro 22 June 2012. On the closing day of the 2012 United Nations Conference on Sustainable Development, known as 'Rio+20', Heads of State and Government and high-level representatives endorsed UN document A/CONF.216/L.1 entitled 'The Future We Want' [12]. That document is the result of a negotiation process organised by the UN Commission on Sustainable Development (UNCSD) that involved representatives of UN member states as well as private sector and civil society representatives. The Rio+20 process officially started in May 2010 in New York and builds on the legacy of the original 1992 Rio conference on sustainable development, the 2002 Rio+10 conference in Johannesburg and the many intermediate thematic meetings (For an overview of the UNCSD process, see the website of the UN Division for Sustainable Development of the UN Department of Economic and Social Affairs, http://www.un.org/esa/dsd/.). The outcome document of Rio+20 recognises energy as one of the central themes of concern for sustainable development. With regard to energy policies, the text reaffirms '[…] *support for the implementation of national and subnational policies and strategies, based on individual national circumstances and development aspirations, using an appropriate energy mix to meet developmental needs* […]' [12,§127]. With respect to the energy technology options eligible to be part of that 'appropriate energy mix', the text makes explicit mentioning of renewable energy sources and cleaner fossil fuel technologies. There is no mentioning of nuclear energy technology in the whole of the text. For an uninformed reader, this may be a sign that the member states that endorse the outcome text have jointly agreed that nuclear energy is problematic and therefore no longer worth mentioning. Nothing could be further from the truth of course. Nuclear energy is not mentioned because it is diplomatically 'too difficult'. Some member states have strategic interests in nuclear energy, others have not. The cynical result is that both nuclear proponents and opponents are happy with the fact that the issue is kept quiet. The negotiation process, in the way it is driven by representatives from member states, the private sector and civil society, has since long found an elegant solution to satisfy both camps. Also in the Rio+20 outcome text that solution is used. The same paragraph 127 mentions, alongside the importance of increased use of renewable energy sources, also that of 'other low-emission technologies'. Everybody is free to interpret this as an explicit reference to nuclear energy technology - or not.

This pragmatic strategy of 'psychological suppression' among negotiators is not new. You may be shocked or it may just make you shrug your shoulders, but the fact remains that, since the Kyoto climate change conference in 1997, nuclear energy has never been discussed formally at UN conferences about energy and the environment. During the UN climate change conference UNFCCC COP6 in 2000, nuclear energy technology was symbolically excluded from the clean development mechanism (one of the flexible mechanisms in the Kyoto Protocol that allows developed countries to build 'clean' technology in developing countries, in return for emissions credits). In 2001, during the 9th United Nations Commission on Sustainable Development (UNCSD9), UN member states did not manage to go beyond an 'agreement to disagree' on the nuclear option. And during the review conference on energy (UN CSD15, 2007), as part of the follow-up process after the 2002 Johannesburg World Summit on Sustainable Development, countries further avoided the issue by restricting nuclear-related language to one short paragraph stating that every country has the right to opt for nuclear energy, on the condition that it does so 'responsibly'. The energy section of the compromise text identified fossil fuels, '*which will continue to play an important role in the energy supply in the decades to come*' and referred to targets on increasing access to energy, energy efficiency and the share of renewable energy. There was no mention of time-bound targets and the word nuclear did not appear in the text [13]. Since two decades of post- Rio global negotiations on climate change and energy, the nuclear issue has been consistently delegated to the level of the member states, that in turn have left it to national party politics. The contrast with the way multilateral negotiations have affected fossil fuel policies cannot be bigger.

Meanwhile, many visions on 'the energy future we want' exist. They differ on many aspects, such as the potential of energy savings in industries, transport or households, or the degree in which a financial crisis or international conflicts may affect oil and gas markets. The most radical difference however is to be found in the ideologically driven prospects that diverge over the question whether the world can deal with the combined challenge of meeting energy demands and tackling climate change with or without nuclear energy. In 2011, WWF presented their Energy Report [14] in which they claim that 100% renewable energy is possible by 2050. The report stresses that '*nuclear energy is an unethical and expensive option*' and puts the emphasis on the waste issue and the proliferation risk. With regard to the feasibility to reach 100% renewables by 2050, WWF makes clear that a determining factor is the assumption that '… *In 2050, energy demand is 15 per cent lower than in 2005*; … *Although population, industrial output, passenger travel and freight transport continue to rise as predicted, ambitious energy-saving measures allow us to do more with less*'. It also recognises that 100% renewables does not mean zero emission of greenhouse gasses, as '… *Bioenergy (liquid biofuels and solid biomass)* [*will need to be] used as a last resort where other renewable energy sources are not viable — primarily in providing fuels for aeroplanes, ships and trucks, and in industrial processes that require very high temperatures* …'. The report further notes that '… *big increases in capital expenditure are needed first — to install renewable energy-generating capacity on a massive scale, modernize electricity grids, transform goods and public transport and improve the energy efficiency of our existing buildings* …' [14,p. 42] but also stresses that '… *investments begin to pay off around 2040, when the savings start to outweigh the costs* …'. On the other hand, the above mentioned OECD report '*The Role of Nuclear Energy in a Low-Carbon Energy Future*' stresses that nuclear energy will need to play a role in the future energy mix. It specifies thereby that, although Fukushima has slowed nuclear growth by about 10% compared with projections before the accident, a slightly increased rate of worldwide nuclear new-build construction this decade, by 3 GWe/year to 16 GWe/year to 2020, will still enable nuclear energy 'to hit forecasted targets' of 1200 GWe in 2050 [9,p. 42].

