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Guest Editorial

Energy in Society: Energy Systems and Infrastructures in Society – Concluding Issue

This issue of *Science & Technology Studies* concludes our three-part special issue that collected articles on new international S&TS research on energy systems in society. Starting from a conference event in Helsinki in 2012, but developing its themes and topics significantly further, the three special issues have now debated and advanced understanding about various energy issues from different vantage points in a number of countries. With an underlying interest in sustainability, energy system transitions, and manifold path dependencies, the authors in the previous issues explored bioenergy and its lock-ins to centralized energy systems in the UK (Levidow et al., 2013), constructing expectations for solar technology at field-configuring events in Finland (Nissilä et al., 2014), and energy system innovations more generally in the UK (Winskel & Radcliffe, 2014) as well as Norway, Japan, and Germany (Fuchs, 2014). Other works drew attention on Finnish pilot projects about electric vehicles (Temmes et al., 2013), "smarter" electric energy grids in Denmark and Germany (Schick & Winthereik, 2013), and political articulations about carbon dioxide capture and storage technologies within the EU and the US (Gjefsen, 2013). A notable addition to these studies mainly of energy expertise and policymaking was a citizen and an end-user perspective. With this in view, the papers in the collection investigated Finnish self-building courses for solar heat collectors as a source of "consumer empowerment" (Jalas et al., 2014) and placed governmental notions of energy security in different countries to the level of energy end-users (Parag, 2014). These diverse themes were drawn together in a broader analytic review of S&TS literature on infrastructures and energy systems published as the first special issue's guest editorial (Silvast et al., 2013).

This third issue of the energy in society presents five further articles on the themes of energy system change, expert knowledge, and end-use perspectives. The issue opens up with an article by Arthur Jobert and Claire Le Renard, titled as "Framing Prototypes: The Fast Breeder Reactor in France (1950s–1990s)". Their case is a study on a shift in nuclear power production from a research phase to an industrial phase. The paper examines the development of Fast Breeder Reactor technology (FBR) in France, from the 1950s to the early closure of the FBR Superphénix plant in Creys-Malville in 1997. The authors discuss how framing a reactor prototype as "industrial" is not only a matter of rhetoric; it may have an important impact on the trajectory of an innovation. If the innovators succeed in making their project a synonym for solving great current problems, their research will be supported. Jobert and Le Renard argue that in S&TS there is tendency to write history backwards and present technological and commercial failures as predictable or even inevitable. They encourage putting oneself in the place of the actors of the studied project and tuning to their views in controversy.

The following, Vincent Ialenti's article, "Adjudicating Deep Time: Revisiting the United States' High-Level Nuclear Waste Repository Project at Yucca Mountain", continues with the theme of nuclear energy and its situating in a wider historical frame. Specifically, Ialenti ties together anthropological and S&TS themes about expertise and law in order to highlight techniques of risk governance in nuclear waste management of the notable nuclear waste repository in the US. Going further than a focus on national energy policies and unprecedented "modernization risks" in the context of nuclear, the author critically considers whether certain legal knowledge practices on nuclear issues stem in fact from times before the nation state. This provides timely input to the classical S&TS works concerning nuclear energy and national imaginaries, technopolitics, policymaking, and epistemology.

The third contribution is by Ana Delicado, Luís Junqueira, Susana Fonseca, Mónica Truninger, Luís Silva, Ana Horta, and Elisabete Figueiredo. Entitled "Not in Anyone's Backyard? Civil Society Attitudes towards Wind Power at the National and Local Levels in Portugal", the article juxtaposes policy and institutional frameworks and civil society attitudes to uncover how wind energy is currently expanding in Portugal and compares its issues to other countries. In so doing, analytical use is made of energy scholar Rolf Wüstenhagen's and colleagues (2007) tripartite model of the "social acceptance" of renewable energy: comprising "socio-political", "community", and "market" dimensions of technology acceptance. The results by Delicado and colleagues demonstrate how some acceptance can shape technological systems even when other forms are absent. In this case, while the Portuguese public and environmental movements clearly lacked enthusiasm about wind power (the community dimension of acceptance by Wüstenhagen et al.), a national-level planning system and tariff mechanisms have still led to significant expansion of these energy generation systems (the socio-political and market dimensions by the same authors).

In the next article, "The Meanings of Practices for Energy Consumption – Comparison of Homes and Workplaces", Jenny Palm and Sarah Darby write about a transition to more sustainable everyday practices by moving to a study on buildings' energy use. They generate new knowledge on the variety of such practices by drawing on mixed methods as well as a multi-sited approach. Interviews, participant observations, and quantitative materials are all presented and compared with a view on passive housing in Sweden and a modern research building in the UK. The first case study shows how the residents managed to make their dwelling increasingly sustainable, given their own preparedness to it and supportive building designs. In the research building case, on the other hand, original design choices and the installed base of technologies preconfigured users and usages and significantly limited the more sustainable maneuvers that the building's users could carry out during their daily work.

The special issue closes with Antti Silvast's and Mikko Virtanen's article "Keeping Systems at Work: Electricity Infrastructure from Control Rooms to Household Practices". Inspired too by a multi-sited point of view and drawing on systems theory as an analytic vantage point, the authors make a comparative analysis of electricity, risks, and reliability in two infrastructure control rooms and households, highlighting differing structuring temporalities, external constraints, and personal skillsets in the three field sites. Based on their results, the authors suggest that the two focal points of many recent S&TS work on energy – the brittleness of energy systems and their "flat" conceptualizations, on the one hand, and wider systemic, cultural, and societal dimensions of energy, on the other hand – should not necessarily be seen as each other's alternatives or as contradictory perspectives.

The editors of these special issues would like to thank all the authors for their invaluable contributions, input, as well as their gentle considerations of the comments during the editing and the review processes. We extend our gratitude to the number of anonymous referees that took their time to provide constructive criticism and help us significantly better the theme numbers. Lastly, whereas the series on energy in society ends with this issue, the *Science & Technology Studies* journal is more than welcoming to your future submissions about energy systems, sustainability, and various other infrastructures issues. Please follow the home page sciencetechnologystudies.org to learn about further special issue calls and find instructions about submitting to open calls or a theme number. Please do not hesitate to contact the journal's editors in charge if you wish to discuss the suitability of a manuscript and its readiness for peer review.

With kind wishes,
The guest editors

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Framing Prototypes: The Fast Breeder Reactor in France (1950s–1990s)

Arthur Jobert and Claire Le Renard[1]

This paper considers a crucial moment in the innovation process: the shift from a research phase to an industrial phase. The empirical study examines the development in France of Fast Breeder Reactor technology (FBR), from the 1950s to the early closure of the Superphénix plant in 1997. A turning point occurred in the late 1960s, when several European countries judged that the FBR technology was a promising electricity generation technology that would soon be mature for commercialisation, in a context of technological nationalism and future energy scarcity. In this paper, we analyse how the framing of the resulting prototype as "industrial" entailed an impact on decisions during the three decades that the project lasted. Aiming at describing the project actors in action without judging their decision-making processes, we use the 'framing' concept preferably to other approaches such as 'path dependency'. This concept choice is the subject of the discussion.

Keywords: nuclear technology, framing, prototypes

Introduction

From a STS perspective, the process of innovation is a temporal one, uncertain and contingent; it is driven by actors who work to find a place for their innovation in a social and economic context which might evolve. A crucial moment in this process is the shift from a research phase to an industrial phase. To bring their projects to the industrial phase, innovators have put their hopes in hybrid objects who must on the one hand, demonstrate the maturity of their technology but, on the other hand, can still be improved before they enter the market. These hybrid objects are given ambivalent names such as 'pilot-series', 'industrial demonstrator', 'industrial prototype'. Based on empirical work dealing with the French Superphénix, this paper discusses how *framing* a prototype as industrial is not only a matter of rhetoric; it may have an important impact on the trajectory of an innovation. 'Framing' will be used here as "a notion which grabs the perceptual lenses, worldviews or underlying assumptions that guide communal interpretation and definition of particular issues" (Miller, 2000: 212).

The *Superphénix* was the industrial prototype of the technology of Fast Breeder Reactors (FBRs); using neutrons in a "fast" regime, this specific nuclear technology was able to "breed" or regenerate fuel while using it. From the 1950s until the 1970s FBRs were being developed in many countries, in the expectation that they would provide a nearly inexhaustible source of electricity, needed to fuel the rapid economic growth of the post-war years. The development of a fleet of commercial fast breeder reactors was therefore considered by many as the logical end-point of a viable nuclear programme. However, the use of neutrons in a “fast” regime meant using a molten metal as a coolant. Sodium was chosen because of its thermal conductivity; it is nevertheless known for its reactivity with water and oxygen. With such features, Fast Breeder technology was to become an object of international competition, technological development, visions, and risk debate.

Approaching a controversial project: Our methodological choices

The history of Fast Breeder technology in France, and of Superphénix in particular – a reactor which was stopped earlier than planned – is a controversial one, and took place over time. Conducting a research devoted to such an innovation supposes taking methodological precautions. There is then the considerable risk of taking side in the controversy or writing history backwards (presenting the failure as predictable or even inevitable). As an answer, we want to state that a methodological stance designed to avoid both these pitfalls enabled us to add new perspectives to the existing research.

Much has been written on this project, be it in the 1970s before and during its construction, during the operation years from 1985 to 1997, or afterwards, when diverse accounts of the project tried to record its history and the lessons learnt. A great variety of primary and secondary sources can thus be found in media coverage, in “grey” literature (expert reports, parliamentary hearings…) and in academic or para-academic publications, a selection of which can be found in the references section of this paper. The main part of this literature contributes to the controversy, some authors highlighting the “failure of FBRs programmes” (see Finon, 1989), other authors in the contrary envisioning the irreplaceable role of FBRs in the future energy supply system and pleading for the continuation of the Superphénix (Vendryès, 1997).

The first methodological pitfall of researching causes for the early shutdown terminating the innovation trajectory of Superphénix would be to explain it by the very beginning. In Spring 1998, after the decision to permanently close the Superphénix was taken by the government, the French Parliament conducted hearings, allowing the concerned parties to express their controversial views. The report following these hearings stressed that the causes of the premature end of the plant were to be found at the very beginning of the industrial prototype: “the decision of creation was taken without transparency, basing on alarming forecasts, for a plant whose role appeared in the end to be fluctuating over time” (Bataille, 1998). Building an explanation on this form of evaluation puts us at a major risk of history being written by the victors. As Rip and Kemp (1998) write, we cannot analyse the trajectory of an innovation as if: “the direction of technological development was determined by the actual paths and the expectations of what could be next steps […]. Our retrospective idea of steps in the direction of the situation as we know is irrelevant”. Therefore, we tried to avoid rereading the history of the technology on the basis of its developments which were known to the researcher but unpredictable for the actors in the on-going project, and we aimed at depicting how the Superphénix was framed as an “industrial prototype”, and what this specific feature – being industrial – meant for such a prototype, associated with solid expectations and new constraints.

In this respect, Bruno Latour's seminal *Aramis or the Love of Technology* (1996) was of great importance to our work. This book traces the history of a public transport project called *Aramis* which was intended to serve the south of Paris with the combined advantages of rail transport and individual cars, but which never reached the commercial stage. Above and beyond a case study, this work offers lessons on the factors for success or failure for such innovative projects, along with a methodological stance from which to talk about the past from the point of view of the researcher's situation in the present.

To avoid the pitfalls evoked above, Latour (1996: 6) suggests "going to see everybody who's being criticized and blamed" by applying a methodological principle of benevolence: the sociological standpoint consists in putting oneself in the place of the actors of the project, with their own representations of the future. The narrator talks to his (fictitious) student as follows:

> Always assume that people are right, even if you have to stretch the point a bit. […] otherwise, you play the sly one at the expense of history. You play the wise old owl. […] Life is a state of uncertainty and risk, of fragile adaptation to a past and present environment that future cannot judge. (Latour, 1996: 35-37)

This obligation to show goodwill is one of the features of the method used during this analysis of Fast Breeder technology. Another feature of the research was the quest for an inside view of events, and the field enquiry lead us to meet the people who had worked on the project.

An investigation focussing on how project promoters frame their project

For Latour, and numerous researchers after him, it is thus not a question of rereading the past in terms of the present or of a form of predestination but rather of grasping the innovators in action. Our methodological choice was thus to carry out a study of the actors involved in a Fast Breeder technology project and to try to understand the uncertain process during which the innovators defend their project and make their choices. It was notably a question of identifying the moments of choice when the actors had to decide how to modify their project to meet the requirements of the time and of the strategy they were following.

The oral sources for this work were thirty-three interviews of twenty-five project actors, two experts from the nuclear safety authority's Technical Support Organisation, and six opponents or critics of the technology (experts and scientists). Among the twenty-five interviewees who had directly worked on the Superphénix project, approximately 20 % had designed the Superphénix and/or the French Fast Breeder technology development, 45 % had engineered or built the plant, and one third had operated it. We met scientists and engineers from the CEA public research agency (Commissariat à l'Energie Atomique), who developed the demonstrators or who were the decision-makers responsible for the programme as a whole. We interviewed the managers in charge of project conception and construction, be it at the CEA, in the engineering company or in the EDF (Electricité De France) plant design and construction division. The Superphénix construction manager gave us a colourful account of events. With regard to the period of operation, we met members of the plant's board of directors and members of NERSA's board of directors (*Centrale nucléaire européenne à NEutrons Rapides SA,* the European project company created for Superphénix).

The following figure illustrates the diversity of the career profile of our

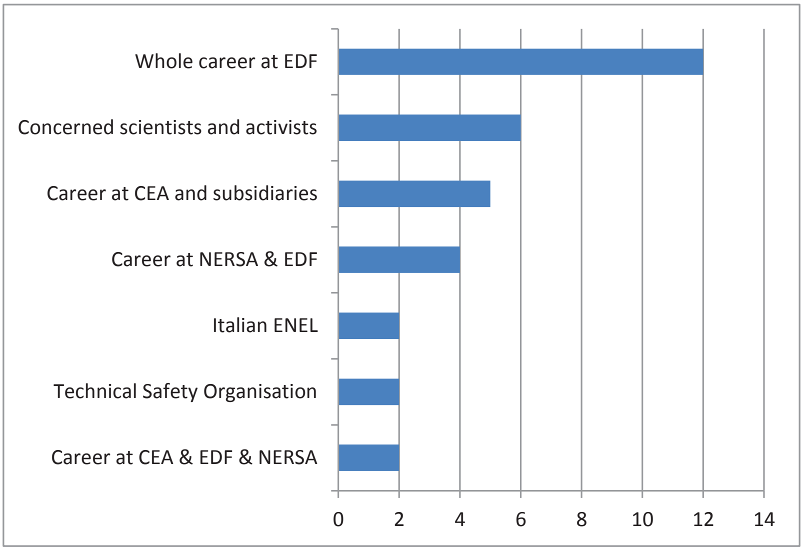


Figure 1. Position and career profile of the interviewees.

interviewees: this project brought together people coming from different professional backgrounds and cultures. Some of the project actors were involved in the first steps of FBR technology, before reorienting their careers towards other areas of nuclear power; others were involved from start to finish, devoting their entire careers to the development of the technology; finally, some worked on the Superphénix for a few years, starting and pursuing their careers in other nuclear projects.

As 76 % of our interviewees were actors of the project, we are conscious that such a dissymmetric approach of a controversial project can be seen as biased. One answer lays in the visibility of the literature critical of the project, which we carefully studied before beginning the field enquiry. Some activist organisations keep the memory of Superphénix alive, publishing their archives, press articles, and argumentations online. We met some activists or concerned scientists to record their views on the events and developments. But furthermore, we cross-checked our interviews with written sources where other stakeholders expressed their views at the time of the debates (e.g. minutes of public hearings, record of TV debate, press articles). There is no guarantee that such a process prevented us from being influenced by our interviewees. However, this cross-checking enabled us to identify critical periods, such as the debate about the re-definition of the project in the 1990s, which will be one of the topics of this paper. In fact, in a first set of interviews, the innovators tended to downplay or not evoke spontaneously this debate.

This research actually made us conscious that within such an ambitious project different opinions existed. Some actors who had the feeling their point of view had not been considered enough were glad to share their opinions in the interviews about events that happened decades ago, as well as the ones whose views had been retained for decision-making. Some of them even had kept an impressive documentation as a personal archive, in their garage or in a devoted office, which they offered us to use – this situation can be related to what Gabrielle Hecht experienced in her research about nuclear developments in France after World War II (Hecht, 2009: 18). As well as her, we can state that "most people seemed eager to share their memories, look for documents, and put [us] in touch with others who might help". And we also experienced that "some things conveyed in the interviews are not in any document, accessible or not".

A last answer lays in the very objective of this research, on which we build the point we want to make in this article. Our objective is not to conduct an evaluation, or to judge the decision of these actors on a normative basis as, in some respect, does the "lock-in" approach which implies that an inefficient technology or product "captures" markets at the expense of better products (Arthur, 1989; Cowan, 1990; Pierson, 2000). Our objective here is to better understand the rationale of actors involved in a controversial innovation project. More precisely we will put forward how the framing of their prototype as "industrial" in the late 60s entailed an impact on decisions during the 3 decades that the Superphénix project lasted.

Therefore, we will first describe the definition of the features of Superphénix as the "construction of a long chain of reasons that are irresistible" (Latour, 1996: 33). The following two parts will depict the decisions of the actors at two moments of trials, when the irreversibility induced by the "industrial" feature of the prototype made it difficult to renegotiate the project. The last part is a broader discussion of framing and irreversibility in such prototype developments.

The "Irresistible" and "Irreversible" Framing of an Industrial Prototype

The history of Fast Breeder technology in France can be better understood by a focus on its framing – in the words of Jasanoff (2005), "a conceptual language that can grapple with both continuity and change, while rejecting some of the rigidities of structure – in order to understand how policy domains are carved out from the political sphere and rendered both comprehensible and manageable". In this section, we want to depict how in the 1950s and 1960s the framing of Fast Breeder technology (FBR) as necessary in the near future resulted in the design of a "European industrial prototype" which was supposed to accelerate access to a commercial stage.

The making of FBRs as the obligatory passage point

In the context of the post-war years, as rapid economic growth entailed a rising energy demand, FBR technology was framed as the logical end-point of any nuclear programme, carrying in it the promise of inexhaustible energy. This assertion requires a little detour in nuclear physics, which we want to make as simple as possible.

