LECTURING ETHICS IN NUCLEAR SCIENCE AND TECHNOLOGY AND RADIATION PROTECTION COURSES: MOTIVATIONS, APPROACHES AND ATTENTION POINTS.

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ABSTRACT

For more than a decade now, the SCK•CEN Academy for Nuclear Science and Technology, in cooperation with the Science & Technology Studies unit of SCK•CEN, organises 'Seminars on Ethics, Science & Technology', either in the form of self-standing events or as part of nuclear science and technology and radiation protection courses. Target audiences include science and engineering students and professionals working in the nuclear field, and seminar formats vary from one-hour-introductions to interactive workshops running over two days.

This short discussion paper presents a specific understanding of ethics in relation to science & technology in general and in relation to nuclear technology in particular[1], and this in the form of five attention points:

- Science & technology studies as the reference framework, from an ethics perspective
- The case of nuclear technology: neutral application contexts for meaningful evaluations
- Risk inherent technology assessment as a responsible policy-supportive research practice
- Ethics, fairness and trust: the idea of fair risk governance
- Education as critical capacity building

The reason to elaborate on these attention points in this text is that they figure as key topics of discussion in the seminars on ethics, science and technology themselves. At the same time, they inspire specific skills required to deal responsibly with risk inherent technologies such as nuclear technology. In the following text, the proposed attention points are each topic of a chapter. While they can be perceived separately, it may be clear that they are closely interrelated. A concluding chapter presents how these attention points are discussed in practice in the seminars on ethics, science and technology organised by the SCK•CEN Academy for Nuclear Science and Technology.

Content

[1] The ideas presented here are elaborated in more detail in (Meskens 2013, 2015, 2016a, 2016b, 2017).

1 Introduction

The last years, one can observe growing interest in ethics of radiological protection and related to nuclear technology as topics of education, research and research policy. The International Commission on Radiological Protection (ICRP) completed a broad reflection process on the ethical foundations of the system of radiological protection[2], International organisations such as the ICRP, the International Atomic Energy Agency (IAEA), the International Radiation Protection Association (IRPA) and the International Youth Nuclear Congress regularly include sessions on ethics in their conferences, workshops or education programmes, and research on ethics is slowly finding ground in various EURATOM-funded networks, platforms and research projects. In addition, more and more academies and universities include sessions on ethics in their education and training programmes related to applications of nuclear science and technology.

Already more than fifteen years ago, the PISA research programme[3] of the Belgian Nuclear Research Centre SCK•CEN started to pay attention to ethical aspects of the application of nuclear technology (Turcanu et al. 2016), and the public dissemination of the research triggered an interest in lectures and courses devoted to ethics from out of the wider nuclear research and policy community. For more than a decade now, the SCK•CEN Academy for Nuclear Science and Technology, in cooperation with the Science & Technology Studies unit of SCK•CEN, organises 'Seminars on Ethics, Science & Technology', either in the form of self-standing events or as part of nuclear science and technology and radiation protection courses. Target audiences include science and engineering students and professionals working in the nuclear field, and seminar formats vary from one-hour-introductions to interactive workshops running over two days.

This short discussion paper presents a specific understanding of ethics in relation to science & technology in general and in relation to nuclear technology in particular[4], and this in the form of five attention points:

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The reason to elaborate on these attention points in this text is that they figure as key topics of discussion in the seminars on ethics, science and technology themselves. At the same time, they inspire specific skills required to deal responsibly with risk inherent technologies such as nuclear technology. Important to stress here is that these skills requirements apply in the same way to anyone concerned with risk-inherent technology applications, being it nuclear workers, scientists, radiation protection officers, managers, policy makers and citizens. As a consequence, the seminars become self-reflexive, in the way they invite reflection and dialogue on the specific role, expertise and responsibility of all participants.

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[2] ICRP Task Group 94 developed an ICRP Publication presenting the ethical foundations of the system of radiological protection recommended by the Commission. The purpose of this publication is to consolidate the basis of the recommendations, to improve the understanding of the system and to provide a basis for communication on radiation risk and its perception. See http://www.icrp.org/icrp_group.asp?id=86

[3] The 'Programme of Integration of Social Aspects into nuclear research' (PISA) is a research programme undertaken by the Science & Technology Studies Unit of SCK•CEN.

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In the following text, the proposed attention points are each topic of a chapter. While they can be perceived separately, it may be clear that they are closely interrelated. A concluding chapter presents how these attention points are discussed in practice in the seminars on ethics, science and technology organised by the SCK•CEN Academy for Nuclear Science and Technology.