2.3. The comfort of polarisation

Since the beginning of the nuclear era, opinion makers from politics, science and 'informed' civil society have been divided into two 'camps'. It would however be wrong to assume that their discourse on the acceptability of nuclear as an energy technology is a 'ratio versus emo' debate. It was and still is a ratio versus ratio debate, although many nuclear proponents still like to speak of 'emotional' negative responses to the idea of nuclear as an energy technology option. Both camps use science and rational reasoning with respect to economic, ecological, social and political factors, and order studies with established universities, research institutes, consultancy firms and think-thanks. But what we see is that opposing rationalisations do not converge. They simply remain stuck over 'conflicting evidences'. After half-a-century of discussing the pros and cons of nuclear energy, we are still using the same language and old arguments as in the beginning. While the technology went through a 'learning process' (although also on this opinions differ), one can only conclude that nothing has been learnt from decades of discourse for the quality of the discourse itself. Popular discussion, serene opinion making or intelligence from the natural, social or human sciences: none of them have provided us with

better arguments or advanced points of view pro or contra nuclear energy. But that does not seem to be a problem. Today, the two camps are turned into non-overlapping comfort zones, maintained by strategic and often populist simplifications of the classical arguments pro/contra. As in a joint conspiracy, both make no effort anymore to convince each other, but now fully focus on 'the general public'. And while the pro camp tries to convince that public, the contra camp claims to represent it.

Since their publication, the above mentioned OECD and WWF reports live an elegant life in the circles sympathetic to the respective organisations and their ideas. Their well researched content but extremely diverged views on the energy path up to 2050 do not stimulate political decision makers to start formal comparative assessments of the views, calculations and assumptions presented. The reports remain 'opinions for politicians to choose from', and to quote accordingly. And if there are no researched views available to choose from, then you might as well order them. In 2005, the Belgian Minister of Economy (Liberal Party) established a commission of experts to study future energy policy options (and their impacts and costs) for Belgium up to 2030 [15]. As the so-called 'Commission 2030' was headed by a university professor who is well know to be 'pro-nuclear' and as the Commission also included Belgian and foreign members who had liaisons with the nuclear industry, the study immediately generated critique among environmental NGO's [16] and with political parties critical to nuclear energy. In the conclusions of the study, the Commission 2030 stressed that '… *Phasing out nuclear power in Belgium by 2025 under a considerable post-Kyoto constraint and in the absence of CCS [Carbon Capture and Storage] will be extremely expensive and strongly perturbing for our economic fabric. Therefore, it is advised to keep the nuclear option open and to reconsider the nuclear phase out*...'. In reaction to the 2030 study, the Belgian Minister for the Environment (Socialist Party) ordered a study to analyse possible CO_2 emission reduction scenarios up to 2020 and 2050 [17]. The study considered three reduction scenarios (−50%, −60% and −80%) and simulations were done by the same institute (the Belgian Federal Planning Bureau) as the one who did the cost simulations for the first study, but while that first study only considered scenarios that included the nuclear option, the second was ordered to only envisage non-nuclear scenarios up to 2050 (in the sense that it assumed the nuclear phase-out would take place). As a result of the study, while the −50% scenario was said to be attainable with a maximum use of the (Belgian) potential of renewable energy (taking into account technological progress and innovation), the report stresses that '… *a 60% reduction of emissions is obtained in 2050 by assuming that together with the technological changes of the first scenario, consumption and production patterns change significantly* …' [17,p. 19]. The −80% scenario assumes the same conditions as the second, but the authors add that '… *The developments necessary to attain the target set by this scenario cannot be envisaged without far-reaching changes in present-day consumption and production patterns* …' [17,p. 20]. Despite all these conditions, the underlying message was that all three emission reduction scenarios are feasible without nuclear energy. When the first study caused critique with nuclear sceptics, the second was considered to be biased by, among others, the Belgian Federation of Enterprises (FEB) [18,19].