Natural uranium is composed of 99.3 % Uranium 238 isotope (^{238}U) and 0.7 % Uranium 235 isotope (^{235}U). In the post-war years, several nuclear technologies were developed, among which the technology of Pressurised Water Reactors (PWRs), using the scarce ^{235}U, and the FBRs, using abundant ^{238}U. The PWR technology had been adopted on American submarines for its compactness, and had experienced more operation hours than any other nuclear technology: for this and other reasons, they were chosen as the main component of a nuclear industrial fleet in the US (Cowan, 1990), and from the 1960s on, in several European countries. The development of this technology appeared then deemed to a brilliant future, raising concerns about ^{235}U fuel scarcity that it might occasion in the medium-term.

The FBRs were then promoted as an answer to this concern: firstly, using neutrons in a "fast" regime, they could generate energy from the fission of the *abundant* isotope ^{238}U. Using therefore the energy potential included in natural uranium approximately a hundred times better, FBR technology stood above and beyond the PWR technology in the eyes of scientists and engineers. Secondly, this technology can use the Plutonium (^{239}Pu), an artificial element, as a fuel. The highly radioactive Plutonium is generated during nuclear reactions in FBRs and other nuclear reactors, when a nucleus of ^{238}U absorbs a proton released during the reaction. Thirdly, if a fuel reprocessing plants extracts fissionable fuel from the used one, the FBRs can reuse their fuel several times, thus achieving "breeding" or fuel regeneration with a Uranium-Plutonium cycle, making the energy potential close to infinite.

In the 1960s, this promise of inexhaustible energy was the horizon of nuclear development in several industrialised countries. In the terms of Latour (1996: 33), we can state that FBRs were then regarded "as the obligatory passage point that will resolve the great problems of the age", thanks to one of "these long chains of reasons that are irresistible". The rationale was the following: economic growth requires abundant electricity; although the PWR technology is retained as an immediate, transition technology, it remains a provisory answer, which uses the energy potential in natural uranium rapidly and poorly, raising concerns of fuel depletion; therefore, FBR technology must be developed and tend towards an industrial maturity as soon as possible.

FBR development as a national project: The irresistible alliance

FBRs were considered a strategic technology, and from the 1950s onwards, research reactors of increasing size were developed in the United Kingdom and in the United States, stimulating efforts designed to establish and demonstrate the feasibility of the technology. In the mid-50s, in an attempt to make up for lost time, France begun its first studies (Vendryès, 1997). Impetus was provided by a study visit by two CEA engineers to the USA: won over by this technology, upon their return they persuaded their hierarchy to grant them sufficient funding to build an experimental reactor in France; it was to be called RAPSODIE and reached criticality in 1967 (Vendryès, 1997). Despite having been completed four years behind schedule, Rapsodie attained full power in just three months and was regarded as a "technical success" (Finon, 1989: 159). At the end of the 1960s, research reactors also reached criticality in the USSR and Germany. The promise of abundant and inexpensive energy fostered technological developments in numerous areas in order to establish the feasibility of the FBR technology. The competition between countries regarding technological achievements served nationalistic purposes, and became a driver as well as a consequence of technology development. Conferences and academic/professional publications were arenas for international competition, as well as for the circulation of ideas, helping to create a common mindset among the experts involved (Goldschmidt, 1967).

At the same time, the exponential growth in energy requirements in the 1960s saw several countries equip themselves with industrial nuclear power. In France, as well as in other European countries, a dispute took place between the advocates of the "national" reactor design and the promoters of the American PWR. Beyond technologies, this dispute opposed arguments centred on national technological excellence vs. inexpensive electricity generation (Hecht, 2009). As they featured more operating experience as well as lower projected generation costs, PWRs were retained for the industrial fleet in the short term. In the late 60s, while the interests and views of the key actors in the French nuclear "establishment" (especially between EDF and the CEA) diverged on many issues, "the breeder reactor emerged as a source of consensus" (Hecht, 2009: 291). On the one hand, building on the experience acquired with national prototypes, it allowed the pursuit of national technological excellence – as Hecht (2009: 293) notes, "they transferred the burden of French grandeur to the breeders". On the other hand, the objective to produce cheap and abundant electricity would be met by the choice of American technology in the short term, and in the medium and long term by the "logic of a breeder future" (Hecht, 2009: 293).

FBRs became then the only remaining nationally developed nuclear technology. Fast breeder prototypes were developed as part of a long-term, national nuclear project, which would include reprocessing and a fleet of industrial 1000 MW breeder reactors (Finon, 1989: 182). In southern France, while the experimental "Rapsodie" reactor was only starting to operate, the design of a 250 MW prototype reactor was already initiated: it was to pave the way for the to-be industrial FBRs. Named after the bird which rises from its own ashes, the "Phénix" reactor represented FBR technology regenerating its fuel. With its 250 megawatts of electricity, it provided the same power as the coal-fired plants of its time. It reached criticality in 1973 and was acclaimed as a technical success: France had made up its lost ground in FBR technology. On March 15, 1974, as the Phénix reactor reached nominal power two weeks ahead of schedule, the Financial Times entitled an article "French world lead in fast reactor technology" (Sauvage, 2009).

Combining the stakes of future energy supply with the achievement of nationalistic "grandeur", FBR development became a privileged cooperation field for the CEA and EDF: D. Finon depicts it as the "irresistible logics of an EDF-CEA alliance" from 1970 on (Finon, 1989: 169).

A project made more irreversible by its European features

Latour (1996: 154) states that "technological projects become reversible or irreversible in relation to the work of contextualisation". By the beginning of the 1970s, atomic energy agencies in several European countries (e.g. in UK, France and Germany) envisaged reactors of a capacity around 1000 MW. These full-scale reactor projects anticipated a future series reactor design which would have to be both industrial (powerful and reliable) and commercial (able to equip the national fleet and to be exportable). The electricity utilities then became key players in the development of such projects, making them reversible in some countries (the British project was stopped in the late 70s, see Le Renard et al., 2013), but contributing to make the project more irreversible in our case study, through the commitments that the French state took vis-à-vis its foreign partners.

In the 1960s, the European community and its nuclear research programme Euratom had attempted to foster the development of a European 300 MW FBR prototype, with limited outcome. But this initiated a European cooperation which would succeed in the next step of the programme, the 1000 MW prototype (Giesen, 1989). Three electricity utilities (the French EDF, the Italian ENEL and the German RWE) had initiated collaboration as early as 1970 to envision a common FBR industrial prototype in order to share costs and operating experience. The deliberations amongst the utilities, the CEA, and the French government resulted in the 1200 MW Superphénix project in the south of France, and its German counterpart, SNR 2, whose construction was to start shortly after that of Superphénix (Marth, 1993). This larger size was comparable with the 1300 MW PWR plants developed at that time. In the same way that the development of Phénix had taken place during the worksite of Rapsodie, in the early 70s, the developments of the Superphénix project were begun in parallel to the Phénix worksite, in order to maintain engineering skills permanently working on the new technology. Beyond its name (an 'extended' Phénix), several significant characteristics of the project development changed with Superphénix, hence marking the shift of FBRs from an experimental to an industrial era:

- The owner of the Superphénix project was a limited company (NERSA) created with equity from several European electricity companies. The EDF held 51% of the capital, ENEL 33%, while the remaining 16% were owned by RWE;
- The CEA licensed the FBR technology to Novatome, an *ad hoc* subsidiary, which would be able to meet orders for future FBRs on an international scale.

This double choice of creating an *ad hoc* company that would from the beginning include European partners was representative of a new way of managing large technological projects. During the same period, the commercial failure of the Concorde triggered the development of the "Airbus model" (Muller, 1989). In the context of increasing competition with large (especially American) multinational enterprises, the aim to develop industrial products that may be commercial on a large scale was added to technological achievement. Bringing together European partners was therefore a way to share the risks and competitive advantages, as well as to expand the potential markets. The agreements to form the European company NERSA provided that the electricity generated by the new plant was to be returned directly to the countries involved on a *pro rata* basis, in line with their levels of participation: the search for a site with the required physical and geographical qualities led to the industrial prototype being located at the centre of the Lyon-Genève-Chambéry triangle (i.e. at a reasonable distance from the Italian and German borders), near the village of Creys and the hamlet of Malville.

As the plans for the creation of the NERSA were well underway, on 13 December 1972, a parliamentary debate was held concerning a bill that established an exception to the 1946 law on the nationalisation of the electricity sector, and would instead allow the creation of enterprises in the domain of electricity that would carry out in France "an activity of European interest". The creation of European companies was contested by the trade unions and by a part of the opposition (especially the communists). The critics feared that the entry of private interests in the energy sector would work in the same direction as the choice of the "American" PWR technology. But the project was then promoted as French technology development, as well as providing energy independence for the nation. The fact that the project was also European did not contradict this idea, quite the contrary: as was the case in many other areas of European politics, the project was seen as a "continuation of France through other means". The project's legitimacy was assured by the political consensus on its objectives both at the same time national and European, commercial and of high technology.

However, the term "industrial prototype" conveyed an ambivalence which was to endure throughout the project. The project was industrial because of its ambitions and the way it was organised. It was a prototype because its role was to test a new technology – at that time no FBR of that size had ever been built. Many of the elements were innovative, either in terms of size, or in terms of the options chosen – some as a continuation of Phénix and others through the European dimension and the experience of collaborating countries.

Work on the Superphénix industrial prototype lasted almost a decade, from 1976 to 1985. The project managers had to overcome numerous difficulties: in creating a 'first in the world,' they were constantly facing new technical challenges, many of them related to handling the huge components of the plant. But these actors were sustained by the conviction that they were working on higher objectives and priorities: making a virtually inexhaustible source of energy available to mankind. Parallel to the construction of the industrial prototype at Creys-Malville, the engineering teams in Lyon were preparing for the next stage, that of defining the characteristics of the series of plants based on the Superphénix, so as to be able to rapidly launch a fleet. They were also investigating future sites.

During this decade of the project, objectors to the project criticised the choices which had been made on two fronts: criticism of the technology chosen and criticism of the industrial option.

Criticism of the industrial prototype aspect of Superphénix came from scientists and concerned individuals in the nuclear sector. They felt that FBR technology had not been sufficiently tested to be ready for the industrial stage, and that it would be wiser to build a smaller plant designed for research or development purposes. They developed this argumentation in documents published by trade-union or political parties (Parti Socialiste, 1978: 35).

The other criticism was radical; it concerned the very structure of the promise of inexhaustible energy contained within the development of FBR technology: the regeneration of fuel meant building a huge fleet made up of PWRs, FBRs and fuel reprocessing plants and keeping them all running over the very long term. For the decision-makers of the time, facing future scarcity of fuel, this was exactly what was needed; for the critics, it was unacceptable. FBRs regenerate their fuel in the form of plutonium, which is both reactive and toxic, and certain isotopes of which can be used for military purposes. Opposing the very principle of this technology, critics organised demonstrations, the most important of which took place in 1977 and led to the death of one demonstrator.

However, although the growth perspectives for energy demand which had led to the creation of Superphénix seemed to have properly stabilised, as from the mid-1970s the contextual aspects changed, one after the other: in 1976, pluralist commissions including academic experts both in the United Kingdom and the United States evaluated the need for FBR technology and its costs and risks. The gradual drop in energy demand, due to the economic slump following the oil crisis, was beginning to chip away at the urgent nature of building an FBR fleet. In fact, nuclear reactor orders in the United States had been drastically reduced in the mid-1970s and brought about a major downward revision of the growth forecasts for nuclear power throughout the world. In reports within their respective countries (Flowers, 1976; Keeny et al., 1977), the evaluation commissions recommended postponing projects for industrial prototypes, because the fast-breeder fleet was no longer envisaged over the short term. Scientists fed these points of view to French associations critical of the project.

The objectives of an initial industrial demonstration nevertheless remained preponderant in the debates which took place over this decade. The government was a key player in the decision-making, and the promise behind this energy technology justified France continuing to develop it, as can be seen in a statement made in Parliament by the minister of industry in June 1977: “it would be very dangerous to abandon this fast-breeder project due to pressure from a small group of people who may be well-informed within their own fields, but who in any case have a poor grasp of the national context in which our energy policy is rooted!” (Journal Officiel, 2 June 1977, quoted by Finon, 1989: 202).

The debates on FBR technology organised by the Europe 1 radio station and the Antenne 2 public television channel in 1980 were a forum for public discussion which confirmed what was at stake: President Valéry Giscard d’Estaing declared that “if uranium from French soil was finally to be used in fast breeder reactors, in France we would have energy reserves comparable to those in Saudi Arabia” (Bériot & Villeneuve, 1980). Questioned about the American halt in FBR development as part of the non-proliferation policy, the French MP and former Prime Minister P. Messmer stated in the same debate series: “the United States would prefer it if we did not maintain our advance, particularly due to the industrial and commercial advantages that it offers us” (Bériot & Villeneuve, 1980, quoted by Finon, 1989: 198).

In France, there was no question of closing off the option that this technology represented: Superphénix was already being built as an industrial prototype, and the principle of commitment to the industrial series envisaged by the CEA and EDF’s plant design and construction division was validated. Meanwhile, from 1979 on, EDF’s general management postponed the decision to commit to the industrial series in order to have one full year of feedback on the operation of the Superphénix reactor (Finon, 1989: 214-218). The argumentation was rooted on economic assessments which compared the competitiveness of FBR technology with that of other types of energy production, the assumptions for the future cost of Uranium being less favourable to FBR than previously.

Pursuing the Industrial Demonstration at the Cost of Technical Flexibility

Confirming the industrial dimension of Superphénix

In 1985, fuel was loaded into Superphénix’s core. After ten years of construction, the Superphénix industrial prototype was finally completed and began its industrial operation. To this end, the small project company NERSA had signed a contract with national electricity company EDF. The Superphénix industrial prototype benefited from the experience and standardisation of the operational nuclear fleet, and as such, personnel would be employed in accordance with the standards of EDF’s organisation charts.

In 1986, the electricity generation unit of the plant was connected to the grid. Yet that same year, several events took place which were to radically change the way the future of energy and the relative value of the different sectors of production were envisaged.

1986 was the year of the Chernobyl accident, which impacted Superphénix in many ways: for the very first time, Chernobyl brought to life the reality of the dangers of a nuclear accident, and, more broadly, marked entry into the "society of risk", according to the eponymous work by Ulrich Beck published a few months later. Many countries suspended their nuclear programmes, reducing even further the foundation of the discourse on the depletion of uranium which had justified development of FBR technology. Among these countries was Italy, which nevertheless maintained its shareholding in NERSA. The actors concerned by the risks with Superphénix saw their case strengthened by a serious sodium fire in a solar power plant in Almeria in Spain, which also occurred in 1986. Lastly, 1986 was the year of the oil counter-shock, which marked another turning point in the way the future of energy was envisaged: energy seemed to be abundant and cheap, and the energy-saving measures which had been recommended since 1973 fell into disuse, as did new technological developments. Long-term concerns relating to the Earth's finite resources were pushed onto the back burner.

Finally, Superphénix was the precursor for a long-term series at a time when people were no longer interested in the long term: *First Of A Kind … without a kind*, it now had to operate as an industrial plant within the EDF fleet, with the objective of providing a return on investment and of continuing to demonstrate the technology, for what was now the distant future.

Over the lengthy term of the project, whilst the context had changed, the industrial objectives remained the same: they were reflected in the size of the plant, in its system of multi-country governance and in its integration into EDF's operational fleet.

Such a nuclear project has a time constant of several decades. The project's engineers remained convinced that they were working on a technology for the future, one which might replace the temporary PWR technology: even if temporarily the conditions did not appear to be ripe for the launch of a fast-breeder fleet, they had to continue to develop existing skills so as to be able to use the technology in the future. At the end of the 1980s, European countries combined their efforts to design the EFR, the European Fast Reactor, which would capitalise on the experience gained with Superphénix. An article in an IAEA bulletin which set out the global situation for developments in 1989 stated: "In Europe, it is now considered that [FBR] plants would begin to replace the decommissioned PWR plants after 2010, in competition with the then-available advanced PWRs." (Golan et al., 1989) The status of the "industrial prototype" without any planned series in the short term was becoming difficult to justify: what was Superphénix a prototype for? Did the characteristics of the plant really make it "industrial"? At a moment when these strategic questions were asked, an incident occurred on a critical part of the plant, which lead project managers to make a decisive technical choice.

Translating the industrial framing into a concrete decision

In March 1987, a sodium leak occurred in the fuel storage "cylinder" tank. To understand the negotiations and the choices made, we need to take a closer look at this technique:

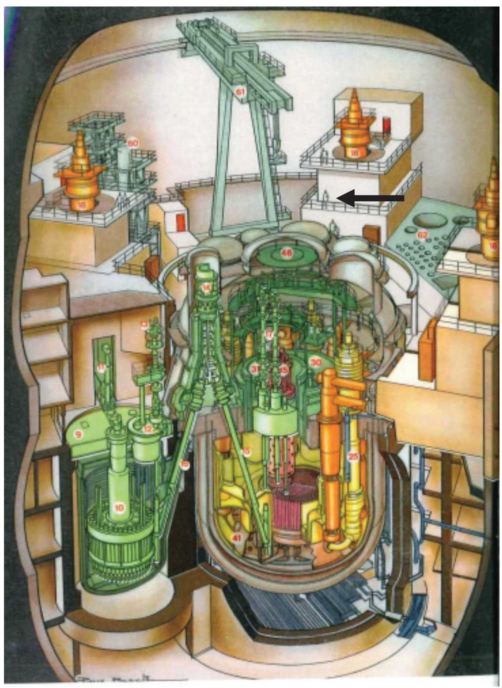
The Phénix plant and associated reprocessing facility had demonstrated the possibility to recycle the fuel, and thus, on a small scale, to fulfil the promise of energy autonomy inherent in FBR technology, on the basis of a "short cycle" involving Uranium and Plutonium (Sauvage, 2009). The Superphénix fuel cycle was to be the same "short cycle" which had been validated with Phénix, and the relevant technical device was very similar, implying a fuel storage cylinder tank. The "short cycle" consists in discharging and renewing a fraction of the fuel contained in the core of the reactor (one third or one quarter) during relatively brief stoppages. The fuel transfer has to take place within the sodium, preventing the fuel which was in the sodium to be brought into contact with air or water. When leaving the core, this fuel gives off a very large amount of thermal power; it must thus cool in order to reach the thermal power designed for the reprocessing facility, five times lower than its level when leaving the core.

As a Novatome document (1981) states:

> "The fuel handling system comprises installation and equipment provided for
> - Simultaneous fuel loading and unloading by means of two sloping ramps, leading from a rotating transfer lock to the reactor on one side and to the fuel storage [cylinder tank] on the other,
> - Storage of spent fuel in a sodium-filled decay [cylinder] tank before being sent to the reprocessing plant. The decay heat is removed by two independent sodium circuits connected to air-coolers."