2 The reference framework: science & technology studies, from an ethics perspective

Science and technology have dramatically changed our world in the last centuries, albeit in conflicting ways. On the one hand, they have significantly contributed to the improvement of our individual life, our collective well-being and the organisation of our society. On the other hand, they have resulted in various threats to life and well-being and provided multiple tools to distort and even destroy our society and habitat as a whole. The development and application of modern science and technology in the various 'sectors' of organisation of our society (health, food, water, housing, energy, transport, industry, …) can be called one of the five evolutions that, in a historical perspective, made up modernity. The other four happened in the 'fields' of politics (the emergence of democracy, the nation state and international politics), economics (the emergence of globalised markets and the financial economy), culture (the emergence of popular culture and modern and postmodern art) and the social (the emergence of new lifestyles and new forms of communication).

Evaluations of how science and technology (might) affect us cannot be done in isolation from the contexts wherein they operate, which means these evaluations have to take into account aspects of the fields of politics, economy, culture and the social as mentioned above. The reason is that the potentialities and (possible) threats of science and technology affect the way we live but also our considerations on the way we want to live. Conversely, current political, economic, cultural and social interests and dynamics affect the way science and technology develop and are applied now and in the future. The recognition of this interrelation is what characterises 'science & technology studies' (STS), and the 'nature' of this interrelation, in terms of its various scientific, technical, political, economic, cultural, social and ethical aspects, is topic of analysis in STS.

The question whether STS should be 'free' from normative thinking or should rather 'allow' or even be driven by normative thinking is a topic of STS research in itself. Based on the underlying research on ethics, science and technology, the seminars on ethics discussed here deliberately take the second position. In other words: ethical aspects of the interrelation of science, technology and society are thus not only seen as 'just another set of aspects' for analysis. On the contrary: the idea is that ethics primarily provide the lens for STS. Evaluations of how science and technology (might) affect us are motivated by a general concern for social justice, environmental protection and sustainable development on the one hand and from a critical perspective on the practice of science as policy advice on the other hand. Danger for bias in this perspective is prevented precisely by the open and deliberative character of the seminars and of the underlying research, taking into account that the meaning of the concepts of social justice, environmental protection and sustainable development are topic of reflection in these seminars themselves.

What do we talk about when we talk about ethics? In simple terms, ethics is about being concerned with questions and concepts of 'what ought to be' with respect to a specific issue in the absence of 'evidence' that would facilitate straightforward judgement, consensus and consequent action. The 'what ought to be' can refer to 'good or wrong conduct' or, on a higher conceptual level, to 'rights and responsibilities'. The missing evidence can refer to knowledge-related uncertainty due to incomplete or speculative knowledge (including scientific knowledge), an undisputable law or an 'absolute' (set of) value(s) to guide behaviour or choice. All of these apply to the case of the evaluation of a risk-inherent technology such as nuclear in our society today, and the idea elaborated in the seminars on ethics is that anyone with a specific interest with respect to a risk-inherent technology such as nuclear becomes a moral agent and has a specific responsibility in dealing with that technology in a 'fair' way.

3 The case of nuclear technology – neutral application contexts for meaningful evaluations

Looking at societal impacts of science and technology, nuclear technology probably represents an extreme case of how science and technology can serve both cure and destruction. While medical applications of nuclear technology save individual lives every day, nuclear weapons have the potential to destroy humanity as a whole. Nuclear energy is a low-carbon source of electricity, but a nuclear accident can have dramatic impacts on the environment and on the physical and psychological health of a whole population for a long time.

What are we speaking about when we speak of ethics in relation to the nuclear risk? Dealing with radioactivity in society is a complex challenge in any respect, but one can distinct four fundamental contexts that require different visions on that complexity, and on what it would mean to responsibly deal with it. The first context is the context of natural radiation. The second context concerns (industrial) practices that result in technically enhanced natural radiation. The third context is the context of peaceful applications of nuclear science and technology. These include applications of nuclear physics processes, such as the fission or fusion of nuclei for energy production or the use of decay radiation in medical treatment and diagnose or in industrial purposes. The fourth context is the use of nuclear technology or material as a weapon, either as a mean for political deterrence, in organised military operation or in terrorist actions.

The reason to distinct these different contexts is motivated by the scope of this chapter: to highlight the importance of 'neutral application contexts' for a meaningful evaluation of the nuclear risk. To put it simple: if we consider average natural background radiation as an element of our natural habitat, then any significantly enhanced level of radioactivity in the vicinity of living species represents a 'health risk' – in the sense of a potential harm – to the health of those living species. In these cases, pragmatic reasoning thus requires us to consider the possibility of protection, mitigation or avoidance, but essentially it requires us to first evaluate why the radioactivity occurs in the first place, and whether we can possibly justify it. Whether that justification exercise can be done meaningfully or not depends on how we perceive the context of the occurrence of radiation.