While, without any doubt, the researchers of the Belgian Federal Planning Bureau who performed the Belgian simulations are experienced and have themselves no particular standpoint on nuclear energy, this case shows that, in the light (or darkness) of the complexity and uncertainty that marks any study about the future, through a political filter, 'you can always get what you want'. The real responsibility is than again with politics, as, in this kind of situation, they would need to overcome preferences and engage in deliberate comparative assessments of criteria and assumptions as a next step. But that would of course also mean that one needs to admit that, in these cases, it is impossible to prove who is right and who is wrong. Certainly many comparable dynamics from other countries can be identified, but the Belgian case might itself be called significantly symptomatic for the comfort of polarisation described above. In politics, it manifests as 'science shopping', in the sense that picking or eventually ordering the appropriate research apparently only serves to support the own political view, and not an imperative higher level of dialectic reasoning.

The polarisation in the political and public domain continues after Fukushima, as occasional rationalisations on the justification of nuclear as an energy technology option seem to move in various and often opposing directions. Germany and the United Kingdom, two European countries comparable on the basis of their energy portfolio and of their political, scientific, industrial and social development, took antipodal decisions on their nuclear policy after the Fukushima accident was evaluated. In addition, in the press one could read articles announcing that '*Fukushima marks the end of the nuclear era*' [20] but also that '*The Japanese disaster proves the value and safety of nuclear power*' [21]. Of course expecting politics or the media to be prepared to engage in reflexive and dialectic reasoning over Fukushima or on nuclear energy in general can be considered as naive. But my claim, illustrated here with only some examples within the limited space of this article, is that today the polarisation around nuclear energy is deeply rooted in the *organisational structures* of politics, science and informed civil society. Research institutes are know to be 'pro nuclear' or 'critical about nuclear', political parties are known to be pro or against (liberals pro, socialists against are the most evident). The result of this 'comfort of polarisation' is not only a discursive deadlock. It also mediates the formal structures of policy-supportive knowledge generation and decision making and hinders the establishment of a deliberate justification process around nuclear as an energy technology option in a broader energy governance context (for a good understanding: a deliberate process is understood here as a process that might either lead to a *more deliberate and thus robust acceptance* or a *more deliberate and thus robust rejection* of the nuclear option). Last but not least, it maintains a power vacuum that allows free play for transnational market forces, and hinders 'dialectic' reflection on a global ethic that would inspire more democratic approaches to risk justification, transgenerational accountability and transnational responsibility for accidents.

3. In search of trust

3.1. Justification in face of risk

The history of justifying nuclear as an energy source can, very roughly, be described as a coming of age in two phases. As part of the post 2nd World War rapid technical and industrial development, nuclear energy technology was seen as a modernist 'tour de force' alongside many other emerging technological and industrial applications. Nuclear energy technology was justified as a promising energy source that could benefit from quasi unlimited resources and that, as it was said, would be 'too cheap to meter'. In addition, in the mid-70's, it got a boost as a political alternative for oil. The approach to risk management remained largely technocratic: power plant siting was decided in small political circles while sea dumping of low level radioactive waste was considered to be a justified practice (a practice that was only finally prohibited from 1994 on [22]). After the Chernobyl accident, the nuclear option had to seek a new rationale, and found it as a justified 'trade-off' in the frame of a bigger problem: climate change and the care for sustainable development. Nuclear proponents justified the technology as 'part of the solution' in the way it could contribute to greenhouse gas 'avoidance' in particular and to sustainable development in general. The outspoken preference for nuclear energy of the Bush administration (wanting to become energy independent from 'politically instable countries') and the Finnish 5th reactor (Olkiluoto 3) as the first order of a new nuclear power plant in

Europe since decades marked for many observers the start of a 'nuclear renaissance'. Indeed, many countries turned to nuclear energy again after Chernobyl, although not because of a sudden intrinsic 'believe' in the technology, but mainly from out of 'fear' for climate change or based on the ambition to secure a critical national energy production capacity. While radioactive waste management and proliferation were the main topics of concern, after Fukushima, safety is again top priority in public and political discourse. Looking at the history of the argumentation around the justification of nuclear as an energy technology option, one thing is clear: the economic and political rationale related to energy policy have never been able to overrule the rational on the acceptability or unacceptability of the radiological risk. It can never be stressed too much that the societal justification of nuclear technology equals the societal justification *of the radiological risk* that comes with applying nuclear energy technology. So, paraphrasing the title of this article, one could say that 'if there would be no risk, there would be no trouble' with nuclear energy. Whatever possible economic, ecological or social assessment of nuclear technology is done, it always needs to take into account the implications of the nuclear risk *on these economic, ecological and social factors*. In the following paragraph, I briefly discuss shortcomings of what I call the simplified rationale of influencing risk perception by delivering 'facts' about nuclear technology. Consequently, in paragraph 2.3, I review the broader picture of argumentation that also takes into account other factors than only risk.

3.2. Risk, between facts and fairness

A short detour over two non-nuclear cases of risk perception can help to illustrate why the rationale on risk acceptance on the basis of 'a transparent communication on facts' about nuclear energy does actually not work.