In the same Novatome document, the following cutaway view shows the rotative device or "carrousel" (10) inside the fuel storage cylinder tank (9), which enables the operator to select and handle any fuel subassembly. This possibility to separately handle the subassemblies is useful for purposes such as research on assemblies or fuel recovery. These handling activities can take place during the operation of the plant, providing flexibility.

Benefiting from the experience acquired with Phénix, this fuel handling system was optimised in the available space and included in the concrete. The sodium leak in the fuel storage cylinder tank was as unexpected as improbable. The choice of the steel nuance used for the tank, which was different from Phénix, was held liable for the leak. Questions about what repairs were required led to a reopening of discussions on the purposes of Superphénix, as it was technically very difficult to replace the tank with an identical one. The impossibilities of the technique meant that it was necessary to negotiate and lower the objectives of the plant, or to come up with a technological "detour" (Latour, 1996: 215) which would make it possible to remedy the insufficiencies.



Picture 1. A cutaway view of the fuel storage cylinder tank, reactor vessel, and fuel handling system (Novatome, 1981). The arrow indicates the figures on the upper part of the reactor vessel, allowing one to imagine the true dimensions of the plant.

The decision to replace the defective tank with an identical one was rejected: according to some interviewees, it was technically impossible or excessively expensive; according to others, it would have required a very lengthy stoppage. But due to its industrial framing, the plant was expected to generate electricity for the partners of the project, and not to be offline for a long time, as a non-finalised prototype might have been.

The storage tank was replaced by a fuel transfer unit which fulfilled certain fuel handling functions, but not its cooling: the fuel then had to cool down within the reactor core itself. This implied an operating mode known as "long cycle", where the reactor must remain stopped for six months for cooling, in order for the used fuel to be discharged and for the new fuel to be loaded. It was no longer possible to renew just parts of the core, and the "long cycle" meant that an entire core had to be burned during each cycle.

The choices made during this period were a consequence of the industrial framing of Superphénix, and they "in-scripted" it even more in the technology: the fuel storage tank was not the only thing to be dropped. The project abandoned a certain flexibility of operation, characteristic of research plants and prohibited by the new system; it also abandoned the idea that the prototype should perfectly reflect the future series, feeling it to have been pushed back into the long term. The use of the fuel transfer unit lengthened Superphénix's operation cycles and made them less representative of a future fleet: "for Superphénix it wasn't very serious, but for an industrial fleet it would not have been viable", explained one of the actors. In his view, in 1988, within a context of discussions on the utility of fast-breeder technology, there was no longer any urgency to demonstrate the feasibility of the exact prototype of the industrial series.

This moment of opening-up and discussing the technical choices to be made whilst facing increased constraints led to a confirmation of the industrial nature of Superphénix and of its mission to produce electricity on a large scale as part of the operational nuclear fleet. Questions concerning replacement of the fuel storage tank were addressed by internal project decisions or by interaction between technical experts to decide what type of work had to be done. The safety of the plant had been controlled throughout the process, and the technical options had been discussed with the Ministry Control Service for Safety of Nuclear Installations (SCSIN) and its Technical Support Organisation.

A Difficult Reframing towards Research: The Weight of Irreversibility Induced by the Industrial Framing?

The plant restarted in April 1989, but another incident occurred one year later: in July 1990, pollution or oxidation of the primary sodium was detected and led to stoppage of the plant. This pollution was due to air entering the argon circuit[2] through a defective membrane in an auxiliary circuit. The stoppage lasted for four years, with the plant only receiving authorisation to restart in August 1994.

This unforeseeable stoppage gave rise to a period of intense controversy. Among multiple subjects of concern, the main issues of the controversy were the safety of the plant and the objectives of this industrial prototype. Both were publicly discussed in official arenas, which had been created in the 1980s after changes in the political majority. The two issues were closely linked, but for the purposes of this article, we will focus on the attempts of reframing the plant's objectives. We'll just briefly state that the safety issues were addressed by interaction between technical experts and led to major works being carried out ; in the 1990s, they were also discussed in official and public arenas.

In fact, as the perspectives for uranium depletion were called into question, the 1990 technical incident opened a broad public phase of project reassessment with regard to the new energy context. This reassessment involved debates between experts on forums or via official reports. Between 1991 and 1998, 14 official public reports examined the project from different standpoints such as: its safety, its objectives and purposes, its costs, or its contribution to the knowledge of industrial FBRs. Seven of these reports originated in parliament and gave rise to public hearings.

Thus in May 1992, the OPECST (Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques / Parliamentary Office for Evaluation of Scientific and Technologic Choices) organised public hearings on the possibility of restarting Superphénix and the future of fast-neutron reactors [FBRs]. Some long-standing opponents argued that the plant should purely and simply be shut down, given the technical difficulties which had been encountered and the absence of any FBR industrial programme for the foreseeable future. Supporters of the project recommended restarting the plant in order to keep the door open, to gain technical knowledge through operation and, by producing electricity, to engender economic gain from the investments made (Birraux, 1992).

This argument in favour of a restart was accompanied by a new proposal. The idea was to take advantage of the flexibility offered by the operation possibilities of the plant, designed to produce electricity by breeding or burning. The plant would thus become a "plutonium incinerator". This idea was nothing new, as since the outset, the relative flexibility of FBR technology and its capacity to operate as breeder or burner, had been arguments regularly used to support the scientific and energy utility of this technology. For instance, Golan et al. (1989) argued: "There is no better way for 'storing' and utilizing plutonium than in an LMFR[3] plant. The recycling of plutonium into LMFRs would also allow "burning" of the associated extremely long-life trans-uranic waste [...]. All these perspectives strongly suggest that we should maintain the momentum for LMFR development and demonstration until at least commercially viable LMFR standard designs are fully licensed and demonstrated. [...] The LMFR is the only proven technology capable of providing virtually unlimited new fissile material from the world's ample supply of depleted uranium, low-grade natural uranium, and thorium resources to fuel the increased need for nuclear power in the next century and beyond." In the early 1990s, this idea found a certain echo following the fall of the Berlin wall, when the West was concerned about the future of the stocks of nuclear weapons from the Soviet empire.

Some people, and the Minister for Research in particular, supported this argument by recommending that the plant be used to carry out experiments on the destruction/transformation of radioactive waste as part of an ambitious 15-year national research programme initiated by a law passed in 1991 (Barthe, 2006). However, this redefinition of the purpose of the plant was challenged. Doubts about the real scientific potential of the plant were expressed during the debate. The plant was deemed to be too large for a research facility, to be unwieldy (particularly due to the loss of the fuel storage cylinder tank) and to be unsuitable for research missions (unlike Phénix). At the end of 1992, the report by the group of experts, led by Minister for Research Hubert Curien (1992), cautiously concluded that there was an opportunity for a research programme which would complement those being carried out elsewhere.

The conclusions of this cautious report were consistent with a certain reluctance on the part of the project promoters to reframe their project with a scientific vocation. They still had the firm conviction that the plant was viable and could fulfil its primary vocation - that of producing a large amount of electricity in industrial conditions. As they confirmed during the interviews, as far as they were concerned, their priority remained to achieve the technical and commercial demonstration of electricity generation by FBRs. In their views, technical features were obstacles to a conversion to research, and the loss of the fuel storage cylinder tank as well as the size of the plant offered little opportunity for carrying out experiments.

But obstacles were also institutional and economic. On an institutional level, France (through the project company) had signed an agreement with its partners for the development of a commercial plant, not a research facility. The European partners were not keen on the suggested redefinition. In 1994, when the research missions took concrete form, they accepted contractual changes to take this reorientation into account. The initial commercial vocation of the plant also affected the way its economic value was assessed (Le Renard & Jobert, 2013). In France, the level of investment was criticised with regard to the amount of electricity actually produced, and the European partners were also concerned about return on investment. For the project company, it was therefore important to be able to continue to produce electricity under the best possible conditions.

At the end of these initial consultations, the government laid down the conditions for restarting the plant. Among these conditions was the organisation of a new public consultation process (*Enquête publique*) which led to new public discussions in 1993. During these debates, the project promoters stressed the "versatility" (*polyvalence*) of the plant, its capacity to operate as "breeder" or "burner", rather than its vocation for research.

The cautious wording of the 1994 government decree authorising the plant to restart reflected this hesitation to give the plant a research mission:

> Given the prototype nature of the plant, it will be operated under conditions which *explicitly* favour safety and the *acquisition of knowledge, for the purposes of research and demonstration*" (decree dated 11/7/94, article 3, emphasis added).

In 1996, while the plant was operating satisfactorily, a new commission was asked "to assess Superphénix's capacities as a research facility" (Castaing, 1996). In turn, it gave a mitigated opinion, concluding that there was the possibility that the plant might make a moderate contribution to research in the area of waste management. A physics researcher (long-standing opponent of nuclear power) resigned from this commission and in an open letter expressed his disagreement concerning the utility of continuing operation for research purposes. At the same time, opponents took legal action and succeeded in establishing an inconsistency between the new objectives of the plant as defined, and these which had been set out in the 1992 file supporting the public consultation process. On the 28th February 1997, when Superphénix was stopped for scheduled maintenance, the 1994 decree was revoked. A few months later, on the 19th June 1997, newly elected Prime Minister Lionel Jospin announced in his inaugural speech to the Parliament that "Superphénix will be abandoned"[4].

This decision opened the way for multiple interpretations of the plant's future. This early termination after one year of perfectly satisfactory industrial operation in 1996 shocked those involved in the project. As far as they were concerned, the decision was premature, because it was not possible to judge a project if it had not been allowed to run its term. For the more critical actors, it was the "natural" end for an overly ambitious project to rapidly move from experimental models to a commercial model. From a more neutral standpoint and using terms borrowed from science studies, one might say that at a given point technology had no longer been able to hold together all of the project's contradictions (Latour, 1996: 232) and in particular those between the commercial vocation and the technological demonstration.

Discussion

As Bruno Latour (1996: 228) states: "Mechanisms cope with the contradictions of humans". Coming back to this assertion appears to us of importance, at a time when the energy policy seems to rely more and more on "industrial demonstrators". We want to broaden our argument to those hybrid objects who must on the one hand, demonstrate the maturity of their technology but, on the other hand, can still be improved before they enter the market. These hybrid objects are given ambivalent names: "pilot-series", "industrial demonstrators", "industrial prototypes".

A difficulty of such technical objects, be it small devices or imposing plants, is to combine the requirements of research with these of industrialisation. They are the inheritors of a series of expectations (Borup, 2006; Bakker, 2011) which gave shape to the research from its first steps; in turn, the research deemed as successful progressively enabled the realisation of bigger prototypes.

The "prototype" development is linked to the research process. If the innovators succeed in making their project a synonym for solving the great problems of the age, through activities of 'enrolment' and 'translation' (Callon, 1986), the research will be supported. In the 1950s and 1960s, FBR technology was developed because it carried with it the promise of virtually inexhaustible energy. This promise of being freed from issues of fuel supply and resource depletion answers one of the biggest issues of energy forecasting. This is the framing for the development of the technology as a long-term horizon.

Such a challenge justifies investing in technology development and setting up prototypes of increasing size in order to overcome the engineering difficulties which come between a promise and its realisation. Each promising prototype makes it possible to continue efforts to develop this technology, thanks to positive technological feedback as well as positive economic and political feedback. In the conceptual tools of "path dependency", this can be described as "increasing returns" (Pierson, 2000). These scientific and technical successes strengthen the promoters' convictions, envisioning a hegemonic presence of their technology in the future.

Meanwhile, at this stage, the development possibilities are open, as the prototypes benefit the protected framework of a "research" status. The economic constraints are those of a research budget, not of an assessment of competitivity. The project can be improved, devices can be modified, Phénix can be stopped for a certain period of time for this purpose, and this is regarded as normal. The material flexibility of the plants equals the flexibility in the discourses regarding the future uses of the technology.

In the late 1960s, in a climate of future energy scarcity and technological nationalism, several European countries judged that the FBR technology was now mature enough for the next prototype to be an "industrial" one. Because this plant was the logical endpoint of the pathway created by the preceding developments, it incorporated some irreversibility, or "path-dependency" – yet this concept implies an ex-post assessment of an economically inefficient choice. As we aimed at describing the project actors "in action" (Latour, 1987) without judging them, we found that their decision-making processes could be better captured by the "framing" concept. Therefore, we want to further discuss how the framing of the prototype as "industrial" entailed an impact on decisions during the 3 decades that the project lasted, as it diminished its flexibility.

Framing the prototype as "industrial" supposes taking it out of its protected research laboratory and confronting it with its "users" or "clients"- and, in this purpose, forecasting what the context of the project will be, which will, in turn, shape the project. For Superphénix, the environment of an "industrial prototype" at the beginning of the 1970s was composed of: a fleet of 1000 MW reactors, which defined a size; modernity and sharing of risks achieved by European projects, which defined a project company; future export of the technology which defined a subsidiary of the CEA that would be the licensee; the aim of generating electricity in the EDF fleet, which defined an organisational model for operation, as well as concerns for return on investment; the obligation to pay back the investors with generated electricity, which defined a location in South-Eastern France. This impressive "chain of translation" describes the moment when the project took concrete form at an organisational and technical level. As the project had incorporated all these dimensions, the project managers and funding authorities were in an operational state-of-mind. The framing through which they interpreted events was that of an industrial prototype of a promising electricity generation technology that would soon be mature for commercialisation. More generally, as "industrial demonstrators" or "prototypes" represent the first step of an industrial development pathway, they translate the link with the future users as well as the commercial dimension in their material shape.

After the first incident in 1987, the project managers' choice to replace the fuel storage cylinder tank with a "fuel transfer unit" was the concretisation of a change in the context, as the need for the technology on an industrial scale had been pushed away to the medium term. This solution also reinforced the industrial framing of the plant, enabling it to restart operation within a reasonable delay. After the second incident, the very industrial nature of the plant was questioned, and the innovators added a research programme to their operation schedule, without believing that the plant could be completely transformed (and reframed) into a research facility. The industrial framing of the project had left its mark in the materiality of the plant and in its organisation: it missed the flexibility of a research project.

In the middle of the 1990s, Superphénix could thus be viewed as an industrial plant which must gain a return on its investment, or else as a socio-technical innovation which must negotiate its boundaries and its technical content in order to integrate whatever has changed in its environment. B. Latour explains cessation of the innovative Aramis transport programme in this way: the promise of industrialisation in the near future makes it possible to rouse interest in the programme but prohibits the constant renegotiation that research requires. In the research phase, technological objects are in the hands of their inventors, open to many options and can be forgiven for many of their technical problems, whereas in the industrial phase they are meant to be fit for their purposes and reliable enough to be transferred to foreign hands. In the words of Latour explaining the causes for the stoppage of the *Aramis* project (1996: 293): "But then you would have needed to acknowledge that this was a research project", and "Oh, you do love science! [...] But technological research is the exact opposite of science, the exact opposite of technology."

In this way, considering the many industrial prototypes or demonstrators, it appears to be crucial to question the combination of the research flexibility of the prototype – leaving the future open – with the more rigid framing implied by "industrialisation" or "commercialisation". Paradoxically, this "industrial" framing understates an environment, users, legal framework, etc., that the project will meet at this stage – and this encounter could in turn require more flexibility. When an innovation has had a relatively long trajectory before reaching this stage where negotiation would be most required, it can be weighed down by the combination of the personal commitment of the innovators, institutional rigidities, economic investments and technical "scripts" introduced during the innovation – all of which might at some stage restrict the innovative actors' capacity to imagine or defend any reframing of their project.

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Notes

1 Corresponding author
2 The inert gas argon was in contact with sodium.
3 Liquid Metal Fast Reactor – an equivalent for FBR
4 http://archives.assemblee-nationale.fr/11/cri/1996-1997-ordinaire1/163.pdf

Adjudicating Deep Time:
Revisiting the United States' High-Level Nuclear Waste Repository Project at Yucca Mountain

Vincent F Ialenti

This paper draws upon perspectives on legal personhood, expert knowledge-practices, and social relations influential in STS and anthropology to revisit the legal-procedural framing of the United States' now-defunct high-level nuclear waste repository project at Yucca Mountain. Specifically, it examines how this project reinvented both (a) conventional figures of legal personhood as what is called a 'reasonably maximally exposed individual' and (b) legal adjudication's familiar 'rule-facts-judge' template as a frame for establishing the repository licensing regime's delegation of roles, responsibilities, and duties in response to its unique regulatory horizons that extended millennia into the future. Unpacking the implications of these familiar legal figures being brought to bear on historically unprecedented 'deep' timescales, this paper concludes by offering alternative lines of inquiry for interdisciplinary analysis of nuclear energy and its associated waste products.

Keywords: nuclear waste, temporality, legal anthropology

Introduction

Nuclear energy has, in recent years, seen increased visibility in both public and academic debates. For instance, Japan's 2011 Fukushima Daiichi nuclear reactor disaster (Kingston, 2012) and ongoing media reports of radioactive leakages from tanks at Washington's Hanford Nuclear Reservation (Johnson, 2013) have raised new concerns about nuclear energy technologies' risks. Meanwhile, countries such as India, China, Turkey, Russia, Finland, Vietnam, France, and the United Kingdom have developed new nuclear reactor initiatives, pushing forward what has been called a 'nuclear renaissance' (Kaur, 2011; Stuhlberg & Fuhrmann, 2013). This has, for some, restaged nuclear energy – which has comparatively low lifecycle carbon emissions relative to the steady and plentiful baseload energy supply it produces – as a pragmatic response to interrelated challenges of energy independence, climate change, and resource scarcity. In this context, the nuclear energy sectors of many countries – including France, Sweden, and the United States – weigh the potential risks and rewards of investing in updates to extend the lives of existing nuclear power plants. Many also wait to see how Germany will move forward after its post-Fukushima pledge to phase nuclear out of its energy mix by 2022 (Patel, 2011). Such changes have led to realignments in environmentalist sentiment. Some have moved to oppose nuclear energy technologies, as in the case of a January 2012 meeting in which ten thousand experts, politicians, activists, academics, and stakeholders from around the world met in Yokohama, Japan to work concertedly toward "a world without nuclear power" (Jussila, 2012). Still others have moved to support nuclear energy, as prominent figures like Greenpeace co-founder Patrick Moore, scientist-environmentalist James Lovelock, and *Whole Earth Catalogue* founder Stewart Brand have come to comprise what some have called a "rise of the nuclear greens" (Bryce, 2013; Walsh, 2013).