For what the first context is concerned, whether we want it or not, natural radiation is there and any naturally enhanced occurrence (e.g. in the case of high concentrations of Radon) has a potential impact on health. Thinking in terms of justification of the presence of that radiation is meaningless, which leaves us with evaluating the justification of exposure, and thus of the possibility of protection, mitigation or avoidance of its impact. In the second context of technically enhanced natural radiation (as in the oil refinery industry or in aviation), radiation exposure manifests as a 'side effect'. Practices as such may be contested (as is the case with the oil or phosphate industry), but very rarely the issue of radiation exposure will become a decisive factor in the evaluation of the justification of these practices. Similar to the case of natural radiation, the radiation justification exercise thus restricts itself to the evaluation of exposure, and thus to the evaluation of the possibility of protection, mitigation or avoidance of its impact. In the third context, evaluation of the justification of the use of nuclear technology obviously takes the reason of that proposed use (the projected 'benefits') as a first criterion, with the aim to 'balance' it with the projected risks. Despite the fact that opinions on these projected benefits and risks differ among people, in this context, an evaluation of the justification of the use of a risk-inherent technology, or thus of the presence or 'creation' of radiation, remains meaningful, and this because the application context is 'neutral': while opinions may differ on how to produce energy or to do a medical treatment, nobody is 'against energy' or 'against medical care' as such. The neutral context thus makes a meaningful joint evaluation of the justification of the nuclear technology application possible, and it will not affect possible outcomes (a rejection or acceptance of the technology) as such. Finally, in the fourth context, a meaningful joint evaluation of the justification of (the risk of) the nuclear technology application is not possible, and this for the reason that the context of application itself is not neutral. A pacifist perspective does not support a principle justification of nuclear deterrence and armed conflict strategies, while, in a perspective that sees politics always as a politics of power and conflict, these strategies may be perceived as justified.

4 Technology assessment as a responsible policy-supportive research practice

The case of nuclear energy technology is also an extreme example of how technology assessment can be troubled by the fact that 'benefits and burdens' of a technology are essentially incomparable. From a philosophical perspective, we could say that, due to the specific character of the nuclear energy risk, the societal justification of nuclear energy is troubled by moral pluralism. That is: even if we would all agree on the scientific knowledge base for the assessment of the risk, then value-based opinions on its acceptability could still differ. 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. Nuclear science and engineering are mature, but we have to acknowledge that the existence of knowledge-related uncertainties puts fundamental limits to understanding and forecasting technological, biological and social phenomena in the interest of risk assessment and governance. Last but not least, we have to accept that important factors remain to a large degree beyond control. These are human behaviour, nature, time and potential misuse of the technology…

The resulting room for interpretation complicates the evaluation of nuclear energy as an energy technology option, and puts a specific responsibility on nuclear science and technology assessment as a policy-supportive research practice. In simple terms, that responsibility comes down to acknowledging and taking into account uncertainty and pluralism as described above, and the consequences thereof for research and policy. This responsibility does not only apply to scientists, but to everyone concerned with applications of science and technology in general and with the issue of nuclear energy in particular.

5 Ethics, fairness and trust: the idea of fair risk governance.

Whatever aspect of nuclear technology we consider, we have to acknowledge that the health risk coming with the use of nuclear technology remains of central concern, given that its evaluation will affect the assessment of all other aspects of the technology (technical, social, economic, political)[5]. Any thinking of 'fair governance' of nuclear technology should therefore start from a reflection on how to 'fairly deal' with the nuclear risk. As this idea is central to the ethics seminars that focus on the case of nuclear technology, it is elaborated a little further in this text.