Case 1: In 2006, a research report was presented at a conference held on the occasion of the 100th anniversary of the 1906 San Francisco earthquake [23]. The current population of this Northern California region is about ten times what it was in 1906. The report, entitled '*When the Big One Strikes Again: Estimated Losses Due to a Repeat of the 1906 San Francisco Earthquake*' estimates that a repeat of the "Big One" will instantaneously kill more than 800 people when the earthquake would happen at night, or more than 1500 people during the day, and seriously injure about 4000 people at night or more than 6000 people during the day. In general, the scientists claim a new earthquake in the area to be 'unavoidable' and the report acknowledges the prediction from the United States Geological Survey that there is a 62% probability that an earthquake, magnitude 6.7 or greater, will hit the San Francisco Bay Area by 2032. On the occasion of its appearance, the report was discussed in the local media, but its doomy predictions did not cause a great escape. The citizens took note of it and continued with their daily occupations.

Case 2: In July 2011, the World Health Organisation released its Tobacco Fact sheet N°339 [24]. The key facts paint a grim picture: tobacco is said to kill up to half of its users. It kills nearly six million people each year, of whom more than 5 million are users and ex-users and more than 600,000 are non-smokers exposed to second-hand smoke. The WHO claims that, unless urgent action is taken, the annual death toll could rise to more than eight million by 2030. It adds that nearly 80% of the world's one billion smokers live in low- and middle-income countries and that consumption of tobacco products is increasing globally, though it is decreasing in some high-income and upper middle-income countries.

My theory of why people voluntarily accept these clearly present and extreme risks is simple. They accept the risk because there is a simple and transparent cause–effect relation on the one hand and a simple and fair distribution of 'benefits and burdens' on the other hand. And, in addition, they are all free to move away from the risk at any time. The context of this article does not allow deeper elaboration, but, in short, apparently people can accept a risk they cannot completely know and cannot completely control simply based on a sense that it is marked by *fairness*. The fairness relates as well to the possibility to move away from the risk as to the issues of informed consent and distributive justice (see table):

San Francisco	Fairness despite of (or rather because of) force majeure Complete freedom because of: - the lack of control of the phenomenon as such and - the freedom to quit at any time Distributive justice: - informed consent (the earthquake risk and character of impact is known) - the citizens 'share' the benefit (living in SF) and the burden (the earthquake)
Smoking	Fairness as, in this context, we are master of the own human fate Complete freedom because of - the freedom to hurt yourself and - the freedom to quit at any time Distributive justice: - informed consent (the smoking risk and character of impact is known) - the smoker takes both the benefit and the burden (and this is why non-smokers don't accept the risk)

The risk that comes with using nuclear energy technology or the risk that is caused by climate change has a totally different character, as there is no simple and transparent cause-effect relation and no simple and fair distribution of benefits and burdens. Therefore, the assessment of the cause-effect relation needs to be based on advanced transdisciplinary science that also includes social, economic and even political aspects. In addition, the decision making that wants to respect this kind of distributive justice logically needs to be inclusive (taking into account the interests and concerns of various stakeholder) and based on a deliberate use of policy supportive science. Therefore, all risk rationales that claim an imposed risk to be acceptable on the basis of facts instead of fairness are useless, misleading and, in principle, unjust.

Still today, most of the nuclear proponents and their political supporters think that gaining public acceptance comes down to influencing people's risk perception related to nuclear technology. They claim that people should be informed because they lack part of the insight or miss a point. Very often, the lament goes that 'if people would see the evidence, then they would understand that the risk is acceptable'. They hire sociologists and psychologists to understand how people perceive and deal with risks, and how to explain them 'the facts' in a simple and convincing way. Their intentions are not necessarily bad, as most of them are driven by a genuine non-opportunistic believe in science and technology and by a true respect for the other's opinion. But their strategies are meaningless and risk to be misleading as long as the concept of informed consent is understood in the passive way as 'consent on the basis of information', and not in the active way as 'consent as an act of *informed decision making*'.

3.3. Deconstructing the broader (anti) nuclear argumentation

But although risk remains at the centre of attention, there are obviously other arguments to take into account in evaluating nuclear technology. Today, economic, ecological and social assessments of

nuclear as an energy technology option in science and policy are integrated in what one calls a 'holistic approach' to energy governance, and judged under the meta-norm of sustainable development. Whether philosophers would agree with this understanding of holism or not, this approach is logic and needed. It provides the possibility to 'enclose' the discussion within the theme of energy governance (as one of the relevant themes in relation to sustainable development) and enables comparative assessment of energy technology options. It has however made the discussion on nuclear energy not more simple. Logically, now both proponents and opponents of nuclear energy refer to sustainable development and extract evidence from the broader energy policy context to make their case. Supporters claim that 'nuclear energy is sustainable' or use the more moderate assertion that 'it can contribute to sustainable development', mostly because 'climate change is a serious problem' and 'nuclear energy is part of the solution'. According to the opponents however, 'nuclear energy is not sustainable', and while climate change is a serious problem, for them the nuclear option is just another problem.