So too has a "new urgency" been said to surround challenges that nuclear energy sectors across the world face in managing the high-level radioactive wastes (HLW) they generate (Galbraith, 2011). As HLW management programs in some countries have faced political gridlock or even all-out failure (see Solomon et al., 2010: 16-17) – as in the case of the Obama Administration's 2009 decision to abandon the United States' nuclear energy sector's longstanding plan to bury its spent nuclear fuel in a permanent geological repository beneath Nevada's Yucca Mountain (Ewing & Von Hippel, 2009) – others have made landmark progress. In 2011 and 2012, for instance, Swedish and Finnish nuclear waste management companies SKB and Posiva Oy submitted construction license applications to the countries' respective nuclear regulatory authorities for what might become the world's first permanent geological repositories for HLW (Posiva, 2011; MEE, 2012). Yet, even while the strategy of burying HLW in geological disposal facilities deep beneath the Earth's surface has achieved substantial international acceptance (NEA, 2009), no country has yet succeeded in licensing and operating such a facility. Hence, much of the 10,000m^3 of HLW generated globally every year can, at least for the foreseeable future, be expected to gradually accumulate in surface-level interim storage facilities located on-site at many of the more than 430 nuclear power plants operating in the world today (IAEA, 2013; WNA, 2013; 2014).

In this setting, approaches to understanding nuclear energy issues that have been influential in the field of Science & Technology Studies (STS) have become increasingly germane. Such literatures have, over the years, provided illuminating ways of reflecting on the broader contexts surrounding nuclear energy technologies. Some have, for instance, examined intersections of nuclear technologies and national identities by contextualizing them within the wider 'technopolitical regimes' (Hecht, 1998) or 'sociotechnical imaginaries' (Jasanoff & Kim, 2009) that constitute them. Others have scrutinized the rationalities of policy-making and public debate enacted in making societal decisions regarding nuclear energy (e.g. Wynne, 1982) or have reflected on the 'anthropological shocks' that nuclear power plant disasters may cause within modern 'risk societies' (see Beck, 1987; 2002; 2009; Irwin, 2000). Others have adopted more ethnographic approaches to study Ukraine's post-Chernobyl circumstances (Petryna, 2002) and to study everyday life in a French community that is home to a nuclear waste incinerator (Zonabend, 1993). Such research has expanded our understanding of what some might call nuclear 'cultures of energy' (Strauss et al., 2013) or 'energopolitics' (Boyer, 2011). In addition, it has provided rich ground from which to take a step back and, as Hecht (2012) has done recently in her thorough study of the global uranium trade, reflect on just how technologies, markets, and substances come to acquire the tag 'nuclear' in the first place.

Approaches to understanding HLW management influential in STS and related disciplines have become increasingly germane as well, especially in the wake of the Yucca Mountain Project's recent stagnation. Such literatures have provided illuminating ways of analyzing HLW management issues in their broader contexts. For instance, Macfarlane (2003) has demonstrated how the 'co-production' of politics and scientific knowledge in the Yucca Mountain Project led to a shift from the U.S. Department of Energy (DOE) justifying the repository project based on site-specific geological evidence to justifying the project through appeals to engineering solutions. Meanwhile, other researchers – some self-identifying STS scholars, some not, but all working at the interface of HLW issues and society – have widened our understanding of the Yucca Mountain Project in many ways (see Macfarlane & Ewing, 2006). Such research has engaged themes ranging from issues of equity (e.g. Okrent, 1999) to repository site selection processes (e.g. Dunlap et al., 1993; Easterling & Kunreuther, 1995; Jacob, 1990; Short & Rosa, 2004; Solomon & Cameron, 1985). They have engaged themes ranging from the American federalist governance structure's implications for HLW disposal projects (e.g. Kearney & Garey, 1982) to comparisons of the Yucca Mountain case with disparate national HLW disposal regimes across the globe (e.g. Hamblin, 2006). And they have engaged themes ranging from contestations about scientific knowledge in public and policy domains (e.g. Endres, 2009) to risk perceptions and 'stigmas' about HLW in locales near and far from the Yucca Mountain site (e.g. Slovic et al., 1991).

Amidst this all, however, it has been noted that there remains a need to further pursue "cross- or transdisciplinary" methodologies and to "bring together the strength of STS with the effectiveness of the comparative methodology of economic history, geography, political science, or sociology" in analyses of HLW management (Solomon et al., 2010: 24). The present paper develops a case study of the Yucca Mountain Project that is inspired by such calls for further interdisciplinary, trans-disciplinary, or multi-disciplinary social scientific analyses of nuclear energy and its radioactive waste products. Its objective is to, by approaching the Yucca Mountain Project from an analytical vantage not yet tapped in these literatures, contribute to such efforts to analyze nuclear energy issues in their broader contexts from ever more standpoints. To do so, this case study juxtaposes selected perspectives from Anthropology, from STS, and from existing scholarship on the Yucca Mountain Project to revisit what is often seen as one of the most unsettling features of HLW management contexts like the Yucca Mountain Project: their extension of the timescales of law and risk governance one million years into the future (see Carter & Pigford, 2005; NEA, 2009). With regulatory compliance horizons stretching across the millennia (NRC 10 CFR § 63.321, 2013), the Yucca Mountain Project is indeed a zone of engagement with what physicist and science fiction author Benford (2000) or historian of science Rudwick (1992) might call 'deep time'. It is hence entangled with the ethical, epistemological, and temporal challenges of what Brand (1999) might call 'the long now'. In light of this, this case study revisits the Yucca Mountain Project as a site in which distant future societies, bodies, and environments are engaged—in which relations between the living societies of the present and the unborn societies imagined to inhabit distant future worlds are made and remade (Ialenti, 2013).

I have opted to focus on HLW's seemingly unimaginable and incomprehensible timescales of hazard – and the epistemological, temporal, and ethical challenges they pose – in part because I believe that they are particularly amenable to analysis from a more anthropologically inflected standpoint. This is because anthropologists have had longstanding interests in examining the limits of the human intellect and imagination (Crapanzano, 2003). Anthropology has also seen recent turns toward exploring both "phenomena operating at the limits of calculation and measurement" (Holmes, 2009) and how "theoretical, technical and professional commitments" operate "at the limits of expert knowledge" (Miyazaki, forthcoming). In this sense, this case study of the Yucca Mountain Project's grappling with such immense timescales contributes not only to the existing nexus between STS and Anthropology engaging nuclear issues (e.g. Gusterson, 1996; Masco, 2010; Miyazaki, forthcoming; Petryna, 2002; Riles, 2013; Zonabend, 1993) but also to efforts to re-function anthropological modes of conceptualization (see Holmes & Marcus, 2005) to bring them to bear on contemporary debates about issues ranging from policy to technology, from science to finance (e.g. Fischer, 2009; Rabinow, 2008; Rabinow et al., 2008).

This case study is also inspired by commentaries on HLW's deep timescales put forth by scholars influential in STS. Shrader-Frechette (2005; 1993), for example, has made many arguments addressing issues ranging from intergenerational responsibility to the ethical and epistemological plausibility of the Yucca Mountain Project's efforts to discern multimillennial timescales through modeling practices. Bloomfield and Vurdubakis (2005) have cast the Yucca Mountain Project, with its unprecedented deep timescales, as a context of conceptual boundary making stretched to extremes. And Galison (2012) – reflecting on the novelties of the challenges HLW poses – has elaborated how "with a million years, you're talking not only about the possibility of political, linguistic, material processes, but biological evolutionary processes undergoing great changes". This paper aims to complement such commentaries by taking an alternate analytical route through some of the core temporal, epistemological, and ethical challenges posed by HLW. For one, rather than focusing on the marked novelty or lack of historical precedents available to guide HLW projects' efforts to reckon deep time, this paper focuses on some markedly conventional and historically-established *legal-procedural frames* that – despite undergirding the Yucca Mountain Project since the late 1970s and early 1980s – have long remained largely uncontroversial, undisputed, and unanalyzed within relevant literatures in STS, Anthropology, and related fields. The goal here is to make visible for scrutiny some of the most stable legal-procedural foundations upon which the Yucca Mountain Project has long been grounded despite their having remained largely off-the-radar in social scientific commentaries. In focusing on such figures of marked stability, this case study also distinguishes itself from the voluminous literature on the Yucca Mountain Project that, while rich, has tended to focus primarily on those aspects of the U.S.'s HLW management endeavors most wracked by socio-technical controversy, litigation, public opposition, and instability over the decades.

The present case study aims to situate the Yucca Mountain Project in a much broader historical frame by analyzing it through lens of legal-procedural frames that predate the Atomic Age by centuries. To this end, it brings perspectives from Anthropology and STS to bear on some of the most enduring legal-procedural foundations enacted in the United States' nuclear waste 'regime'—its "set of integrated laws, organizations, and agencies, principles, norms, rules, and institutional procedures created to regulate and coordinate action for the disposal and management of radioactive wastes" (Solomon, 2009: 1012). To develop this analysis, I took cues from Latour's (2004) reflections on legal procedure in France's *Conseil D'Etat*, from Murphy's (1997) understanding of 'adjudication as a social practice and as a set of governmental techniques', and drew upon STS-inflected renderings of notions like 'black box' (see Latour, 1987; Jordan & Lynch, 1992: 77) and 'boundary object' (Star & Griesemer, 1989). To develop ways of articulating how certain aspects of the project's legal-procedural frames have entered into such immense spans of time and vice versa, I tapped anthropological perspectives on legal personhood (Douglas, 1995; Mundy & Pottage, 2004; Riles, 2011; Supiot, 2007) and on what anthropologists have termed processes of 'invention' and 'reinvention' (Robbins & Murray, 2002; Strathern, 2002; Wagner, 1981). In making visible these aspects of the Yucca Mountain Project, fresh sets of questions were revealed regarding legal knowledge, deep time, and nuclear risk. I suggest in this paper's concluding discussion that these alternate sets of questions ought to be broached in the future by scholars in STS, in anthropology, and in other social scientific fields that engage the Yucca Mountain Project, HLW's deep timescales, and nuclear energy issues broadly construed.

This paper is organized as follows. First, it presents an empirical overview of some of the historical and political backdrops to the Yucca Mountain Project's legal-procedural frames in order to provide context for the analysis I present in the latter half of this paper. Second, it analyzes how the American HLW disposal regime reinvented a classical figure of legal personhood as what is called a 'reasonably maximally exposed individual' to form a baseline standard according to which radionuclide exposures to distant future societies could be gauged. Third, it analyzes how the Yucca Mountain Project reinvented classical figures of legal adjudication – specifically, Euro-American legal thought's historically established relation between rule, fact, and judge – to establish a broad legal-procedural frame through which myriad experts', agencies', and managers' roles, responsibilities, and duties were to be orchestrated. In these sections, both the reasonably maximally exposed individual and the rule-facts-judge adjudicatory template are analyzed in light of the Yucca Mountain Project's markedly long-term compliance horizons that extended millennia into the future. Concluding, the paper reflects on the implications of the present case study for (a) interdisciplinary research trajectories analyzing nuclear energy and its associated waste products in general and (b) extant research on HLW disposal regimes like the Yucca Mountain Project in particular.

Background

The United States' avenues for managing its HLW have, in recent years, reached something of a crossroads. Repeatedly mobilizing the term 'sound science' in support of the final repository that the DOE proposed to be built beneath Nevada's Yucca Mountain, few were surprised when former U.S. President George W. Bush approved the site just one day after former U.S. Secretary of Energy Spencer Abraham's official recommendation in February 2002 that it be used as a final disposal site (see

Macfarlane, 2003: 794; Vandenbosch & Vandenbosch, 2007: 44). However, just a few years later, the Obama administration declared the Yucca Mountain plan "no longer an option" in March 2009 and drastically slashed the project's funding for fiscal year 2010, allocating financial support only for the NRC's regulatory evaluation of the DOE's then recently submitted License Application for the facility's construction (Deutch et al., 2009: 11; DOE, 2008; Hebert, 2009). In late July 2009, U.S. Senate Majority Leader Harry Reid, a Nevada native and a longtime voice in the anti-Yucca movement, announced an agreement with the White House to discontinue the repository licensing procedure funding for fiscal year 2011. After decades of contestation between scientists, the public, academics, activists, politicians, and local coalitions, the high-level nuclear waste repository project at Yucca Mountain appeared to have been dismantled. Announced less than a decade apart from one another, the Bush and Obama administrations' polarized decisions are perhaps emblematic of the divided politics and epistemic contestations that increasingly challenge the country as it plods forward in the twenty-first century (cf. Conway & Oreskes, 2010).

Not long after the Yucca Mountain Project's collapse, the Blue Ribbon Commission on America's Nuclear Future was assembled to "provide advice, evaluate alternatives, and make recommendations for a 'new plan' to manage" the United States' HLW (Blue Ribbon Commission on America's Nuclear Future, 2012: i). The Commission submitted its final report in January 2012 after two years of examining how the United States can "go about establishing one or more facilities for permanently disposing of high-level nuclear wastes in a manner and within a timeframe that is technically, socially, economically, and politically acceptable". It did this by holding deliberative sessions, listening to expert and stakeholder testimonies, and visiting France, Japan, Sweden, Russia, Finland, and the UK to "learn first hand about their disposal programs". Affirming permanent geological disposal as a viable option for pursuing "integrated" management of the United States' HLW, the Commission stressed how "Americans have benefitted from the energy and deterrent capacity provided by nuclear technology for more than fifty years". It also stressed that America "cannot and must not continue to defer responsibility for dealing with the resulting high-level wastes and spent fuel" (Blue Ribbon Commission on America's Nuclear Future, 2012: ii-iii). Decisions are now left to actors in the United States' executive and legislative branches as to what will come of the Commission's recommendations.

These developments have an extensive backstory that, in the present section, will be reviewed broadly as it pertains to the legal-procedural frames that came to organize the Yucca Mountain HLW disposal regime over the decades. This story could begin with U.S. President Harry Truman signing the 1946 U.S. Atomic Energy Act, which transferred control of atomic energy from military to civilian hands and established the Atomic Energy Commission (AEC) as both promoter and regulator of nuclear power (see Shrader-Frechette, 1993: 2, 23). 1957 saw the publication of the AEC's and Oak Ridge National Laboratory's *Status Report on the Disposal of Radioactive Wastes* and of the National Academy of Sciences (NAS)'s and National Research Council's Committee on Waste Disposal's publication of their *The Disposal of Radioactive Waste on Land* report. That is when the United States begun considering deep geological disposal as a viable option for the long-term management of its HLW.

Years later, the 1975 U.S. Energy Reorganization Act responded to growing public mistrust in a single agency serving the contradictory functions of simultaneously promoting and regulating nuclear power by dividing the AEC into two agencies: the U.S. Energy Research and Development Administration (ERDA) and the NRC. In 1976, the U.S. Environmental Protection Agency (EPA) was officially delegated the duty of developing dose-limit standards for nuclear waste-induced radionuclide exposure. One year later, the Interagency Review Group on Nuclear Waste Management (IRG) was established to assess the problem of HLW management (IRG, 1979). That same year, the 1977 U.S. Energy Organization Act formally abolished ERDA and transferred its duties to the newly established DOE (see Vandenbosch & Vandenbosch, 2007: 35). While relationships between these three agencies were complex over the decades that followed, the basic structure of this legal-procedural frame maintained until the project's recent stagnation: to generalize, *the NRC has been responsible for regulation and licensing, the EPA has defined radiation protection standards, and the DOE has been responsible for research, development, and the operation of repositories* (see Shrader-Frechette, 1993: 23).

In 1978, the DOE began investigating the viability of Yucca Mountain as a potential HLW repository site. Four years later in 1982, the U.S. Nuclear Waste Policy Act (NWPA) was established as the first piece of legislation specific to radioactive waste disposal, mandating permanent subsurface isolation of waste and establishing decision-making timetables for disposal. The NWPA delegated management and site characterization burdens to the DOE, the duty of setting dose-limit standards to the EPA, and licensing and enforcement responsibilities to the NRC. Financing programs through a Nuclear Waste Fund that levied at one mill ($0.001) for every kWh generated by commercial nuclear power plants, the NWPA also established the DOE's Office of Civilian Radioactive Waste Management (OCRWM) to oversee the repository site selection process (Craig, 1999). Directing the DOE to nominate five potentially suitable repository sites and recommend three to the President for characterization, the act prompted years of not-in-my-backyard politicking and whittling down of possible locations (Carter, 1987; Colglazier & Langum, 1988; Jacob, 1990). This culminated in the 1986 selection of three potential sites: Washington's Hanford Nuclear Reservation, the Nevada Test Site, and Deaf Smith County, Texas (Easterling, 1992). Around the same time, the DOE announced its decision to abandon its initial plans to build a second HLW repository somewhere in the Eastern U.S. (see Blowers et al., 1991: 212; Kraft & Clary, 1991). Since many saw this "surprise decision" as "politically motivated" in a context of "vociferous complaints from potential repository hosts in the East", a "backlash" from states in the Western U.S. on "social equity grounds" arose (Solomon, 2009: 1013).

By 1987, it became increasingly clear the NWPA timetables could not be met, that budgetary constraints would render characterization of three sites unrealistic, and that the DOE's shortlist would face acute political opposition. The subsequent NWPA Amendments Act resolved several disputes by selecting only one site for characterization – Yucca Mountain in the politically weak state of Nevada – sparking wide dissent from local coalitions assembling against what came to be known as the Screw Nevada Bill (see Vandenbosch & Vandenbosch, 2007: 41). This 1987 Amendments Act led to the construction of the on-site Exploratory Studies Facility, an underground laboratory accessible only through an eight-kilometer tunnel, to produce research aiding a site characterization project that the DOE hoped would meet forthcoming EPA exposure limits (Cotton, 2006). Since then, the state of Nevada has worked for more than two decades to "challenge its political isolation" and "prevent a repository on all possible grounds" (Lemons et al., 1990; Solomon, 2009: 1013). In protest of what many saw as an inequitable imposition of an HLW repository on a politically weak state that in fact had no nuclear power plants of its own, Nevada's legislature passed a 1989 bill that made HLW disposal illegal within its borders (Kunreuther et al., 1990). Since then, Nevada's Agency for Nuclear Projects has introduced several lawsuits aimed at halting the Yucca Mountain repository project (see Solomon, 2009: 1019). Amidst all this politicking, as Bloomfield and Vurdubakis (2005: 739, 742) have noted, the temporal question of how to contain HLW's deep timescales of risk has transformed into a spatial question of "where can the waste be placed?" and of the DOE's capacity to ensure that the HLW "must remain inside the canisters, the canisters must remain inside the repository, the mountain must remain above, the water table must remain below, and the desert must remain around it". In asserting its imperative to contain HLW within and across space, the U.S. nuclear risk governance regime presented itself as it long has in many other contexts: "as a responsible regulator of a potentially runaway technology that demands effective 'containment'" (Jasanoff & Kim, 2009: 119, 130).