Gaining insight in the character and meaning of fairness (and of the consequences for risk governance) can start with a simple comparison of specific risks we (might want to) take in our highly 'technological' society today. Knowing that any evaluation of the acceptability of a risk-inherent practice in general may be based on knowledge-based opinions and values-based opinions, we can construct a simple picture of four distinct cases as presented in the table below. The table may be oversimplified in the sense that one cannot 'distinct'

[5] As an example: the issue of insurance and liability anticipating a potential nuclear accident directly affects any assessment of the economics of nuclear energy.

knowledge from values (in risk evaluation, specific knowledge may influence the importance of specific values and specific values may influence as well the importance of specific knowledge as the way it is used in evaluation) but it can be used as a meaningful tool to determine key concepts of fairness of risk assessment and governance and to understand differences between risky practices in that respect.

risk-inherent practice acceptable?		value-based assessment	
		dissent 'moral pluralism'	**consent** 'shared values'
knowledge-based assessment	**uncertainty** (incomplete and speculative knowledge)	governance by **deliberation** <u>examples</u> *nuclear energy* *(fossil fuels)* <u>fairness:</u> caring for 'intellectual solidarity' in dealing with incomplete & speculative knowledge and moral pluralism ↓ <u>key concepts</u> precaution informed consent transparency confrontation of rationales accountability to next generations	governance by **pacification** <u>examples</u> *medical applications of radioactivity* *mobile phones* *smoking* <u>fairness:</u> caring for 'intellectual solidarity' in dealing with incomplete & speculative knowledge ↓ <u>key concepts</u> precaution informed consent transparency confrontation of rationales
	consent (consensus on 'evidence')	governance by **negotiation** <u>examples</u> *(fossil fuels)* <u>fairness:</u> caring for 'intellectual solidarity' in dealing with moral pluralism ↓ <u>key concepts</u> precaution informed consent confrontation of rationales accountability to next generations	governance by **'simple' regulation** <u>examples</u> *traffic* *bungee jumping* <u>fairness:</u> caring for 'intellectual solidarity' in our behaviour towards each other ↓ <u>key concepts</u> precaution informed consent fair play

Justifying risk – Mapping the field (adapted from (Hisschemöller and Hoppe 1995))

The context of this text does not allow broad elaboration on the table, but it shows primarily that the risks of bungee jumping, mobile phones or nuclear energy are incomparable as joint evaluation of their acceptability depends in different ways on knowledge and values. The bungee jumper will not ask to see the test procedures of the rope before making a jump. In general, the jumper trusts that these ropes will be ok, but, more importantly, he or she makes the decision to jump on a voluntary basis. Despite the fact that more than one million people die in car accidents globally[6], no reasonable person is advocating a global car ban. Similar to bungee jumping, the key concepts of fairness related to taking the risk are precaution, informed consent and fair play. In the case of car driving, precaution not only refers to protection measures such as air bags but also to the value of driving responsibly. And fair play refers in that case to the idea that one can only *hope* that the other drivers also want to drive responsibly.

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[6] The World Health Organisation (WHO) Global status report on road safety 2013 indicates that worldwide the total number of road traffic deaths remains unacceptably high at 1.24 million per year (World Health Organisation 2015).

The evaluation of the risk that comes with smoking or the use of mobile phones is what one could call a 'semi-structured' or 'moderately structured' problem (Hisschemöller and Hoppe 1995) that can be handled on the basis of 'pacification'. The reason is that, despite of the uncertainties that complicate the assessment of those specific risks[7], people agree to take or allow them on the basis of 'shared values'. Shared values are thus about those situations wherein we have the feeling that we all accept or allow a specific 'risky' practice in light of a shared value. This shared value can be a joint benefit (such as in the case of mobile phones) but also a specific freedom of choice 'to hurt yourself' in view of a personal benefit, taking into account that this behaviour should not harm others (such as in the case of smoking). With reference to the table, one could say that fairness is thus in the way we care for 'intellectual solidarity' in dealing with incomplete and speculative knowledge, and the key concepts of fairness in this sense are precaution, informed consent, transparency (with respect to what we know and don't know and with respect to how we construct our knowledge) and our joint preparedness to give account of the rationales we use to defend our interests ('stakes'). Because of the uncertainties that complicate the assessment, protection measures are essentially inspired on and supported by the precautionary principle. In the case of mobile phones, this principle translates as the recommendation to use them in a 'moderate way' and the recommendation to limit the use by children. For smoking, it translates as anti-smoking campaigns towards (potential) smokers (with special attention to young people) and as measures to protect those 'passively involved' (the passive smoker). Knowing of the addictive character of smoking, additional measures are gradually adopted to 'assist' smokers who want to quit. In similar sense, evaluating the risk coming with the use of radiation in medical context can also be called governance by pacification. The value of informed consent remains central and also applies to the close relations of the patient (family members), but essentially all agree that the patient takes the risk of a delayed cancer (due to diagnose or therapy) in light of a 'higher' benefit (respectively information about a health condition or the hope that the current cancer will be cured).