The seven arguments and counter-arguments can be summarised in the following table.

	Argument pro nuclear energy	Counter-argument
1	The stability and reliability of the fuel market	Limited uranium resources
2	The low CO_2 burden of the nuclear fuel cycle	Significantly underestimated CO_2 emissions
3	The competitive price of nuclear electricity in base load	Subsidies, not enough provisions for waste & dismantling
4	Good NPP safety records of modern & 'safer' future plants	TMI, Chernobyl, Fukushima, old plants, human error, force majeure
5	Nuclear energy contributes to (national) energy security	Unpredictable factor in energy policy, given accidents and consequences for perception
6	Fuel cycles can be made proliferation-safe	Warfare, irresponsible regimes, proliferation, terror
7	Available technical and social solutions for radioactive waste disposal	Unproven technical solutions, questionable social solutions

If one would ask the question which of these issues could be resolved in a fair, open and transparent dialogue, then the answer is easy: the first three. In principle, it is sufficient to try to acquire knowledge, apply causal reasoning and make fair estimates about the situation (which doesn't mean that this is an easy task). It is impossible to prove who is right and who is wrong, but one could compare different views and try to find out why they differ. We could draw conclusions from these comparative assessments, reach a consensus on the knowledge base and inform policy. The result would be an estimate that could be supported by societal trust because of the deliberate and inclusive 'research method' and not because of a predicated scientific proof. In addition, also comparison of nuclear energy with alternatives is possible. Last but not least, it would not be too bad if we would turn out to be wrong, and the consensus on the knowledge can be adapted continuously if more facts and insight on causality would become available.

In a comparative study performed by my research group [25] in relation to the CO_2 burden of nuclear energy technology (argument/counter-argument 2), three life cycles were recalculated in order to make a comparison of both energy use and greenhouse gas emissions (GHG) for the different process steps in the nuclear fuel cycle. The study shows that, regarding the energy use for industrial activity in the fuel cycle, it is clear that the divergent results are due to the assessment method, the selection of input data and various estimates and assumptions. Obviously, these varying energy intensities are in their turn reflected in the diverging GHG emissions. As discussed in the study, the GHG intensity of the background economy forms a major influencing parameter as well. The study shows that assessment of the total GHG emissions of the nuclear energy life cycle depends on factors such as the enrichment method, the carbon intensity of the electricity used for the enrichment and on chosen mining technologies, but also on less quantitative 'best guesses' about prospected total emissions from the back-end of the fuel cycle (plant dismantling and waste disposal).

For what arguments 4, 5, 6 and 7 are concerned, engaging in deliberate and inclusive research methods is possible but not sufficient to generate societal trust. The reasons are obvious. The issues are marked by *risk* that needs to be *controlled* while essential factors are beyond full control (human culture, nature and time). Comparison of views usually triggers values rooted in culture, but in these cases, it is not only impossible to prove who is right and who is wrong but also *irrelevant*.

In conclusion, when looking for evidence in facts and argumentations in the interest of making a pro- or contra-claim, one has to admit that for 1, 2 and 3 evidence can be found in the *method* of assessment (although the method will never lead to an exact quantitative result), while in the case of 4, 5, 6 and 7, one has to conclude that *there simply is no evidence*. Even more: how we, as researchers, economists, politicians, citizens or activists, reason about these issues depends on the general values we use to make sense of ourselves, the world and the issues at stake, or thus on the question to what extent we, as example, think that

… nature is to be considered as a resource for exploitation
… markets should be free
… market dominance by big corporations is acceptable
… technology can be made fail-safe
… humans can behave fail-safe
… Iran is telling the truth about itself
… the US is telling the truth about Iran
… future generations should be protected against our harmful activities
… future generations should have freedom of choice
…

A recent 'post-Fukushima' report from the UK parliament's Science and Technology Committee [26] stresses that '… *Independent regulators should play a greater role in communicating the risks associated with energy generation and distribution because the government is not considered as an impartial source of information*'. The Committee states that '… *The UK government's position as an advocate for nuclear power makes it difficult for the public to trust it as an impartial source of information*' and that, therefore, '*this perceived lack of impartiality further emphasises the importance of government demonstrating that all energy policies are strongly based on rigorous scientific evidence*'. It further specifies that '… *Technically competent public bodies that are independent of government - such as the Health & Safety Executive and the Office for Nuclear Regulation - are "in a unique position to engender public trust and influence risk perceptions*".

In light of my previous considerations, I dare to claim that this kind of talk can only be characterised as symptomatic for an enduring myopic positivist view on the societal justification of a technological risk such as that of nuclear energy. If an official authoritative Science and Technology Committee that is supposed to deliberately represent society does not succeed in transcending this kind of rhetoric, how can we ever expect civil society at large to be able to do it?