The U.S. Energy Policy Act of 1992 clarified the EPA's role in setting standards by directing it to issue health-based radionuclide dose-limits for human bodies within a chosen timescale of compliance. It also mandated that the EPA take into account NAS "recommendations on reasonable standards for protection of public health and safety" (Vandenbosch & Vandenbosch, 2007: 42; NEA, 2009: 119). In June 2001, the EPA released standards establishing dose-limits of fifteen millirems (mrem) per each 'reasonably maximally exposed individual' within a compliance timescale of ten thousand years. These standards were remanded in a 2004 ruling of the U.S. Court of Appeals for the District of Columbia Circuit citing the EPA's failure to heed recommendations of a 1995 NAS report (Reblitz-Richardson, 2005; Shrader-Frechette, 2005). This study suggested that compliance timescales must be extended beyond the time of peak dosage occurring hundreds of thousands of years in the future (Carter & Pigford, 2005). In late 2008, the EPA released a final two-tiered dose-limit requiring exposure to fall below fifteen mrems per year within a ten thousand year compliance timescale, and below one hundred mrems per year within a one million year compliance timescale (NRC 10 CFR § 63.321, 2013). At this time, the question of when and if the Yucca Mountain repository would go into operation remained open as "scientific uncertainty... national and state politics" and "continued legal wrangling" had long imposed delays on the project. As Barry Solomon (2009: 1020) has noted, "[f]irst there was the legislative mandate for the DOE to open the first HLW repository in 1998, then 2010 and 2012 were proposed, and more recently the plan was to open the facility in 2017".

The sections that follow analyze how, despite such ongoing scientific, political, public and legal contestation, this nuclear waste regime remained all the while grounded on a familiar set of legal-procedural frames. These frames are noteworthy in their remaining relatively stable in orchestrating myriad experts', agencies', and managers' roles, responsibilities, and duties over the years. This is perhaps why they have also remained quietly outside of critical, academic, and media debates. In response to this, the next sections flesh out these legal-procedural frames analytically with the aim of opening them to greater attention, understanding, and scrutiny by scholars in STS, in Anthropology, and in related fields. Of specific interest is how such conventional legal figures maintained unimposingly in the backdrop of a technoscientific regime assumed by many to be novel given its reckonings of historically unprecedented timescales. Turning analytical attention to these aspects of the Yucca Mountain Project brings an alternate depiction of it into view. The implications of this will be unpacked in the concluding discussion.

Legal Personhood Exposed

It is often noted how the development of nuclear power has left humanity to cope with waste products bearing risks that extend distantly into the future. Elements like plutonium-239 and neptunium-237, for instance, boast half-lives of 24,100 years and 2.1 million years respectively. Therefore, they impose burdens of long-term stewardship on the risk governance regimes delegated as custodians of nuclear power plants' atomic refuse. Such has led to the development of novel practices of long-term scenarios forecast, risk analysis, and stewardship in nuclear waste regimes across the world. In December 2012, for example, Finnish nuclear waste management company Posiva Oy submitted its construction license application and Safety Case for its prospective geological repository to be built deep beneath Western Finland's island of Olkiluoto. Its goal was to demonstrate to the country's Ministry of Employment and the Economy (MEE) and Radiation and Nuclear Safety Authority (STUK) that radiation doses to future populations are unlikely to exceed legally defined radionuclide human exposure limits (MEE, 2012). Taking into account numerous technical models of distant future geological, ecological, and social conditions in the Olkiluoto region to get a sense of the interactions that will occur there over the next few hundred thousand years (Hjerpe et al., 2009), some experts involved with the project investigated topics like 'Climate scenarios for Olkiluoto on a Time-Scale of 120,000 Years' (Pimenoff et al., 2011). Others examined potential earthquakes that might occur as massive glaciers retreat from the region following the next Ice Age (Fälth & Hökmark, 2012).

As in Finland's HLW disposal regime, the United States' now-defunct Yucca Mountain Project too developed computer simulations and technical modeling practices to reckon distant future worlds. In that context, Monte Carlo and Total System Performance Assessment (TSPA) predictive modeling techniques were redeveloped to meld myriad individual subsystem models into composite meta-models. They then laid out probability distributions for many possible future events, assigned them potential sequences, and ran random samples of uncertain parameters that resulted in a number of unique radionuclide dose projections for a body matching the legal definitions of what was called a *reasonably maximally exposed individual* (Macfarlane & Ewing, 2006: 21; Vandenbosch & Vandenbosch, 2007: 110; Whipple, 2006: 60). This reasonably maximally exposed individual was the hypothetical human body according to which the Yucca Mountain Project regime gauged the potential for hazardous radionuclides emanating from the buried HLW to trigger adverse health effects among exposed individuals in futures near and distant. As such, it was legally presumed by the NRC to have the attributes of a present-day human living above the "highest concentration of radionuclides in the plume of contamination", who has the same diet and lifestyle of present residents of the nearby town of Armagosa Valley, who drinks two liters of well water per day, and is an "adult with metabolic and physiological considerations consistent with present knowledge of adults" (U.S. NRC 10 CFR § 63.312, 2013).

As the legally defined beneficiary according to which the final TSPA models were to evaluate expected radionuclide dosages, this hypothetical body operated as something akin to what an STS scholar might call a 'boundary object' (Star & Griesemer, 1989) to facilitate coordination among the diverse teams of experts involved with the project. Its purpose was to provide a standard according to which statistical curves plotting an individual body's expected annual dose over time could be generated to assess compliance with legally defined human radionuclide exposure maximums (see Vandenbosch & Vandenbosch, 2007: 110-1). With this in view, it becomes apparent how the Yucca Mountain regime came to (a) structure predictive models of the region surrounding the proposed repository site, (b) define radionuclide exposure dose-limit standards, and (c) gauge the prospective repository's safety in light of its future impacts on human health each according to the legal definitions constituting this *hypostatization of a single human body*. And, by way of this legal figure, the end-goals of each of these safety assessment procedures were framed as measures to protect a legal reification of what anthropologists might call the unitary liberal subject, the modern rights-bearing individual, or the bounded legal person (Douglas, 1995; Pottage & Mundy, 2004; Supiot, 2007: 3-29). Hence, it would seem that the Yucca Mountain Project extended into million-year timescales the most familiar *telos* guiding nearly every Euro-American governance project. That is, by taking society to be a journeying unity progressively "going somewhere"—toward greater satisfaction of the needs, rights, happiness, choices, and safety of the *individual* subject enabled according to the Kantian imperative of being treated as an *end* in itself (Strathern, 1996: 37-39).

The Yucca Mountain Project's grappling with deep time can thus be seen as grounded on classical figures of legal personhood or of Euro-American unitary selfhood. It can also be seen to have adapted or – to use a term very familiar to anthropologists – 'reinvented' (see e.g. Hobsbawmn & Ranger, 1983; Robbins & Murray, 2002; Strathern, 2002; Wagner, 1981) this hypothetical person to extend its existence into the multi-millennial futures that the nuclear waste regime gazed upon. In its reinventing the figure of the legal person as a reasonably maximally exposed individual, the Yucca Mountain Project can be seen as just one more context in which humans have gone to lengths to – to quote Huen (2009: 161) reflecting on the contributions of anthropologists Wagner and Strathern – "concretize *new* knowledge *from* what is already known". As such, an anthropologist might see the Yucca Mountain Project as just another site in which humans have drawn upon fragments of the past to reinvent them in the present to serve new purposes in new contexts. With this in view, the next section will turn to another set of legal-procedural figures that have long grounded the American HLW disposal regime. Specifically, it will revisit the Yucca Mountain Project by focusing on a familiar template of adjudicatory process that organized the regime's efforts to protect this reasonably maximally exposed individual from radioactive harm for the radical long-term.

Adjudicating Deep Time

The Yucca Mountain Project regime empowered the EPA to produce *rules* in the form of radionuclide dose-limit regulatory standards, the DOE to produce *facts* in the form of million-year technical models, and the NRC to *judge* DOE models according to EPA standards. In practice, this meant that the DOE developed a License Application – thousands of pages long – containing safety analyses, environmental impact statements, descriptions of engineering strategies, and projections of the distant future conditions of the region to surround what is today called Yucca Mountain (DOE, 2008). This pile of technical evidence was then handed-off to the NRC in June 2008 for docketing, hearings, and regulatory review. From then on, the NRC's duty was to judge whether to authorize the Yucca Mountain repository's construction. In March 2009, the NRC formally implemented the EPA's updated set of radiation protection standards developed to protect the reasonably maximally exposed individual throughout multi-millennial futures.

While the NRC's review process commenced upon the License Application's submission, it was halted in September 2011 in light of the Obama Administration's decisions against the Yucca Mountain Project. The review process seemed then to be fated to remain stagnant. This changed in August 2013 when the U.S. Court of Appeals for the District of Columbia ruled that the NRC was "simply flouting the law" by stopping the review procedure and that the NRC still has the duty to determine whether to "approve or reject the Energy Department's application". The appeals court also noted that "[t]he president may not decline to follow a statutory mandate or prohibition simply because of policy objections" (Daly, 2013). Regardless of what the future holds for the License Application review process, its details reveal much about how the Yucca Mountain Project regime adjudicated deep time in practice prior to the 2011 halt or hiatus:

> Once the application was docketed, the NRC's technical staff in the Office of Nuclear Material Safety and Safeguards initiated a detailed, thorough and comprehensive review. This review involves more than 100 staff and contractor employees with expertise in several technical and scientific disciplines, including geochemistry, hydrology, climatology, structural geology, volcanology, seismology and health physics, as well as chemical, civil, mechanical, nuclear, mining, materials and geological engineering. Staff members at NRC's headquarters in Rockville, Md., the Region IV office in Arlington, Texas, and the NRC's Las Vegas office are participating. The Center for Nuclear Waste Regulatory Analysis in San Antonio, Texas, a federally funded research and development center, will provide technical assistance to the NRC. Throughout the review, the NRC staff will request additional information from DOE to help clarify the application... At the completion of its technical review, the NRC staff will issue a Safety Evaluation Report (SER) containing its findings on the repository design. The SER will determine whether the proposed facility will meet NRC regulations to protect public health and safety and whether construction of the facility may be authorized. (NRC, 2012.)

Alongside this were to be held adjudicatory hearings conducted by the NRC's Atomic Safety and Licensing Board Panel (ASLB) (NRC, 2013). The ASLB, composed of judges versed in technical or legal expertises of various kinds, was to appoint judicial boards to hear 'contentions'. Contentions admitted by the NRC generally posed technical or legal concerns with the DOE's application. Twelve groups, each wishing to be admitted as parties involved in the hearings process, filed 319 contentions in total. Evidentiary hearings – in which interested parties would conduct cross-examinations, put forth arguments, and present witnesses – were also to be a critical part of this legal procedure. In those hearings, ASLB judges were to listen to evidence and to make judgments regarding contestations of technical aspects of the DOE's application or of existing NRC decisions. These were to be supplemented by 'limited appearance' sessions, which temporarily offered the floor to members of the public offering oral or written statements about the repository project. Final decisions about contentions, if appealed, would then be sent to a U.S. Court of Appeals (NRC, 2012).

By reflecting on the broader legal-procedural frames underlying this regulatory review process, one can begin to see how the Yucca Mountain Project moved to contain such distant future timescales by drawing from a rather conventional repertoire of legal figures. Indeed the licensing procedure for building the repository took as its conceptual foundation a systematically reproduced formula of legal adjudication. This adjudicatory formula required, as noted, a set of fixed textual *rules* (as EPA exposure standards), situation-specific *factual evidence* (as developed in the DOE's License Application), and a dispassionate judge responsible for rendering *judgment* (in this case, the NRC) (see Latour, 2004: 102; Murphy, 1997: 42, 56). Hence, it would seem that this rule-facts-judge template – a familiar, perhaps even archaic, figure of legal form – has been transposed rather straightforwardly to organize the Yucca Mountain Project's nuclear waste repository construction licensing procedure in accordance with the conventions of modern bureaucratic delegation. In such modern bureaucratic contexts, it has been noted, practices of "modeling decision processes on ordinary and familiar court systems" are commonplace (Murphy, 1997: 57).

The Yucca Mountain Project, hence, responded to the novel multi-millennial challenges to safely burying HLW by reproducing a legal formula that is, quite literally, ancient. After all, law's rule-facts-judge formula has maintained throughout a long Euro-American legal history in which, to quote Murphy, "the occasional brilliant *apercus* of the Roman jurists… were torn out of the context of the concrete cases of the Pandects and were raised to the level of ultimate legal principles from which deductive arguments were to be derived". Subsequently, Euro-American legal history is said to have seen the coalescence of "purely systematic categories" in which "definitely fixed legal concepts in the form of highly abstract *rules* are formulated" and repeatedly applied to "a set of *facts* disclosed through logical analysis". The result was a "legal unification and consistency" that solidified contextual facts and context-transcending rules as the two variables that must be present if legal judgment is to be performed with legitimacy (Murphy, 1997: 42). Hence today, as Latour has noted, legal adjudications of many varieties require the establishment of "a domain of unquestionable *fact* as quickly as possible… so that it can be subsumed to a *rule* of law… in order to produce *judgment*" (Latour, 2004: 102; Murphy, 1997: 56).

An STS scholar might approach this rule-facts-judge template as one of Euro-American law's cardinal *black boxes*—as a *step* that is "unspoken, unexplored, used ritualistically" and "otherwise taken-for-granted" in its routine enactments. If a black box is understood to be but a preliminary "means for setting up more interesting phases" of an expert practice (Jordan & Lynch, 1992: 77), then perhaps one can say that law's rule-facts-judge template has, over the centuries, served as but a preliminary means for setting up more interesting phases of legal judgment and evidence discovery in countless adjudicatory contexts across the world. In light of this, one might suggest that the function of this rule-facts-judge template is to simplify the messy complexities of reality into something more comprehensible and hence more amenable to legal adjudication. Thus, this rule-fact-judge template could be construed as but one of law's reductive "devices for making decisions in conditions of uncertainty" to fashion "crude, pragmatic, instruments of probabilistic reasoning" to facilitate judgment (Pottage, 2004: 12).

If such is the case, then the specific pragmatic legal device enacted to uphold the rule-facts-judge template is law's postulate that the 'corporation is a person'—law's consciously fictive assertion of unitary personhood upon complex networks of actors that rarely, in actuality, fit neatly into static boundaries of any kind. Still, in the universe of law, as it is often noted by legal anthropologists, corporate entities are held to be "simple, steady, singular and unchanging… marked by a highly rigid division between inside and outside" (Riles, 2011: 39). The same can be said of how the EPA, the DOE, and the NRC were hypostatized when wedged into their respective positionalities within law's familiar rule-fact-judge template. That is, in the Yucca Mountain Project's repository licensing procedure, the DOE, the EPA, and the NRC were reified respectively *as* fact-producer, *as* rule-definer, and *as* judge. To this end, experts who participated in this adjudicatory ritual, at least in theory, were required to act as if such was actually the case. They were to perform their fidelity to the 'purifications' and 'separations' (Latour, 1993) wedged between these legally discrete agencies that endowed the broader adjudicatory procedure with its semblance of coherence.

Indeed, as in any exercise of legal judgment in any of the past few centuries, *litigants* cannot legitimately be empowered to *judge* their own cases, *legislators* cannot be legitimately empowered to interpret their own *rules*, and a *judge* cannot be personally involved in the disagreements of the *litigants* he or she is to impartially oversee. To cross lines drawn between rule, facts, and judge – or, in this case, for an expert to cross boundaries between his or her allegiance to either the EPA, the DOE, or the NRC – would imply corruption, conflict of interest, or some illicit sort of inter-agency capture. The three entities must, therefore, be imagined as separate and singular, each fulfilling particular roles and functions vis-à-vis one another. All three agencies must be present, functional, and purified and separated off from one another if legal judgment is to be undertaken in conformity with legal protocol. Such could be understood as a reinvention of this classical legal adjudicatory template on a new, perhaps novel, terrain. This is because the rule-facts-judge figure organizing the Yucca Mountain Project repository licensing procedure framed legal judgment precisely as it has framed legal judgment throughout the ages. It is on these legalistic grounds, ancient in origin, that this American nuclear waste regime established that repository licensing decisions be hashed out.

With all this in view, the Yucca Mountain Project, while gazing at radically distant futures, can be seen as bound to legal adjudicatory templates that predate the Atomic Age by centuries. From this perspective, the formal legal-procedural layout of a risk governance project that presents itself as distinctly modern or novel can be seen to rest inextricably on a legal relation between rule, fact, and judge that presents itself as strikingly ancient or conventional. This reveals a legal-procedural formula with great historical precedent underlying a risk governance endeavor assembled in response to imperatives to render seemingly historically unprecedented timescales intelligible. And, perhaps in the same way that familiar figures of legal personhood were reinvented as the Yucca Mountain Project's reasonably maximally exposed individual, a seemingly ancient legal adjudicatory template seems to have been reinvented to organize a HLW disposal regime with ambitions to reckon distant future worlds. Revisiting the Yucca Mountain Project from this perspective brings into view new sets of questions that will be fleshed out in the discussion that follows.

Discussion

This case study began with a brief historical outline of the legal-procedural frame that came to organize the HLW disposal regime at Yucca Mountain. Next, inspired by anthropological perspectives on legal personhood, expert knowledge-practices, and social relations, it examined how this regime reinvented familiar figures of legal form in response to its novel mandate to demonstrate repository safety in regulatory horizons that extended 10,000- and 1,000,000-years into the future. In so doing, it focused on how the Yucca Mountain Project reinvented figures of the unitary legal person and of the tripartite rule-facts-judge adjudicatory relation to ground its legal-procedural frame. Both of these examples brought into view how – despite the aura of idiosyncrasy long enchanting the radically distant futures the Yucca Mountain Project engaged – the regime could be cast as just another venture in which humans draw upon fragments of the past to reinvent them to serve new purposes in new contexts. As Strathern (1995: 428) has noted in a similar vein, if "we see present-day cultures as the offspring of past ones, we see new combinations forever being put together out of old cultural elements". This case study hence demonstrated how the Yucca Mountain Project, presented often as somehow idiosyncratic (e.g. Bloomfield & Vurdubakis, 2002) or historically unprecedented (e.g. Beck, 2002: 40; Benford, 2000), is entangled with processes of invention and reinvention that have long been constitutive of the human experience.