In contrast to complex problems that can be handled on the basis of 'pacification', justifying or rejecting nuclear energy seems to be an unstructured problem that will always need deliberation. Not only do we need to deliberate the available knowledge and its interpretation, deliberation will also need to take into account the various 'external' values people find relevant in their judgements, and the arguments they construct on the basis of these values. Therefore, the fairness of evaluation relates to 'intellectual solidarity' in dealing with incomplete and speculative knowledge but also in dealing with moral pluralism. The key criteria are then again precaution, informed consent, transparency and (the preparedness for a) confrontation of rationales, now completed with a sense for accountability towards those who cannot be involved in the evaluation (the next generations). In comparison with nuclear energy, the evaluation of the risk that comes with the use of fossil fuels is a complex problem that, in principle, can be treated on the basis of 'consent on causality'. The 5th Assessment Report of the Intergovernmental Panel on Climate change states that […] *Human influence on the climate system is clear* […] and that […] *Warming of the climate system is*

[7] With regard to mobile phone use, the WHO states that 'The electromagnetic fields produced by mobile phones are classified by the International Agency for Research on Cancer as possibly carcinogenic to humans' (World Health Organisation 2014). With respect to smoking, of course there is the known relation with lung cancer, but the lack of evidence is in the delayed effect and especially in the fact that there is contingency into play (there is no evidence (yet) for why apparently some individuals are more susceptible than others). In addition, while the WHO now clearly states that tobacco kills up to half of its users (World Health Organisation 2015), we don't see these statistics 'happening' in our near social environment. To put it more provocative, our shared values support the idea that we should protect the non-smokers from the smokers, but also the idea that we still live in a free and democratic society where informed people have 'the right' to smoke themselves to death. It is true that the addictive character of smoking is influencing 'the freedom of choice', but nowadays addicted smokers can always decide for themselves to seek medical and social assistance in their attempt to quit smoking.

unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen […] (Intergovernmental Panel on Climate Change 2014). Despite this evidence of a 'slowly emerging adverse effect', the assessment of whether *concrete* droughts or storms can be contributed to human induced climate change or what the *concrete* effect of specific mitigation or adaptation policies would be remains troubled by knowledge related uncertainty. Therefore, also fossil fuel use is a complex problem that requires 'deliberation', and the key concepts of fairness remain the same as for the evaluation of nuclear energy: precaution, informed consent, transparency, confrontation of rationales and accountability to next generations.

The discussion of the table above allows us now to make three reflections related to ethics, fairness and trust in relation to risk governance. Obviously these reflections are based on my specific understanding of risk assessment in relation to fairness and are therefore presented as list of ideas that are as such open to discussion:

1. The assessment of what is an acceptable health risk for society is not a matter of science; it is a matter of justice.

1.a. A health risk is not a mathematical formula: it is a potential harm that you cannot completely know and cannot fully control but that you eventually want to face in light of a specific benefit. People will accept a risk they cannot completely know and that they cannot fully control simply when they trust that its justification is marked by fairness. And fairness relates primarily to the value of precaution, but even so to the possibility of self-determination ('informed consent').

1.b. Despite the differences between the cases discussed, they can all be characterised in relation to one idea with respect to self-determination: the idea that 'connecting' risk and fairness is about finding ground between ensuring people *the right to be protected* on the one hand and *the right to be responsible* themselves on the other hand. The right to be responsible leans thereby on the prime criterion of the right to have information about the risk and the possibility of self-determination based on that information, but one has to take into account that, in a society of capable citizens, self-determination with respect to risk-taking can have two opposing meanings: it can translate as the right to co-decide in the case of a collective health risk (as in the case of nuclear energy), but also as the freedom to hurt yourself in the case of an individual health risk (as in the case of smoking or bungee jumping).

1.c. For any health risk that comes with technological, industrial or medical practices and that has a wider impact on society, 'the right to be responsible' equals 'the right to co-decide'. And enabling this right is a principle of justice.

2. Societal trust in the assessment of what is an (un)acceptable collective health risk for society should be generated 'by method instead of proof'.

2.a. With respect to nuclear energy, no scientific or political authority can determine alone whether the risk would be an acceptable collective health risk for society. Good science and engineering, open and transparent communication and the 'promises' of a responsible safety and security culture would be necessary conditions but they can never generate societal trust in themselves. The reason is that there will always be essential factors beyond full control: nature, time, human error, misuse of technology.

2.b. The fact that people take specific risks in a voluntary way and often based on limited information may not be used as an argument to impose risks on them that might be characterised as 'comparable' or even less dangerous. That principle counts to the extreme. As examples:

The fact that the risk of developing cancer from smoking might be ‘higher’ than that from low-level radiation may not be used as an excuse to impose a radiation risk on people.