4. The moral approach to justification

4.1. In search of a new rationale

Advancing on the 'deconstructions' and analyses done in the previous part, one could sketch a bleak picture of the rationales on nuclear technology. The considerations motivate the claim that, when it comes to societally justify nuclear technology…

- the positivist view on the why and how of influencing risk perception fails
- the science & engineering rationale with regard to plant safety fails
- the science & engineering rationale with regard to waste safety fails
- the economic rationale (the rationale of the market) fails
- the political rationale with regard to non-proliferation fails

And, most importantly, taking into account the inadequacies of these different rationales 'as such', they don't add up to compensate each other in the interest of 'full justification'. Obviously I am not saying that these rationales are useless. Besides the first one, they are of course useful and needed to make the technology work in practice. But they cannot do the job for justification, not alone and not in combination. To put things in perspective, with the exception of point 5, the same can of course be said about justifying the use of fossil fuels (but this detailed analysis falls outside of the context of this article).

So what is left? The essential, as this conclusion means nothing less than that we need to develop (and apply) a new rationale, one that aims to seek societal trust 'by method instead of proof'. If the nuclear sector and their political and economic supporters are serious about the 'ultimate criterion of public acceptance', then they would need to accept that good science, a responsible safety culture and clear information are necessary but insufficient conditions for societal trust. Any justification policy that accepts this insight will understand that it needs to rely on 'opinions that cannot be turned into facts' and that policy choices, in these cases, can be 'deliberate-political' but not (purely) rational-scientific. In addition, there is a need for a more considerate use of the term ethics in this sense. A technology cannot be ethical or unethical, but a policy related to that technology can be. Therefore, it is meaningless to ask whether nuclear energy is ethically acceptable or not.

What is this 'deliberate-political' that could generate societal trust? If nothing has been learnt from decades of nuclear discourse in terms of developing better technical arguments, then what can be learnt today is that technical rationales do not help society to choose side. A deliberate-political approach to knowledge generation and use on the one hand and to decision making on the other hand is primarily a political undertaken by political decision makers in interaction with all other actors concerned. It recognises further that there are no comfort zones for taking position on nuclear energy anymore. It understands that our potential to use scientific knowledge is limited by 'cognitive perplexity', in the sense that the use of rational evidence as basis of justification of risk-inherent practices is limited simply because risk assessment will always have to deal with uncertainties, ambiguities, unknowns and unknowables inherently connected to the concerned natural, technical and social phenomena. A nuclear expert who defends a technical solution for high level waste disposal needs to make use of hypothetical performance assessments and prognoses, and must thus admit that his defence is based on what he 'believes but cannot prove' and on what he 'hopes but cannot guarantee' (and the same counts for the opponent who does *not* believe in the technical solution). A deliberate-political further understands that justification is also troubled by moral pluralism, in the sense that, even if we *would* all agree on the scientific knowledge base for the assessment of the risk, opinions could still differ on its acceptability. Science in particular, and rational reasoning in general, may thus inform us about the technical and societal aspects of options, they cannot instruct or clarify the choice to make. To name just one example: whether we should dispose nuclear waste retrievable or non-retrievable can only be a *deliberate-political choice*, not a rational-technical one.

In a figurative way, one could say that the deliberate-political approach to justification would need to squash the political dynamics of mediation and resulting polarisation in between a 'top-down' layer that would enforce transparency on the one hand and a 'bottom-up' layer that would enable reflexivity on the other hand. In this 'bottom-up' layer, research and education have a central role to play. A responsible education and application of science in this respect simply comes down to fostering a sense of reflexivity and to develop critical attitudes and advanced scientific methods accordingly. With respect to making fair estimates and comparative assessments, but also in relation to calculating probabilities and constructing hypotheses and prognoses, education and research have the responsibility to develop additional reflexive discourses about what the natural and social sciences can and cannot prove, and about interpretation of data and results. And this approach can only work when it is embedded in a reflection on the norms and values that should not only inform education and research as such, but that also relate to how we, as humans, make sense of ourselves, of respect for nature, of a just society, and finally of well-being in general. Important to note is that, almost 'by definition', the research community can and should not develop this reflexive discourse alone. This should be done in interaction with civil society in the broadest sense, and with the 'end users' from politics and the private sector.

In sum, a deliberate-political will thus understand (and advance from the understanding) that the justification of nuclear technology will always remain a so-called 'unstructured problem' (see table). In other words: whatever decision taken on the nuclear option (introduction, continuation or phase out), it will always need to be done without consensus on the knowledge base and without consensus on the values at stake. And if one *could* imagine a world where discussion on nuclear as an energy technology option is possible within a 'closed' shared value framework, then still this value framework would be 'incomplete', as it cannot take into account the ethical stances of those generations concerned that do not exist yet. But whether this is a consolatory thought for those involved in energy policy or not, at least this last issue nuclear energy has in common with fossil fuels.