More than just an extreme variant of the paradigmatic problem of contemporary 'risk society' – that is, to "predict the unpredictable, to communicate beyond the limits of language, and to bind that which respects no boundaries" (Bloomfield & Vurdubakis, 2002: 752-753) – this case study recast Yucca Mountain Project as having precedents entrenched millennia before key elements of risk society's 'new modernity' are said to have coalesced (see Beck, 1992; 2009). More than resting on governance conventions of public hearings and of technocratic policymaking that have contoured decision-making in capitalist democratic states in the twentieth and twenty-first centuries (see Wynne, 1982), this case study fleshed out how the Yucca Mountain Project communed with a deeper structure of legal-procedural form established in eras past. More than just caught up in national 'sociotechnical imaginaries' like those Jasanoff and Kim (2009) noted in the United States and South Korea or the nationalistic 'technopolitical regimes' observed by Hecht (1998) in France, this case study demonstrated how U.S. nuclear risk governance has been tethered to legal-procedural figures that predate the concept of the nation-state (see Branch, 2011). More than just a matter of ethics, responsibility, or epistemology (e.g. Shrader-Frechette, 1993; 2005), this case study revisited the Yucca Mountain Project with an alternate focus on legal personhood, legal-procedural form, and expert knowledge-practices. Doing so has unveiled fresh conceptual space in which further social, historical, or cultural research on HLW disposal regimes or on nuclear energy broadly construed could be developed at the nexus of STS, Anthropology, and related fields. Following Solomon et al. (see 2010: 16-17) in advocating more interdisciplinary humanistic and social scientific research on such topics, I conclude now by listing three potentially generative lines of inquiry that developing this case study of the Yucca Mountain Project has unveiled.

First, it has made apparent how revisiting the Yucca Mountain Project as a zone of engagement with distant future societies, bodies, and environments can reveal it as a potentially apt object of comparison with other zones of engagement with distant future societies, bodies, and environments. It could, in other words, be taken as but one context to be juxtaposed with other contexts in which relations between the living societies of the present and the unborn societies imagined to inhabit distant future worlds are invented and reinvented. For example, as carbon emissions reduction programs are increasingly informed by risk projections plotting climate change futures in centurial timeframes, new governmentalities are increasingly assembled to temper irreversible depletions in biodiversity and extractions that alter ecosystems indefinitely. As sustainability discourses increasingly situate entire populations in wider timescales of intergenerational planning and responsibility, regulators and bioethicists increasingly grapple with prospects of emerging human enhancement technologies that may not only alter the tempo of our gradual natural evolution, but could also render irreversible effects on our descendants in futures both near and distant (Bainbridge & Roco, 2003). With contexts like these in view, the Yucca Mountain Project can be recast as but part of a broader historical moment in which human inclinations to know, to destroy, and to protect are increasingly drawn into previously untapped futures. This historical moment could hence be cast as a response to unprecedented rates of resource extraction, anthropogenic manipulation of the environment, population increase, and expansion in technological capacity. In this sense, this paper has laid ground for analyzing the Yucca Mountain Project not only in comparison with the HLW disposal regimes of other nations, but also with other contexts of similarly longsighted risk governance that have emerged elsewhere in the world.

Second, it has carved out analytical space for examining (a) if and how reinventions of familiar figures of legal, scientific, ecological, or technocratic knowledge are unfolding in other contexts of engagement with markedly deep timescales and (b) whether and how such reinventions could be tapped to improve HLW disposal projects' initiatives to engage similarly deep timescales. Presently, for instance, strategies to extend the ambit of risk governance far into the future are being cultivated in contexts like the RAND Corporation's Pardee Center for Longer-Range Global Policy and the Future of the Human Condition, Cambridge University's Centre for the Study of Existential Risk, Oxford University's Future of Humanity Institute, and Stewart Brand's The Long Now Foundation. They have also been cultivated in more idiosyncratic projects like Norway's Svalbard Global Seed Vault, which was designed to preserve millions of seeds in a "doomsday" chamber to "safeguard the world's crops from future disasters such as nuclear wars" and to create a genetic "back-up" of Earth's reserves of plant life in the face of rampant extinctions and climate shifts (BBC News, 2007). With projects like these in view, context is revealed for research on the reinventions of familiar conceptual figures as they emerge in other contexts of marked long-termism. The goal here would be to explore whether insights garnered amidst similar reinventions unfolding elsewhere could be drawn upon to optimize approaches currently being developed to govern distant future timescales in HLW disposal regimes.

Third, it has perhaps revealed additional clues as to how and why the United States' ambitiously longsighted HLW disposal program ultimately succumbed to conditions so tethered to the here and now. Indeed it is uncertain whether, in the twenty-first century United States, *any* technoscientific project predicated on such conventional or even archaic figures could survive the three decades of political onslaught and epistemic contestation that eroded the Yucca Mountain Project over the years. More specifically, it poses the question of whether the regime's (over) extension of such familiar figures of legal form to encompass such unfamiliar distant future timescales ought to be construed as a response imaginative enough to effectively govern the protracted timescales that it was assigned by law to govern. As an example, while the rationale for reinventing the liberal legal person as a reasonably maximally exposed individual to forge a bottom line standard according to which repository safety was to be gauged might seem self-evident today, it is unclear whether societies thousands of years from now would instead opt to enable entirely different abstract beneficiaries. In other words, rather than working toward enabling a hypothetical individual, perhaps distant future societies would instead frame the HLW disposal project as enabling, say, hypothetical ecosystems, hypothetical human collectives, or sustainable life in general. Or perhaps they would see themselves as enabling conceptual figures of which societies of the present cannot yet conceive.

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Not in Anyone's Backyard?
Civil Society Attitudes towards Wind Power at the National and Local Levels in Portugal

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This article attempts to explain the swift development of renewable energy, in particular wind energy, in Portugal, by assessing the socio-political, community and market acceptance of renewables. We examine, on the one hand, the institutional and policy framework, the approaches to planning, and the ownership of facilities, and, on the other hand, the attitudes of Environmental Non-Governmental Organisations and citizens towards renewable energy in general and local windfarms in particular. Results show that a highly attractive feed-in tariff system and a system of planning decisions at the national level has led to an expansion of wind power, regardless of a less than enthusiastic public opinion and a sceptical environmental movement.

Keywords: renewable energy, public opinion, environmental non-governmental organisations

Introduction

In March 2007, the leaders of the European Union (hereafter EU) made a commitment to implement a highly energy-efficient low carbon economy (EC, 2007). Two years later, through the climate and energy package, they agreed on a set of targets known as the "20-20-20" (EC, 2010), establishing three key objectives for 2020: a 20% reduction in EU greenhouse gas emissions from 1990 levels; an increase of 20% of the share of energy produced from renewable sources in the EU; a 20% improvement in the EU's energy efficiency. Among these key objectives, the most relevant for the present article is the one related to the share of renewable energy (hereafter RE) sources in the overall energy consumption in the EU. This objective has been the main driver for investments in RE across Europe.

The position of Portugal in European rankings concerning social and environmental indicators is usually low. But, when it comes to RE, Portugal is at the top of the list. The percentage of RE in total consumption is already 25% (the goal for 2020 is 31%), which places Portugal in the sixth place in the ranking of the 27 EU member states (Eurostat, 2011). This is mainly due to hydro power (whose inclusion as RE is debatable) and to wind energy, with close to 240 windfarms operating in the country and a few others under construction. Can this be due to a widespread acceptance of RE, both at the general and the local level? Is civil society in Portugal strongly in favour of wind and solar energy? Or, are there other factors at play when it comes to implementing policies aimed at sustainable energy systems?

The two main purposes of this article are to understand the conditions that made possible a swift development of wind energy and to assess civil society's attitudes towards this energy source in Portugal. We have chosen two types of social actors who are usually defined as representatives of civil society – citizens and Environmental Non-Governmental Organisations (hereafter ENGOs) – and two scales at which to gauge their attitudes: the national level, scrutinized by using public opinion surveys and interviews with representatives from ENGOs; and the local level, studied by using the participation of citizens and ENGOs in public consultations of Environmental Impact Assessment (hereafter EIA) processes of windfarms.

Literature Review

Energy issues are urgent environmental, economic, political, and social challenges. The threats of climate change and the scarcity of conventional energy sources have led many European countries to increasingly invest in alternative, renewable energy sources. Despite a common agenda set by the EU, European countries have experienced different levels of success in implementing RE. In 2011, RE represented 20% of electricity generation in the EU 27, but with great internal variations: from over 40% in Sweden, Austria, Portugal and Latvia, to under 10% in Belgium, the United Kingdom (hereafter UK) and several Eastern European countries (Eurostat, 2013a). Besides the more traditional hydro power, which is still the main provider of RE, wind energy accounts for much of the growth in RE in Europe. In 2011, it was responsible for generating close to 180 thousand gigawatt hour in the EU27, whereas solar photovoltaic generated only 45 thousand gigawatt hour and tide, wave and ocean energy are still underdeveloped, with 500 gigawatt hour (Eurostat, 2013b).

Several authors have looked into the differences between countries in terms of policy and institutional framework for explaining the diversity in the level of development of wind energy. Wolsink (2000) examined the cases of the Netherlands and Germany, and ascertained that the greater development of wind power in the latter could be attributed to the feed-in tariff, whereas the low level of implementation in the former is due to structural barriers in the electric sector, the actions of political actors and the opposition of ENGOs. Some years later, the same author (Wolsink, 2007a) expanded his comparative scope and sought to understand the rapid wind development in Germany, Denmark and Spain, the slower growth in Sweden, Italy, Greece and France, and the sluggishness in the Netherlands and the UK. He identified as relevant variables the planning regime, the financial support system, the values attached to landscape quality and preservation, and the degree of local ownership of schemes to build windfarms, concluding that the main barrier to wind power development is the top-down planning of large scale developments and that participatory open-ended approaches are fundamental. Similarly, Loring's (2007: 2658) comparison between England, Wales and Denmark verified that "projects with high levels of participatory planning are more likely to be publicly accepted and successful". Conversely, Toke (2005) ascertained that the rate of planning permission approvals is quite low in the UK, but that the development of wind energy has been hindered mainly by problems in the financial incentive system and the lack of uptake by developers (only two thirds of the capacity of contracts issued has even applied for planning permissions). Bell, Gray and Hagett (2005) offer different explanations for the (relative failure) of wind energy in the UK (democratic deficit, qualified support and self-interest) and propose several policy measures that can address them. More recently, the same authors (Bell et al., 2013) expanded their analysis to include place attachment (see below), the relationships between factors, concerns about landscape and fairness, and local relations of power.

Also regarding the policy and institutional frameworks of RE, Jobert, Laborgne and Mimler (2007) drew comparisons between France and Germany and highlighted the role played both by institutional conditions, such as economic incentives and regulations, and by site-specific conditions (territorial factors), such as the local economy, the local geography, local actors and the actual on-site planning process (project management). Breukers and Wolsink (2007) focused again on the cases of Germany (only one of its states), the Netherlands, and the UK and sustain that institutional capacity building is the fundamental factor in wind power development, combining financial incentives, local bottom-up mobilisation and the formation of policy communities. Another, wider, cross-country study by Toke, Breukers and Wolsink (2008) attributes the diverse levels of wind power development in Denmark, Spain, Germany, the Netherlands, Scotland and England to differences in planning systems, financial support mechanisms, the actions of landscape protection and the patterns of ownership of wind power.

Another dimension that many of these studies also cover, but takes center stage in other published research, is the civil society reactions to wind energy and the siting of windfarms. Several authors have sought to explain the success or failure of wind energy development by examining three types of data: attitudes of the general public towards wind energy, ENGOs positions and localised case studies on the resistance to the setting up of windfarms.

With respect to the first, most studies ascertain that public opinion surveys show a generalised support for RE and even for wind energy (Walker, 1995; Ek, 2005; Bell, Gray & Haggett, 2005; Wolsink, 2007b; Aitken, 2009), usually perceived as “clean”, “green” or “environmentally friendly” and as an extension of traditional technologies like wind mills (Pasqualetti, 2001; Nadaï & van der Horst, 2010). However, some authors have pointed out that public opinion on RE is also not homogeneous: there are many “publics”, and attitudes vary across social groups (Walker, 1995; Ek, 2005). Nevertheless, in many cases, literature in this area has identified what has been called a “dilemma” (Barry, Ellis & Robinson , 2008), a “social gap” (Bell, Gray & Haggett , 2005; Breukers & Wolsink, 2007), or an “attitude-behaviour gap” (Haggett & Futák-Campbel, 2011): a mismatch between generalised support to RE and local opposition to the siting of energy-generating facilities, particularly windfarms.

Regarding the particular case of ENGOs, Warren et al. detected what they call a “green on green” controversy: “in the case of wind power there are strong ‘green’ arguments on both sides of the debate. Some environmentalists advocate windfarms because of their ‘clean energy’ credentials, while others oppose them because of their landscape impacts. Still others are caught awkwardly in the middle, supporting renewable energy in principle but opposing specific windfarm proposals” (Warren et al., 2005: 854). Other authors also highlight the critical stance of ENGOs (especially at the local level, against windfarms in particular locations) as a barrier to the development of wind energy in some countries (Walker, 1995; Wolsink, 2000, 2007a; Bell, Gray & Haggett, 2005; Breukers & Wolsink 2007; Cowell, 2010). However, it must be noted that opposition to windfarms stems mainly (but not exclusively) from landscape protection ENGOs, particularly active in the UK, whereas in Germany and Denmark some ENGOs actively support the development of renewables (Toke, 2005; Breukers & Wolsink, 2007; Loring, 2007; Toke, Breukers & Wolsink , 2008).

Although windfarms present very few risks, controversies have arisen in most countries, motivated by concerns over issues such as noise, pollution, health effects and impacts on wildlife (especially birds and bats), but also the perception that the turbines ruin the countryside and threaten natural and cultural heritage, with not only symbolic consequences, but also on tourism and the economic value of properties (Nadaï & van der Horst, 2010; Wolsink, 2007a; Cowell, 2010; Devine-Wright & Howes, 2010; Havas & Colling, 2011; Phillips, 2011).

In the 1980s and 1990s local opposition to the siting of facilities with presumed environmental impacts was often characterised as NIMBY (Not In My Backyard) reactions, that acknowledged the need for such facilities, but refused to accept them in the vicinity (Dear, 1992; Wolsink, 2000). Most current studies on windfarms stress the uselessness of that concept, emphasising instead issues such as feelings of place attachment and identity, planning procedures, perceptions of fairness, transparency and environmental justice, lack of confidence in government and companies, dearth of opportunities for citizen participation and engagement (Walker, 1995; Devine-Wright, 2005; Bell Gray & Haggett, 2005; Jobert, Laborgne & Mimler, 2007; Breukers & Wolsink, 2007; Wolsink, 2007a, 2007b; Barry, Ellis & Robinson, 2008; Aitken, 2009; Devine-Wright & Howes, 2010; Haggett & Futák-Campbel, 2011). In addition, there is neither empirical evidence for the connection between oppositions to windfarms with geographical distance (Walker, 1995; Wolsink, 2000, 2007b; Devine-Wright, 2005; Warren et al., 2005; van der Horst, 2007) nor with positive attitudes towards RE in general (Ek, 2005; Warren et al., 2005; Eltham, Harrison & Allen, 2008).

In an introduction to a special issue of *Energy Policy* (where several of the works cited above were published), Wüstenhagen, Wolsink and Burer (2007) propose a model of social acceptance of renewable energy that encompasses the variety of actors involved and that takes into account both the institutional framework and the siting of specific infrastructures, in short the national and local level. The authors put forward three dimensions of acceptance: socio-political, community and market. The first combines the acceptance by the general public (measured generally by public opinion surveys), by key stakeholders and by policy makers. Community acceptance refers to "the specific acceptance of siting decisions and renewable energy projects by local stakeholders, particularly residents and local authorities" (Wüstenhagen, Wolsink & Burer, 2007: 2685) and is conditioned by perceptions of distributive justice (the allocation of costs and benefits), procedural justice (a fair and participated decision-making process) and trust in promoters. Market acceptance relates to the consumers (in the case of distributed production of energy and green power marketing), investors and intra-firms.

This article seeks to contribute to the existing literature by discussing the case of a southern European country where wind energy development has been significant and swift, but that has been left out of international comparisons, namely, Portugal. In order to draw comparisons with the literature in this area, we will examine the institutional and policy frameworks, in particular the financial incentives, the approaches to planning and the ownership of facilities, on the one hand, and the attitudes of ENGOs and citizens towards renewable energy in general and local windfarms in particular, on the other hand. The purpose, therefore, is to assess both the socio-political, community and market acceptance of renewables in Portugal. For this purpose, we have opted for a combination of extensive methods.

Methodology

Data on the policy and institutional framework comes mostly from document analysis: legislation, policy papers and programmes, parliamentary debates, news articles, companies' reports and websites. The time scope of the document analysis ranges between 1988 and 2013.

The analysis of civil society attitudes towards wind energy combines empirical data from three main sources. Firstly, public opinion data on RE were gathered from Eurobarometer surveys (Eurobarometer 65.3, 2007; Eurobarometer 69.2, 2008; Eurobarometer 73, 2010; Eurobarometer 75.4, 2011), whose databases were accessed via the ZacatGesis website. Data treatment consisted of extracting survey results from Portugal and the EU average of variables related to attitudes towards wind energy. Despite its benefits, notably in terms of cross-country comparisons, Eurobarometer surveys have limitations: the questionnaires are created for policy, rather than scientific aims, and the way questions are built do not fully fit the intended research objectives (Nissen, 2013).

Information on the position of ENGOs regarding RE stems from two different empirical techniques: content analysis of documents (publications, reports, position papers, interventions in seminars, press releases) and interviews with ENGOs' representatives. Six national ENGOs were selected, based on their actions regarding RE (awareness campaigns, public statements, participation in consultation procedures of EIA of windfarm projects): three are the largest ENGOs in Portugal and have a broad scope of action, and the other three are focused mainly on fauna conservation. The interviews were conducted either with the president or with a representative from the specific working group dealing with RE. The interviews were recorded and fully transcribed, and content analysis was undertaken.

Thirdly, local attitudes towards RE were assessed through an analysis of Public Consultation Reports (hereafter PCR) of EIA processes regarding windfarms. We collected 76 PCR, concerning 83 EIA of windfarms, carried out between 2001 and 2012, from the archive of the Portuguese Environmental Agency. These PCR summarize the written comments sent in by public and private entities and were coded in a QDA software to build a database of written comments, identifying the entity that produced them and the orientation of the comment – positive, negative, or conditional. Particular attention was paid to the statements from civil society (citizens, citizen groups, Commons Councils, local entrepreneurs, ENGOs). These data were both used to extract overall statistics on participation in the public consultation of windfarms' EIA and to draw data for discourse analysis.