The fact that a nuclear worker may voluntarily accept an accumulated occupational dose of 20 mSv per year may not be used to justify a citizen’s dose of 1 mSv per year originating from a nuclear technology application without asking for his or her informed consent.

2.c. Fair risk governance is risk governance of which the method of knowledge generation and decision making is trusted as fair by society. When the method is trusted as fair, that risk governance has also the potential to be effective, as the decision making will also be trusted as fair with those who would have preferred another outcome.

3. A fair dealing with the complexity of risk assessment and justification requires new governance methods.

3.a. Is fair risk governance with respect to collective health risks as characterised above possible today? In other words: do the methods we use to produce policy supportive knowledge and to make political decisions have the potential to enable ‘the right to co-decide’ (as a principle of justice) and to generate trust by their method instead of by their potential or promised outcome? My short answer is no. In (Meskens 2016a) and (Meskens 2017), I argue in depth why and how the ‘governance methods’ we use today to make sense of the complexity of assessment and justification of typical collective health risks remain to be driven by the doctrine of scientific truth and the strategies of political ‘positionism’ and economic profit. As the context of this text does not allow deeper reflection on this general argument, the following reflections are restricted to the case of nuclear energy in the context of energy governance.

3.b. For the nuclear energy case in particular, I argued in (Meskens 2013) that, because of the doctrinal working of science and of the strategies of political ‘positionism’ and economic profit, the nuclear energy issue is now locked in a comfort of polarisation that does not only play in public discourse but that is deeply rooted in the working of science, politics and the market. As a result, in sharp contrast with the way fossil fuel energy technologies are now subject of global negotiations driven by the doom of climate change, nuclear energy technology remains to ‘escape’ a deliberate justification approach as an energy technology on a transnational level.

3.c. Critiques and appraisals with respect to the nuclear energy option are meaningless if not formulated ‘within’ the general theme of energy governance as the context of concern. This also implies that highlighting the benefits of other nuclear technology applications, such as those in the medical, industrial or space context, cannot be used as a strategy to indirectly put nuclear energy in a more positive light.

Energy governance is a complex social problem in itself, and probably today one of the most complex humanity is facing[8]. The complexity goes beyond that of dealing with climate change or nuclear energy as such. In energy governance, there is complete interdependence of the local and the global, and the scientific and technical issues cannot be isolated from the social, political and cultural dimensions of the governance practices in which these issues figure. Moreover, every energy-related act, whether undertaken by individual citizens, private companies or political regimes, involves

[8] I develop a characterisation of complexity of complex social problems and a reasoning on how to deal with that complexity ‘fairly’ in (Meskens 2016a) and (Meskens 2017).

ethical considerations with respect to freedom, authority, vulnerability (of men and nature) and individual and collective responsibilities now and in the future.

However, with the minimisation of adverse impact on health and the environment as a central concern, and despite the fact that opinions with respect to the nuclear option differ fundamentally, it is possible to formulate three policy principles of energy governance with which, in principle, most people could agree. In order of priority, these policy principles can be phrased as follows:

1. The policy principle to minimise energy consumption (or thus to maximise energy savings) through democratic deliberation on how and where;

2. The policy principle to maximise renewables through democratic deliberation on how and where; and

3. The policy principle to organise a fair debate on how to produce what cannot be done with 1 and 2 yet, and to 'confront' in that debate fossil fuels and nuclear, being the two 'nasty' risk-inherent energy technologies, with each other. Democracy in this sense implies that a society would need to be able to decide on how to produce 'the rest' of its needed energy for the time to come: with nuclear, with fossil fuels or with a combination of both. In line with the reasoning above, a fair method of decision making would in this context be a method that would be sensed as fair because of its method by all concerned, regardless of whether the decision making would result in the acceptance or in the rejection of nuclear energy or fossil fuel use. The fact that we are in a historically evolved situation where nuclear and fossil fuels are present while there have never been real democratic debates on their introduction cannot be used as an excuse to not organise this kind of debate now. While it is true that, in terms of their adverse effects, nuclear and fossil fuels are 'incomparable', that additional complexity would not prevent a democratic society to make deliberate decisions on them.

Although we don't live in a world where politics, science and the market would be prepared to engage in deliberation that would put policy principles 1 and 2 upfront and that would take principle 3 serious, we have the capacity to put that deliberation in practice. Justice with regard to how a specific collective health risk such as the risk of nuclear or fossil fuels is evaluated in society remains the central ethical principle, and that ethical principle translates in practice as the need for transdisciplinarity and civil society participation in scientific research and the need for participation of the potentially affected in democratic decision making.