	Societal values-based consensus for justification? No ('moral pluralism')	Societal values-based consensus for justification? Yes
Consensus on knowledge base? No ('cognitive perplexity')	**Unstructured problem** →Governance by deliberation *Nuclear technology* (*Fossil fuels*)*	**Moderately structured problem** →Governance by pacification *Mobile phones*
Consensus on knowledge base? Yes	**Moderately structured problem** →Governance by negotiation *Fossil fuels*	**Structured problem** →Governance by regulation *Traffic*

Four Models of Governance, adapted from [27]. Concepts 'cognitive perplexity' and 'moral pluralism' and examples in italics added by the author.
*: The IPCC's 4th Assessment Report states that it is now very likely that human activity is changing the climate, but there remain various voices contradicting this.

4.2. Contemporary hindrances to a moral approach to justification

It is reasonable to say that that the current informal and formal (institutionalised) processes of knowledge generation and decision

making about nuclear as an energy technology option are not informed by implications of cognitive perplexity and moral pluralism. The science–policy interface is mediated and our traditional political democratic systems continue to force eventually nuanced views on nuclear energy into simplified political party positions. As an example: in Belgium, as in many other countries, Socialists and Greens are against and Liberals are pro (and this counts for both language sides). In addition, the Christan-Democrats are pro but see nuclear energy not as an opportunity but as a 'necessary evil' (see also [28]).

In order to keep this article within a reasonable length, I have only briefly sketched in the previous paragraph what could be the moral approach to justification of a risk-inherent technology such as nuclear energy technology (again, taking into account that the outcome of such a justification process might as well be an acceptance or a rejection of the technology, given that societal trust would rather be connected to the method of knowledge generation and deliberation and thus only indirectly to the outcome of the decision making itself). The 'deliberate-political' described above would of course not concentrate on the nuclear option as such (neither as vantage point nor as end focus) but would frame challenges and opportunities in an energy governance context that also takes into account other technologies and broader economic, environmental, socio-cultural and political factors. In this short additional paragraph, I only want to mention and warn of two current rationales that may give the impression that this particular moral approach described above is not needed, as there are 'pragmatic' architectures in place that can also do the job. The first relates to the current legal settings to enable 'public participation' and the second is the idea that the solution is to be found in the working of the energy market.

Although I made the claim that the polarisation over the nuclear option is rooted in the organisational structures of politics, science and informed civil society (see §1.3), this evidently does not exclude that more deliberate opinions in civil society or in the public at large exist. The possibilities to formally bring these into the debate are however limited. Everyone knows that public participation in the context of environmental regulation is now structurally possible, at least in theory. To take the example of Europe: the European Commission's Directives 85/337 ('on the assessment of the effects of certain public and private projects on the environment'), 2001/42 ('on the assessment of the effects of certain plans and programmes on the environment ') and 2003/35/EC ('providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment') aim to regulate public involvement in environmental matters. Directive 2003/35/EC aimed to 'translate' the Aarhus convention [29] into European law (and thus subsequently into the national law of its member states). Specific for the nuclear case, there is also the recent Council Directive 2011/70/Euratom of 19 July 2011 'establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste'. A close reading of the texts is beyond the scope and practical limits of this article, but it would show anyway that the language on how the public can effectively participate is rather vague. Phrases such as '*early and effective opportunities to participate*' (2003/35/EC article 2) [30] hint at good intentions, but the quote '*Transparency should be provided by ensuring effective public information and opportunities for all stakeholders concerned* […] to participate in the decision-making processes in accordance with national and international obligations' (2011/70/Euratom) rather sounds as circular reasoning, as the reason for public participation should not be 'better transparency' but 'better justification'. A study undertaken by the University of Brussels in cooperation with my research group [31] reiterates the fact that legal obligations to involve the public (in siting projects as well as in principle design decisions) are today still confined to the form of a 'public inquiry'. Although the authorities have the obligation 'to take into account' the result of an inquiry, the public has no decisive power. The study analyses the implications for the nuclear case, and suggests that its specific technical and social complexity and the long time scales involved may be incentives to question the effectiveness of the legal procedure concerned. Adding simple language to the conclusions of the study, the legal procedure for public involvement may be satisfactory for the evaluation of the installation of a large gas pipe or a chicken farm, the complexity of the evaluation of the potential impact of a nuclear power plant or a radioactive disposal site is too high for the issue to be tackled effectively through this formal procedure. In addition, in most of the cases, projects and plans presented have evolved already into such a stage of development that reflections on principles and alternatives can easily be put aside. Taking these considerations into account, one cannot but conclude that legally based fair and effective public participation in decision making on the nuclear option remains nothing else than a myth.