The data from the PCR have some limitations, since there are some differences in access to the public consultation process by different kinds of stakeholders, mostly due to how information is spread. NGOs and the local authorities are directly informed of the public consultation by the National Environment Agency, but the local population is dependent on the publicity of the public consultation by local authorities, whose interests can be opposed to a broad public discussion of the project (Chito & Caixinha, 1993; Gonçalves, 2002).

In addition, the interviews with the ENGO representatives also provided some information on the limitations of the PCRs as a source of data. The high number of windfarm EIA processes over the last few years limited the NGO's capacity to participate in public discussions as they have limited resources and must divide their attention across several environmental issues.

Much of the research literature in this area has relied on localised case studies, concerning one or perhaps two windfarm projects (Woods, 2003; Warren et al., 2005; Eltham, Harrison & Allen, 2008; Devine-Wright & Howes, 2010; Aitken, 2009). Some publications (Jobert, Laborgne & Mimler, 2007; Loring, 2007) compare the results of several case studies. The work based on local studies has its own strengths, but for the Portuguese context, where the implementation of wind energy was product of a centralized process developed over a short period of time, it is important to also grasp this issue at a broader level.

Toke (2005) followed this kind of approach, by looking at 51 planning applications for windfarms, with their respective decisions, recommendations from local parish councils, planning authorities, conservation and landscape groups. Through a regression analysis, he sought to identify the conditions for approval or rejection of the windfarms. Van der Horst and Toke (2010) also examined the planning decisions of windfarms and appeals in the UK to look at associations with a wide array of geographical and socioeconomic variables. They ascertained that less affluent areas have a higher rate of approvals, which is evidence for environmental injustice and the critical role played by social capital.

Another strand of studies concerns discourse analysis of wind energy supporters and opponents (decision-makers, companies, citizens, ENGOs, local authorities) with recourse to interviews and documents (Barry, Ellis & Robinson, 2008; Cowell, 2010; Haggett & Futák-Campbel, 2011). The study by Haggett and Toke (2006) explored how this two approaches can be used simultaneously, providing complimentary insights into the wind power planning process. In a similar fashion, this article combines empirical data from three main sources, both quantitative and qualitative, at the national and local levels, to provide a better understanding of civil society's attitudes towards wind power.

Development of Wind Power in Portugal

In the past decade, Portugal has made an extensive investment in RE generation. The ambitious target of 45% of electricity from RE sources by 2010 was met and the percentage of RE in total consumption is already 25% (the goal for 2020 is 31%). The main source of electricity through RE is still hydro power (43%), but by a very short margin, since wind energy now represents 42% of renewable energy generation, a sharp increase from the 6% registered in 2004 (DGEG, 2012). In fact, windfarms have grown exponentially in the last decade. After a slow start in the 1990s, with just 18 windfarms functioning by the end of the decade, in December 2013 there were close to 250 windfarms in the country. These windfarms have a total of 2,474 turbines, with the total capacity of 4,730.5 MW (INEGI, 2013).

This sudden development can be explained by a very favourable policy framework in the past decade (in line with the findings of Wolsink, 2000; Ringel, 2006; Breukers & Wolsink, 2007; Toke, Breukers & Wolsink, 2008), as well as by the uptake of wind energy by the private sector. Following Wüstenhagen, Wolsink and Burer 's (2007) model, the political and market acceptance of renewables is assured in Portugal. The first legislation concerning feed-in tariffs for renewable energy was issued in 1988[1] but only a decade later, in 1999[2], was it revised in order to provide stronger financial incentives. In the same year, the 4E programme (Energy Efficiency and Endogenous Energies)[3] was launched, with the ambitious aim of achieving 39% of renewable energy in electricity generation in a decade. Subsequently, in 2002, the first tender for granting rights to connect to the electricity grid was issued, awarding rights for more than 3,000 MW of wind power. The second tender, for connection rights of up to 1,700 MW, was issued in 2005 and also included evaluation criteria aimed at creating an industrial cluster in renewable energies: the winning bids had to include setting up factories for wind turbine manufacture in the deprived areas of the country, in order to generate employment, limit imports and boost exports.

Successive Energy Policy Plans in 2003[4], 2005[5] and 2010[6] and the 2010 National Action Plan for Renewable Energies (following the 2009/28/CE Directive, of April 23, 2009) established more ambitious targets for renewable energy, as well as sets of measures to achieve them, several of which concerning wind energy: higher feed-in tariffs, fiscal incentives, green certificates (through which companies are financially rewarded for the environmental benefits of generating renewable energy), simpler and swifter planning procedures, a new tender for connection rights (which has not been launched yet) and funding for R&D projects.

All these policy measures have mostly favoured large companies, which have bought the bulk of renewables licences, rather than individual or community operators – which are predominant in Germany and Denmark (Devine-Wright, 2005; Warren et al., 2005; Breukers & Wolsink, 2007; Toke, Breukers & Wolsink, 2008). Much like in Spain, which has a similar level of wind energy development (Toke, Breukers & Wolsink, 2008), all windfarm developers in Portugal are large companies: over 80% of the market share is held by just 10 developers, four of which are responsible for approximately 60% of the market share (INEGI, 2013). These four developers are in fact just three companies: EDPr (a branch of the major electric utility company in Portugal), Iberwind (a holding owned by several private equity companies, solely dedicated to wind energy, formed in 1998), Generg (a group owned by a SICAV fund, an open-ended collective investment scheme, and a French multinational electric utility company, that besides windfarms also manages hydroelectric dams and solar power plants) and ENEOP, a consortium of companies (including the three mentioned) that responded to the second tender. These large companies were able to make the bulky investment necessary for building a large number of windfarms in a short amount of time.

The fact that planning decisions on the siting of windfarms are taken at the national level can partly explain such high success rates, as in the Spanish case (cf. Wolsink, 2007a; Toke, Breukers & Wolsink, 2008). Permissions for setting up energy generating facilities are granted by the Energy Department (usually under the Ministry of Economy). EIA, which are mandatory only for larger windfarms (over 20 turbines) located near already existing ones or in protected areas, fall under the jurisdiction of the national Environmental Agency. Smaller windfarm projects in Natura 2000 sites are required to perform an Environmental Effect Assessment (EEA), whose decision is issued by regional authorities.[7]

Between 2000 and 2012, 131 EIA procedures regarding windfarms were conducted, namely, concerning the construction of new farms and the setting up of more turbines in existing ones. Contrary to what happens in other countries, such as the UK and the Netherlands (Bell, Gray & Haggett, 2005; Toke, 2005; Wolsink, 2007a; Loring, 2007; Aitken, 2009; van der Horst & Toke, 2010; Haggett & Futák-Campbel, 2011), the vast majority of windfarm projects were approved (71%) and only 8% were rejected (the remaining were withdrawn by the promoter or found in breach of EIA rules). Local councils also have to give their approval to windfarm projects, by signing an agreement with the developer. But, since developers are legally obliged to pay them a monthly fee of 2.5% of the windfarm revenue, in the vast majority of cases that approval is granted.

With the economic downturn and a change of government in 2011, renewable energy policy suffered a slight reversal. High feed-in tariffs and their costs for consumers had come under heavy criticism from the opposition party (during previous governments) and supporters of other energy sources, namely, the "nuclear lobby". The new government renegotiated the feed-in tariff agreements and revised the National Action Plan for Renewable Energies,[8] with the aim of reducing costs and rebalancing the targets in view of the reduction in demand for electricity, favouring the increase in power in existing windfarms over the construction of new ones. However, the impact of this new policy trend is not noticeable yet.

Overall, it can be said that the development of wind energy in Portugal in the last decade can be attributed to strong policy incentives, centralised planning and decision-making, as well as the investment of large companies in this sector. The question now is: since some literature cited above also postulates that civil society support/opposition (both in terms of general public and local communities) can help/hinder the development of renewable energies, how is the case of Portugal similar or different from other cases reported?

At the National Scale: Public Opinion on Wind Energy

There are few sources from which to gauge the evolution of public opinion regarding wind energy in Portugal, since Eurobarometer surveys do not maintain regular series of data on this issue. Our analysis will, thus, focus on more recent surveys, comparing the way Europeans and the Portuguese population perceive the present and future roles of RE in the energy mix, with a particular emphasis on wind energy.

When it comes to expressing an attitude towards wind energy, the Portuguese show a

Table 1. Attitudes towards wind energy (%).

	In favor	Balanced	Opposed	Don't know
EU 25	82	6	6	5
PT	78	3	3	16

Source: Eurobarometer 65.3 (2007)

tendency to be less favourable to this power source than Europeans in general (Table 1), but that happens not so much as an expression of disagreement, but mostly due to the number of people who feel unable to answer this question. This is more due to lack of knowledge than to a clear opposition.

When we stretch the timescale to 2050 (Table 2), we can find some differences between the opinions of Portuguese and Europeans regarding future visions of RE use. Thus, in a recent Eurobarometer survey (2011), the Portuguese were amongst a small group of European countries (including Poland, Romania, Italy, Lithuania, Bulgaria and Hungary) that were less likely to believe in the wide use of wind and solar power as energy sources in 2050 (Table 2). The most positive outlook came from Denmark (82%) and Sweden (79%) (see also Ek, 2005). Moreover, 10% of Portuguese citizens (against 4% of Europeans) answered “don’t know” to this question, which shows a difficulty in perceiving the role of RE in the future.

Table 2. Expectations of using renewable energy sources (e.g. wind and solar power) more than now in 2050 (%).

	PT	EU25
Yes, definitely	32	51
Yes, probably	50	38
No, probably not	5	4
No, definitely not	1	1
No change	2	1
Don’t know	10	5

Source: Eurobarometer 75.4, (2011)

Such results may be attributed to several factors. On the one hand, attitudes towards wind energy in Portugal tend to be more favourable in social groups with a higher educational attainment, and literacy levels in Portugal are low. Second, there has been a clear increase in the number of windfarms in Portugal, particularly since 2004 (see above). The more marked presence in the landscape and the need to live with some of the less positive aspects of these energy infrastructures might form the basis of a slightly less favourable attitude towards wind energy, when compared to the European average. As has been seen in case studies around Europe, especially when analysing local cases of opposition to this source of energy, different reasons emerge as justification and many are related to factors such as noise, pollution, health effects, impacts on wildlife or aesthetical and cultural values resulting from the need to live daily with these energy infrastructures (Nadaï & van der Horst, 2010; Wolsink, 2007a; Cowell, 2010; Devine-Wright & Howes, 2010; Havas & Colling, 2011; Krough, 2011; Phillips, 2011). Along with this increased visibility, there is another possible explanation that has more to do with the public debate around the costs of RE and incentives that are being given to RE producers and its impacts on energy prices for the consumer. Although this needs to be confirmed with other empirical data (notably from media analysis), we believe that this debate may have contributed to a change of opinion regarding RE, particularly in a context of economic crisis.

At the National Scale: ENGO Positions on Renewable Energy

According to several authors (Wolsink, 2000; Toke, 2005; Eltham, Harrison & Allen, 2008; Toke, Breukers & Wolsink, 2008), ENGOs, in particular the ones dedicated to landscape protection, have also been instrumental in contesting or even blocking the construction of windfarms, whereas their absence (such as in Spain) has been used to explain the success of wind energy projects.

In Portugal, a similar situation occurs. At the national level, however, there are no specialized landscape protection ENGOs. Three of the twelve national ENGOs can be described as "generalist", in the sense that they act in a variety of fields (nature conservation, energy, climate change, water issues, etc.) and the others are focused on wildlife (birds, wolves), leisure activities, animal rights, organic farming, or heritage. At the local level, ENGOs tend to campaign on a variety of issues, including landscape protection.

Only a handful of ENGOs carry out activities on the issue of wind energy, since, on energy matters, hydroelectric dams are a much more pressing issue for Portuguese ENGOs.[9] Activities concerning RE take the form of awareness campaigns (with dissemination materials, such as booklets), participation in scientific seminars, publication of reports (for example, on the impact of windfarms on birds), media statements or press releases, written comments to EIA processes and judicial actions (e.g. injunctions, lawsuits, complaints to the European Commission).

Regarding their stance on RE, no significant differences were found between the discourses of "generalist" and specialised ENGOs. Almost all interviewees took care to highlight the role of RE sources in climate change mitigation and the dire need to replace fossil fuels, in what could be a case of what Haggett and Futák-Campbel (2011: 213-214) identified as a "disclaimer", a means for "avoiding the dismissal of one's claims as being biased, ill thought through, or just what would be expected of someone in this position, and orienting to the fact that wind power is thought to be popular":

> We obviously acknowledge the serious problems our planet is facing, connected to the greenhouse effect and to the depletion of the ozone layer, and climate change on a global level, and we recognise that fossil fuels are the main responsible for climate change. [...] And so we are favourable in general to the replacement of carbon based energy by energy from renewable, non-polluting sources (Interview ENGO6).

However, all also highlighted the existence of negative environmental impacts and the need to evaluate them and to strike a balance between the protection of different values, an ambivalence also identified in other studies concerning ENGOs' stance on RE (Walker, 1995; Bell, Gray & Haggett, 2005; Warren et al., 2005; Breukers and Wolsink, 2007):

> We are obviously in favour of renewables. But there are two principles we advocate: the cost/benefit principle and the precautionary principle. Both in wind and solar power, we have very negative impacts, especially in wind energy, due to the turbines and the choice of the location. [...] And when we don't know the potential negative effects, we shouldn't build. [...] The second principle is how far should we invest when there are better forms of generating energy or better solutions (Interview ENGO2).

Conversely, much of the discourse of ENGOs representatives on windfarms tends to focus on its negative effects. They use much the same justifications that are commonly mentioned in the literature (Wolsink, 2000; Devine-Wright, 2005; Warren et al., 2005; Barry, Ellis & Robinson, 2008; Eltham, Harrison & Allen, 2008; Cowell, 2010) and in the public consultations of EIA (see below): the endangerment of animal and plant species, the defacement of natural and cultural landscapes, and the noise of the turbines. In most interviews, especially with

ENGOs focused on nature conservation, the macrogeneration of RE is an option that should best be avoided, in favour of energy efficiency (a similar discourse to ENGOs in other countries, cf. Barry, Ellis & Robinson, 2008).

ENGOs are also highly critical of the way the process of expanding RE has been conducted in Portugal, namely, the lack of planning and the "rush", which is an argument also identified by other studies (Warren et al., 2005; Cowell, 2010; Haggett & Futák-Campbel, 2011; Jobert, Laborgne & Mimler, 2007):

> First, they should have done an overall study and then, after this study, analysing its impacts, its advantages, then use the solar and wind energy. [...] The government should have planned all this. (Interview ENGO3).

Another point of contention is the favouring of concentrated production and large companies, instead of the more consensual community-owned production (Breukers & Wolsink, 2007):

> The investment in microgeneration is bound to fail. If this continues to be controlled by two or three companies, there is no room for individual investors. If you have a two acre farm, you could place there a couple of solar panels or a couple of turbines. But, you face a lot of hurdles, you have no incentives and you must supply the power to the network, instead of using it directly. It's just a lot of obstacles, there is no political will; there has never been any political will to solve this and to allow the use of more renewables. The political power is stuck on three or four electrical companies in Portugal (Interview ENGO6).

Nevertheless, several interviewees expressed concerns at the change in political priorities since the current government came to power in 2011. Tax incentives for RE have been revoked, subsidies have been reduced and new legislation under discussion would end the acquisition and tariff guarantees, which will severely discourage energy producers from investing in RE.

ENGOs are also quite dissatisfied with how the media is portraying RE. In accordance with a strong policy emphasis in the implementation of RE in the country, these technologies gained a "very positive" image, as one interviewee says, being conveyed as harmless and misleading the media into disregarding its negative impacts (this was also pointed out by Afonso and Mendes, 2010):

> There is in society the big dogma that this [renewable energy] is the solution, this will solve [...]; this is very good, there is absolutely no problem with this. And I think that sometimes even the media end up not making a very thorough search of what are the negative impacts associated with this and, above all, what are the alternatives (Interview ENGO2).

The media could be a channel for claims-making by ENGOs. However, the media coverage of their claims and of environmental issues in general seems to be in a stage of gradual decline of public interest. One explanation offered for this phase of the attention cycle of environmental issues coverage is the current economic crisis that affects both the editors' perceptions of audience's interest and of what issues should be allocated greater salience, and also the media system itself, which is reflected in reductions of the number of reporters and the time they can devote to each story and, hence, their capability of conducting their own research. Additionally, due to their complexity, news coverage of energy issues requires some specialized and interdisciplinary knowledge that only a few reporters have (Horta, 2008).

At the Local Scale: EIA of Windfarm Projects

At the local level, it is the actual location of windfarms that may have an impact on the attitudes of civil society. In Wüstenhagen, Wolsink and Burer's (2007) model, this pertains to the dimension of community acceptance of renewables. In Portugal, there is only one offshore windfarm, since the coastal sea bed is too deep. Most windfarms are located in mountain ranges in the North and Centre regions of the country, as well as close to the coast north of Lisbon. Moreover, the most favourable locations for windfarms tend to coincide with natural parks, protected landscapes and other conservation areas (Afonso & Mendes, 2010), which raises a point of contention.

We have taken the Environmental Impact Assessment processes of windfarm projects – namely, participation in public consultation – as an indicator of civil society attitudes on wind energy at a local level. EIA procedures establish a mandatory public consultation period, in which the Non-Technical Report is made available and written comments from public and private entities are received. Although it is only a minority that participates in these procedures, these comments, favourable or unfavourable, can be taken as an indicator of attitudes towards local windfarm projects and shed light on potential controversies.

However, the limitations of these reports as empirical evidence must be acknowledged. The conditions under which EIA public consultation takes place in Portugal have been the target of criticism, pointing out that the hearings are used mainly to inform the public rather than to foster debate (Lima, 2004: 154) and that various strategies are mobilized to discourage participation: scant publicity of projects, difficult access to documentation, failure to provide design alternatives, discussion of works already under construction (Chito & Caixinha, 1993). As Gonçalves notes,

> The difficulty of applying EIA legislation in Portugal has its roots in a double institutional limitation, which has affected the incorporation of scientific and public opinion into EIA procedures. The relative weakness of the Portuguese scientific system and the lack of institutionalised forms of scientific advice for public administration [...], together with an inactive civil society, has contributed to maintaining the status quo of traditional administrative practice, which is most typically centralised, hierarchized and secretive. (Gonçalves, 2002: 251)

In fact, out of the 76 public consultation reports (PRP) analysed in our research, only 44 mentioned the participation of civil society (citizens and non-governmental organisations). The majority of comments are technical statements issued by government bodies, in charge of the environment, tourism and culture, national defence, communications, energy and transport, as well as regulators and large private companies in the same domains. Local authorities also sent written comments in slightly under half the cases of public consultation (32), of which the vast majority (56 in 61 comments) were in favour of windfarms (especially because they receive financial compensation, as mentioned above), albeit stipulating conditions in most cases.