6 Education as critical capacity building

The previous considerations may make clear that a fair and effective dealing with complex problems such as technological risk governance would require advanced governance methods that would have the potential to generate trust by their method instead of by anticipated or promised outcome. The context of this text does not allow further elaboration on the specific motivations, forms and practical workings of these methods, but they can be identified as follows:

1. Inclusive democratic deliberation as a collective holistic learning process, bottom-up, connecting the local and the global;

2. Transdisciplinary and inclusive research, seeking synergy among 'disciplines' and between expert knowledge and lay knowledge;

3 Education inspired by plurality and with a focus on developing an ethical sense and the capability of critical-reflexive thinking.

While these ‘advanced methods’ may seem rather utopian, it may also be clear that we don’t need to wait for a total reform of society to apply them in practice already now. Even in the ‘old’ forms of politics, politicians have the choice to organize public participation and deliberation on concrete issues and to take the outcome of that deliberation seriously. In the case of research, there are in principle no ‘diplomatic’ or practical hindrances to care for transdisciplinarity and inclusion and to put them in practice. For what education is concerned, one knows that disputes remain on how to organise basic (primary and secondary) and higher education, taking into account professional requirements directed by the ‘job market’ but also cultural differences and the still enduring influence of religion. In (Meskens 2017), I argue that basic and higher education should move beyond the 19th Century disciplinary approaches and cultural and religious comfort zones, and become pluralist, critical, and reflexive in itself. Instead of educating young people to optimally function in the strategic political and economic orders of today, they should be given the possibility to develop as a cosmopolitan citizen with a (self-)critical mind and a sense for ethics in general and for intellectual solidarity in particular.

The context of this text does not allow further elaboration on these thoughts. Rather, given the focus on science & technology, I restrict myself to formulating the idea of critical capacity building in higher education in the interest of a responsible dealing with science and technology. In short, the idea is that, for anyone concerned, developing an ethical sense with respect to how science and technology (might) affect us (for better or worse) and with respect to how this relates to general concerns for social justice, environmental protection and sustainable development essentially starts from critical-reflexive thinking, or thus from critical thinking with respect to ‘the bigger picture and yourself in it’. The preparedness of someone to be reflexive about her/his own position and related interests, hopes, hypotheses, beliefs, and concerns in this respect can be called a moral responsibility, but that preparedness essentially leans on the capability to do so, as nuclear worker, scientist, radiation protection officer, manager, policy makers or citizen. In other words, reflexivity as an ‘ethical attitude’ requires reflexivity as an intellectual skill. How this is put in practice in seminars on ethics, science and technology is elaborated further in the following chapter.

7 The SCK•CEN seminars on ethics, science and technology

It is in the spirit outlined above that the seminars on ethics, science and technology (with a focus on nuclear technology) of the SCK•CEN Academy for Nuclear Science and Technology are organised. Seminars typically start with an analysis of the complexity of nuclear risk governance to then link these insights to the question of how approaches to science as policy advise and political decision making could ‘generate societal trust’. The idea is that this trust would need to be generated ‘by method instead of proof’, regardless of whether the outcome of decision making would be acceptance or rejection of the technology. The overall aim of the seminars is to stimulate thinking and dialogue with respect to the complexity of the relation between ethics, science and technology in general (and of risk-inherent technology assessment in particular) and to reflect on the moral foundations for risk governance as well as the practical implications for research and policy. One can understand that this approach unavoidably inspires thinking with respect to specific skills required to deal responsibly with risk inherent technologies such as nuclear technology. As stressed in the introduction, these skills requirements apply in the same way to anyone concerned with risk-inherent technology applications, being it nuclear workers, scientists, radiation protection officers, managers, policy makers and citizens. As a consequence, the seminars become self-reflexive, in the way they invite reflection and dialogue on the specific role, expertise and responsibility of all participants.

The topics treated in a ‘basic’ format of the seminar on ethics, science and technology are:

- Analysis of current issues, challenges and controversies;
- Ethics, fairness and trust: the idea of fair risk governance;
- Seeking societal trust facing scientific uncertainty and value pluralism – the challenge for science as policy advice (this includes case studies such as post-accident situations);
- 'Ethical skills' or 'virtues' for nuclear workers, scientists, radiation protection officers and managers;

If time allows, the basic format of the seminars can be extended with the following topics:

- Further reflections on the concepts of social justice, environmental protection and sustainable development;
- The bigger picture – a critique on modernity (critical views on how traditional approaches to political decision making, scientific research and education, inherited from modernity, fail to 'grasp' the complexity of challenges such as fair risk governance);
- Reflections on advanced methods for political decision making, research and education, able to 'grasp' the complexity of challenges such as fair risk governance and able to generate societal trust by their method instead of by anticipated or promised outcome;
- An understanding of the interrelation of science & technology and society, from an ethics perspective (including deeper discussion of concepts such as 'post-normal science' (Funtowicz and Ravetz 2003), 'science as social knowledge' and 'contextual empiricism' ((Longino 1990), (Longino 2001)), 'well-ordered science' ((Kitcher 2011a), (Kitcher 2014)), 'Mode-2 science' (Gibbons 1994), 'transdisciplinarity' (Bernstein 2015), 'the co-production of science and social order' (Jasanoff 2004), ...);
- Ethical foundations of the system of radiological protection;
- Ethics in relation to science and technology – the consequences for radiological protection and safety culture;
- Ethical case studies in the nuclear energy, medical applications and NORM fields;
- Ethics of energy governance, including reflections on existing energy technologies (nuclear, fossil fuels, renewables) and on the issue of climate change;
- Historicism of ethics, science and technology;
- Analysis and discussion of existing law, soft law, standards and recommendations relevant to applications of nuclear technology and radiological protection (IAEA standards and recommendations, ICRP recommendations, EC Directives, the Aarhus Convention, UNSCEAR assessments, …).

List of invited seminars on ethics in 2015 and 2016:

- Ethics and Lightening the Dark Side of Science, Trinity College, Dublin, 25 February 2015
- The ethics of justifying nuclear technology applications, European Master in Radiobiology, Mol, 13 March 2015
- Ethical aspects of the radiological risk, BelV RP course, Brussels, 2 April 2015
- Ethical considerations on the application of nuclear technology, BNEN Course Nuclear and Radiological Risk Governance, SCK•CEN, Mol, 20 – 24 April 2015
- Ethics at the science-policy interface, Gent University Permanent Education – Contemporary Philosophy 2014 – 2015, 6 May 2015
- The trouble with justification: exploring the ethical dimensions of risk-inherent energy technology assessment, World Nuclear University Summer Institute 2015, Uppsala, 4 August 2015
- Workshop ethics and radiological protection, Technical University Delft - Reactor Institute, Delft, 9 November 2015
- Seminar on Ethics - the case of nuclear technology applications, Universidad Politécnica de Madrid, 24 & 25 November 2015
- Seminar on Ethics - the case of nuclear technology applications, Aachen University of Applied Sciences, Campus Jülich, Jülich, 17 & 18 December 2015

- Ethical aspects of the radiological risk, Radiation Expert Course, University of Hasselt | SCK•CEN, 29 January 2016
- Ethical aspects of the radiological risk, Refresher Course RP FANC, Brussels, 2 March 2016
- Ethical considerations on Nuclear and Radiological Risk Governance, Course on Nuclear and Radiological Risk Governance, SCK•CEN Lakehouse, Mol, 18-22 April 2016
- Beyond Paternalism and Strategy: Understanding Radiological Risks as a Mutual Learning Experience, Seminar “The Chernobyl Accident: 30 years later”, Ghent University, 26 April 2016
- The ethics of justifying nuclear technology applications, European Master in Radiobiology, Mol, 3 May 2016
- Ethical aspects of the radiological risk, RP training for Doel NPP, SCK•CEN, 17 May 2016
- The trouble with justification: exploring the ethical dimensions of risk-inherent energy technology assessment, World Nuclear University Summer Institute 2016, Ottawa, Canada, 20 July 2016
- Ethics and the future generations in the case of radioactive waste governance, IYNC2016, Hangzhou, China, 28 July 2016
- The politics of hypothesis - An inquiry into the ethics of scientific assessment, Opening of the 15th BNEN academic year 2016-2017, KU Leuven, 28 September 2016
- The trouble with Justification: an Inquiry into the Ethics of Nuclear Technology Assessment, IAEA, Vienna, 12 October 2016
- Ethical aspects of the radiological risk, RP Course | 2016, SCK•CEN, 21 October 2016
- Seminar on Ethics, Science and Technology, The case of nuclear energy, Universidad Politécnica de Madrid, Madrid, 27 – 28 October 2016
- Workshop ethics and radiological protection, Technical University Delft - Reactor Institute, Delft, 28 November 2016

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Meskens, Gaston, 2016b, 'Overcoming the framing problem—a critical-ethical perspective on the need to integrate social sciences and humanities and stakeholder contributions in EURATOM radiation protection research', Journal of Radiological Protection, IOP Publishing.

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