Whereas the rationales on the possibilities for and effectiveness of public participation still leave some room for interpretation, the myth of the potential of the market as a tool for justification is easier to dismantle. Today, private companies, either in their role of vendors of nuclear power plants or as electricity producers, do not justify an eventual choice for the nuclear option on the basis of ideological views. While safety and security are obviously part of their concerns, 'customer expectations' are not a criterion guiding utility decision to invest or not in nuclear power. Their criteria are the political climate with regard to nuclear energy in the envisaged country or region, the possibilities for subsidies, the margins for electricity production cost, the ranges for consumer price setting and the short and long term outlook of the markets for financial investment. In a similar sense, big customers of electricity (in the form of big corporations or cartels) may consider building nuclear power plants for their own electricity production or may lobby politics in favour of nuclear energy, but they will logically only do so based on pragmatic economic reasoning (a reasoning that might as well take into account the implications of climate change regulation). Finally, while small private sector customers and even the citizens are free to install wind or solar power for own use, they have no economic influence at all on the technologies that provide the base load electricity in 'their' national grid. The market rationale for the nuclear option fails because it remains uncertain how (and how much) externalities should be internalised and because 'going nuclear' cannot be done without structural subsidies. This last claim does not only resonate in anti-nuclear camps, but also, on occasion, within the private sector itself (as an example, recently, the Chief Executive of General Electric called nuclear power 'really hard to defend financially' [32]). But, in a broader perspective, the market rationale fails because it fails for the whole of the 'energy market' as such. All energy technologies benefit from subsidies, and the issue of externalities also counts for fossil fuel technologies. The private energy sector asks transparent and robust 'enabling frameworks' for investment, but, apparently, politics, on all levels, is unable to provide them. Last but not least, the energy market is not only ineffective in economic terms, it is also essentially unfair in socio-political terms. It would in principle be possible to design policies that include the poor in a fair way, but as long as nuclear energy technology and fossil fuels will play a role, an essential group of 'customers' that carries part of the environmental and financial burden is ruled out, for the simple reason that they are not born yet.

Taking into account the previous reasoning, one cannot but conclude that also the rationale of the market as a basis for justification of nuclear as an energy technology option in particular and of energy technologies in general is a myth. And, to put things in perspective, that reasoning in principle also counts f.i. for solar power, as the same can be said of the use of heavy metals and hazardous chemicals in PV cells. Economics obviously do play a role, but they will need to be embedded in a deliberate-political approach as described above.

4.3. Elements of an advanced framework for deliberation on energy

It may be clear from § 4.1 that the elaborations on the need for a moral approach to the justification of nuclear as an energy technology option, and on what this implies in theory and practice, are essentially motivated from out of a philosophy of ethics, in combination with critical observations of reality. In my research on global sustainable development governance [33], I develop the reasoning that this approach not only applies to how we make sense of technological risk, but also to other 'artefacts of civilisation' that are marked by cognitive complexity and moral pluralism, such as 'environmental occupation' and 'market dependency', among others. The general claim is that the quality of governance essentially depends on the quality of the working of 'the knowledge-policy interface', and that this 'quality' concerns a specific morality with regard to the generation and metamorphosis of knowledge prior to and in decision making itself.

Despite this needed 'holistic' and contextual approach, it is however possible to extract a list of 'pragmatic' requirements for a fair and effective deliberation on the nuclear option specifically. In conclusion to this article, I present these requirements as 'elements of an advanced framework for deliberation on nuclear energy'. By deliberately presenting them as a list, they may serve as discussion points for further reflection:

Elements of an advanced framework for deliberation on energy:

1. for society at large: see technological risk simply as an 'artefact of civilisation', not (only) as a historical product of ill-considered technocratic politics
2. for those concerned with global sustainable development governance: approach energy governance as a theme among the other themes of sustainable development (water, food, transport, …) and organise the multilevel energy governance process in parallel to these other themes
3. for those from politics, civil society and the private sector concerned with energy policy and R&D: organise/foster/support transdisciplinary research and inclusive deliberation within the 'neutral frame' of energy governance and in the spirit of reflexivity, transparency, accountability and social justice, in particular along the following lines:
   - 3a treat renewable energy and energy saving not as trade-offs but on the basis of their own 'ideological' merits in the context of sustainable development
   - 3b confront nuclear energy technology as an option with the other 'problematic' energy technology (fossil fuels) in a resigned but responsible energy politics 'anticipating full alternatives' (whether they come or not)
   - 3c in addition to striving for intra-generational democratic informed consent with regard to the use of specific energy technology options, organise accountability and compensation towards (potential) victims of collateral harm and towards future generations (towards the last also by providing them with a resigned explanation of why we thought this was the best thing we could do)

These elements, presented as discussion points, concern nuclear energy opponents, supporters and those who have a more neutral stance towards the nuclear option, but essentially also everybody who cares about fair and effective energy governance. There is, in my view, however one additional requirement that concerns nuclear advocates alone, and that is their sole responsibility in terms of a moral stance (and its practical consequences): taking part in a deliberate-political energy governance process, the nuclear sector will only get a fair chance if it also openly distances itself (in word and deed) from military applications of the technology. The claim that 'we can't help it that others are misusing our technology' cannot be used any longer as an excuse.

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