Citizen participation in EIA

In the last decade, citizens participated in only 24 of the 76 public consultations regarding windfarms. In total, we identified 40 written comments from citizens, citizen groups and local entrepreneurs, concerning 30 windfarm projects to be implemented in different parts of the country. We found both favourable and unfavourable comments from citizens regarding the windfarms, although the EIA limitations stated above prevent us from drawing firm conclusions on the local communities' responses based on the number of positive and negative comments. Concerning the outcome of these 30 windfarm projects, only four were rejected and one was withdrawn by the promoter before the completion of the EIA, while the remaining were conditionally approved (though mitigation measures were imposed).

These comments enable us to draw a picture of the arguments in favour and against the siting of windfarms deployed by citizens. As shall be seen below, attitudes towards windfarms diverge mainly on account of impacts: whereas economic impacts can be seen both as an argument for and against windfarms, environmental and landscape impacts (as well as, on a smaller scale, effects on health and quality of life) are always mobilised to reject proposals.

As to the favourable comments, in line with international research (Woods, 2003; Toke, 2005; Jobert, Laborgne & Mimler, 2007) and with the case study of the proposal for a windfarm in Montesinho (Afonso & Mendes, 2010), citizens mostly underline the positive inputs windfarms bring to local development. For example, in one comment, 331 local residents "show support to the implementation of the project, for considering it as an asset that will contribute to a more sustainable development of the region and to national energy sustainability" (PCR 2255). Likewise, in another RPC, three local associations stated that they "welcome the implementation of the project, viewed as a great asset for this demographically and economically depressed region [...], [through] encouraging population growth and settlement" (PCR 772).

However, even favourable comments are often interspersed with some concerns. Two major issues emerge, the first of which is the route of power lines, which is referred to mainly in terms of health and visual impacts. Though the problems posed by power lines are far from exclusive to wind energy, the sheer number of windfarms (compared to other energy generating facilities, both renewable and non-renewable, far less frequent in Portugal) and their remote location has called for the construction of many more lines. For instance, regarding a windfarm project, the Commons Council[10] argues that "a set of measures should be taken in order to mitigate the inherent impact", including

> ...monitoring of avifauna and the death of birds by collision, the placing of underground power lines [and] the reformulation of characteristics of wind turbines, the choice of colours to better frame the turbines [in the environment] [and] the use of architectural solutions: materials, colour, volume (PCR 1769).

The second recurring issue is the installation of wind turbines on lands whose owners were not previously notified. For example, with regard to several windfarm projects, one Commons Council states that "despite being in favour of the deployment of such infrastructure", complain that "it should have been contacted about the implementation of some wind turbines in the commons under its ownership" (RCP 1138 and 1139).

The unfavourable comments address several major recurring topics of concern. The first one relates to the environmental impact of the windfarms. For example, a local resident:

> ...refutes the information contained in the EIA due to multiple errors, namely, in terms of fauna and flora assessment and the conclusions presented. It considers that the Iberian wolf is particularly affected, because it is a species in danger of extinction and some wind turbines will be located in areas of high importance for the species, namely, reproduction areas (PCR 1769).

The second cause for complaint concerns the socio-economic impact of windfarms. Regarding another windfarm project, a local tourism entrepreneur criticizes the EIA due to:

> ...the low importance given to the natural values identified, the assessment of sound impact, [...] the compatibility of the project with the instruments of land management, the magnitude of the impact on the landscape, [...] and the fact of not taking into consideration aspects related to Rural and Nature Tourism, currently the main points of local investment, in the analysis of socio-economic impact (PCR 2034).

Another major topic of concern, already mentioned in the previous quotation, is the impact on the landscape, often associated with the visual intrusion of turbines and overhead power lines and its negative effects on tourism, an issue also highlighted in research undertaken in other countries (e.g. Walker, 1995; Wolsink, 2000; Pasqualetti, 2001; Woods, 2003; Warren et al., 2005; Wolsink, 2007b; Eltham, Harrison & Allen, 2008; Cowell, 2010; Devine-Wright & Howes, 2010; Jobert, Laborgne & Mimler 2007; Toke, Breukers & Wolsink, 2008). Regarding one windfarm project, a local tourism company focusing on mountain and nature activities

> ...considers that the project should be located out of the [Serra da Estrela] Natural Park and the Mondego valley, since it will significantly affect the landscape and tourism, contributing to the desertification of this region. It refers that the impact on the landscape is huge, leading to the adulteration of nature and affecting the visual and sound quality, the harsh character, the diversity of shapes, colours and texture, and the pattern of calm that, until now, were the main assets of this region, attracting tourist flows from large cities and abroad. (PCR 2034)

A fourth topic of apprehension is the impact of windfarms on health, which is usually associated with overhead power lines, water contamination and noise. These concerns are increasingly echoed in the literature (Havas & Colling, 2011; Krough, 2011; Phillips, 2011). For example, citizens living in a close-by village

> ... contest the implementation of four energy generators, for considering them too close to the village, and point out a number of negative effects, such as noise pollution, contamination of groundwater resources due to oil change of wind turbines, and even lack of knowledge about other negative impact such as radioactivity (PCR 978).

A final major topic of concern, already present in the previous quotation, is the impact on the quality of life of residents. One Commons Council is of the opinion that the local windfarm project "neglects aspects needed for the preservation of the quality of life of people" (PCR 1302).

In conclusion, within the EIA, local opposition to windfarms by residents is scarce. First, most public consultations receive no comments from citizens, which can be construed both as a sign of acceptance (many windfarms are located in such remote areas that no populations are affected) or as evidence for the poor dissemination these participation procedures receive and a weak civil society in Portugal (Gonçalves, 2002). Second, when they do participate, several of the comments from citizens are in favour of windfarm projects. And in the case of unfavourable comments, they seem to have little impact on the administrative decision, since most windfarms are approved.

However, it should be noted that participation in public consultations is a restricted indicator of citizens' attitudes towards RE in specific local settings, albeit the only one that is able to give a general picture without resorting to an accumulation of case studies (which though valuable, are time and resources consuming and outside the scope of this article). Public consultation is mainly geared towards the expression of opposition rather than support (Bell, Gray & Haggett, 2005). Literature shows that the acceptance of windfarms tends to grow over time, especially when they are already built (Wolsink, 2000, 2007a, 2007b; Pasqualetti, 2001; Bell, Gray & Haggett , 2005; Devine-Wright, 2005; Warren, et al., 2005; van der Horst, 2007; Eltham, Harrison & Allen , 2008). But also, controversies can occur after the EIA process, at the time of the construction or when the windfarms start to operate. Research has shown that local populations in Portugal have other ways of expressing dissatisfaction and protesting against what they perceive as environmental hazards, such as road blocks, public demonstrations and picketing at the proposed locations (Figueiredo & Fidelis, 2003).

ENGO participation in EIA

Between 2001 and 2012, out of a total of 76 public consultations, only in 31 cases have ENGOs submitted written comments. We identified 55 comments from 17 ENGOs, six of a national scope (the ones covered by the interviews analysed above) and 11 of a local character. Local ENGOs usually submit comments only to one EIA, regarding a windfarm in their area of interest (an exception is a local ENGO that submitted seven comments, but it concerns an area in which there are multiple windfarm projects), whereas all national ENGOs have taken part in several EIAs. About a third of public consultations received comments from more than one ENGO (in two cases four ENGOs took part) and in five cases a group of ENGOs coordinated their efforts by submitting a joint written comment:

> Once in a while [we act together]. The aim is to pull together resources. [...] So together we have a more powerful voice. (Interview ENGO5)

Absence of participation in public consultation of EIA should not be interpreted as unconditional support to the construction of the windfarms. The interviews with ENGO representatives also shed light on how ENGOs become involved in these processes. The role of local ENGOs or of local chapters of national ENGOs is crucial for signalling cases where intervention is needed to safeguard environmental interests. Where these groups or organisations do not exist, EIA of windfarms can go unnoticed:

> Regarding windfarms, our criterion [for intervening] is whether there are impacts or not. But above all, what is more decisive is if there is a regional structure of ENGO2 in the vicinity of the windfarm. I fully admit that there

> may have been windfarms with impacts over the fauna or the landscape even worse than the ones we contested but just because there was no one there, no ENGO2 branch with the time, the experts or the motivation to complain. (Interview ENGO2)

The high number of processes and the wide range of fields in which ENGO act, as well as their lack of financial and human resources, makes it impossible for them to assess each case.

As expected, ENGOs comments were largely unfavourable to the construction of the windfarms (41 out of 55 comments). The remaining comments, though favourable to the construction, stressed the need for the inclusion of missing information in the EIA (such as the path of power lines and the number of pylons), the importance of taking into consideration the cumulative impacts of several windfarms in the same area and the inclusion of specific mitigation measures.

As to the unfavourable comments, a handful (especially in public consultation reports from the beginning of the decade) included an initial acknowledgement of the benefits of wind energy in terms of replacing fossil fuels and mitigating climate change (as well as other positive aspects, such as the turbines being manufactured in Portugal), followed for specific reasons for rejecting the project. But, the vast majority focused solely on the negative effects of windfarms.

The arguments presented by ENGOs focused mainly on environmental issues, such as the negative impact on animal species, especially birds and bats (excess mortality by collision and electrocution from power lines) and wolves (classified as an endangered species, windfarm construction disrupt their habitats, breeding habits and communication between different populations), on trees and vegetation, on habitats (loss or fragmentation), and on geological features. Social and cultural aspects are also mentioned: the negative impact on archaeological sites and monuments, the destruction of the landscape and the disturbance of local inhabitants, through noise from the turbines, devaluation of property, inconveniences caused by construction work and misuse of economic profit from land rental (construction of roads instead of social benefits and requalification of villages).

While in only one case the size of the windfarm (number of turbines) is cited, ENGO comments often mention cumulative effects of several windfarms in the same area and with other structures (roads, mines and quarries, hydroelectric dams) and the failure of individual EIA in accounting for them. Other sources of negative impacts pointed out by the ENGOs, besides the turbines and the windfarms themselves, are the construction works (widening roads, reinforcement of bridges, disturbance of local populations), the power lines that connect the windfarms to the grid (affecting especially birds and the landscape) and access roads: previously inaccessible, unspoilt areas become reachable, causing disturbances to fauna and flora, illegal hunt and collection of plants, and fire hazards.

Many ENGOs' unfavourable comments are based on the perceived deficiencies of the EIA: incomplete inventory of affected species, lack of cartographical detail, undervaluation or overlooking impacts, failure to consider alternative locations, insufficiency of mitigation measures. In many cases, the argumentation of ENGOs also points out the disregard of regulations, national legislation or European directives, by proposing to implement windfarms in protected areas (natural parks, Natura 2000, special areas for the conservation of animals and habitats).

The tone of these comments is mostly objective, relying mainly on legal, technical and scientific arguments. As Aitken (2009) has demonstrated, expert knowledge carries far more weight than local knowledge in windfarm planning decisions. ENGOs rely on their own scientific resources to prepare these comments, since their members are usually highly qualified: many have Ph.D. in biology or environmental engineering, many are academics.

There are a few exceptions, chiefly from local, less professional ENGOs, that tend to use more emotional arguments in their comments: e.g. "The construction of these windfarms is an *aggression* that will endanger, in the medium and long run, the fundamental dual purpose of preserving and make profitable the mountain area" (PCR 1041). Arguments about the effects on the landscape also tend to be more expressive, relying on the use of adjectives and contrasting the artificial character of turbines with the natural character of landscape:

> The landscape impact is undervalued, since it transforms one of the places where human presence is least felt into a *highly artificial landscape*, where 17 126m turbines will negatively affect its relation with the surrounding area, *irredeemably transforming* a scenery of *rare beauty.* [...] Having been created the Protected Landscape of the Mountain of Montejunto, and since preserving the landscape is the main motivation for the classification of these places, there is a clear paradox in setting up a windfarm at that location. (PCR 2449; emphasis added)

Despite the mostly negative statements of ENGOs, only in six cases did the final decision of authorities in these EIA cases go against the construction of the windfarms and these were mostly cases in which several ENGOs expressed a negative opinion, although some of the more contentious projects were approved, as also happens in other countries (cf. Bell, Gray & Haggett, 2005). As seen above, most EIA decisions of windfarms have been favourable, and some ENGOs feel quite powerless in this regard:

> The administration is impervious [to our negative comments]. [...] I think that ENGO activity on this issue in the past few years has had very few results. And when a windfarm isn't built, it's not because of the ENGOs. ENGOs bring the issue to the attention of public opinion, of media, and they help a little, they do. But the main role is played by the experts of the Environmental Agency (Interview ENGO1).

However, for other ENGOs, a conditional approval, listing mitigation measures for the windfarms, can be enough to allay their concerns. Nevertheless, ENGOs have other resources to try to prevent the construction of windfarms, namely, starting petitions, filing lawsuits and even complaints to EU authorities. These are on occasion successful and windfarm construction is stopped or restrictions are placed on their operation.

Conclusion

It is often said that social acceptance is a prime factor for the development of renewable energies, which have been touted as the main solution for mitigating climate change and addressing the foreseeable depletion of fossil fuel reserves. Local opposition to windfarms has been blamed for hindering their siting and is in contrast with strong public support for RE.

This article sought to contribute to the existing literature by discussing the case of a southern European country where wind energy development has been significant and swift, but that has been left out of international comparisons, Portugal. In a country that has made, during the last decade, a massive investment in RE generation, particularly through wind power, understanding social attitudes towards RE is a relevant endeavour. This was carried out by using a two scale analysis (national and local) and taking into account two types of social actors: ENGOs and citizens. Considering the national level, data from the public opinion surveys show a less favourable attitude of Portuguese citizens regarding wind energy, compared with their European counterparts. These results are reflected in the future of energy sources, as the Portuguese are more sceptical about the wide use of RE. This can be partly explained by the literacy and environmental information levels of Portuguese population (lower than the EU average), as well as by the rapid growth of windfarms and the recent public debate regarding the costs for the consumer at the onset of the economic crisis.

Empirical evidence from the analysis of the interviews with ENGOs representatives highlighted their ambivalence towards RE. In what Warren et al. (2005) called a "green on green" controversy, ENGOs support the development of clean energy but at the same time show concerns over the negative environmental effects of windfarms, and often oppose them at the local level, by participating in public consultations of environmental impact assessments with unfavourable comments, focusing mainly on negative environmental impacts (particularly regarding effects on local fauna and flora), as well as social and cultural aspects (mostly the destruction of the landscape). Other relevant apprehensions expressed by ENGOs are related to the way the process of expansion of RE has been conducted in Portugal (poor land use planning and top-down decision processes), the favouring of large companies in the production of wind energy (concentrating power in a few energy corporations) and the mass media coverage of RE, which fostered a very positive image, disregarding negative impacts and expert opinions.

At the local level, the analysis of the public consultation reports of EIA of windfarm projects allow us to conclude that social participation regarding this matter, as other spheres of social concern, is still scarce in Portugal. However, when citizens do participate, positive comments outnumber (although slightly) negative ones. These are mainly related to the positive impacts windfarms can have on local development. The main concerns expressed by citizens in these processes were related to five main topics: environmental impacts, socioeconomic impacts, landscape impacts often associated with the visual intrusion of the turbines and its negative effect on tourism, health impacts and negative effects on the quality of life of local population.

Thus, local attitudes towards windfarms are also varied. Local authorities and citizens tend to favour the siting of windfarms, whilst ENGOs, often sustained on legal and scientific evidence, tend to oppose them. Despite these objections, public administration nearly always approves the projects.

This is probably the main factor that explains the success of wind energy in Portugal. In line with the work on the policy and institutional framework of RE (see Table 3), Portugal has had (until now, at least) a highly attractive feed-in tariff system, but not the participatory open-ended approaches that explain the success of renewables in Germany and Denmark. Unlike the UK, Netherlands and France, where top-down planning of large scale developments has hindered the development of RE, in

Portugal (and in Spain) a strong centralised and administrative tradition (inherited from an enduring authoritarian state that lasted between 1933 and 1974) that has yet to fully come to terms with open, democratic and participatory approaches, has led to an expansion of wind power, regardless of a less than enthusiastic public opinion and a sceptical environmental movement. In addition, ownership of the windfarms is often private or a combined partnership of private-public sectors (as occurs in Spain), whereas community owned windfarms, that tend to be less controversial in other countries, are rare (Walker, 1995; Devine-Wright, 2005; Warren, et al., 2005; Wolsink, 2007a; Breukers & Wolsink, 2007; Jobert Laborgne & Mimler, 2007; Loring, 2007;

Table 3. Factors that support or hinder the development of renewables.

	UK	Nether-lands	France	Germany	Denmark	Spain	Portugal
Positive factors							
Feed-in tariffs				(3) (5) (7) (9) (12)	(7) (9)	(7) (9)	X
Participatory approaches to planning				(3) (5) (13) (14)	(6) (9) (13)		
Predominance of local ownership of facilities		(9)		(9) (11)	(6) (9) (11)		
Government intervention in planning				(7) (9)	(9)	(9) (14)	X
Support of ENGO/ grassroots				(3) (9)	(6) (9)		
Negative factors							
Top-down planning	(1) (2) (3) (4) (6) (10) (13)	(3) (12)	(5) (14)			(2) (9)	X
Insufficient incentives	(3) (8) (9)	(3) (9) (12)	(5) (14)				
Opposition of local authorities	(3) (8) (9) (11)	(3) (9) (14)	(5)				
Opposition of ENGOs/landscape protection groups	(1) (2) (3) (4) (8) (9) (10) (11) (13)	(12)	(5)				X
Predominance of company ownership of facilities	(6) (9) (11)		(5) (14)			(9)	X
Slow uptake by developers	(8)						

(1) Bell, Gray & Haggett, 2005; (2) Bell et al., 2013; (3) Breukers & Wolsink, 2007; (4) Cowel, 2010; (5) Jobert, Laborgne &Mimler, 2007; (6) Loring, 2007; (7) Ringel, 2006; (8) Toke, 2005; (9) Toke, Breukers & Wolsink, 2008; (10) van der Host & Toke, 2010; (11) Warren et al., 2005; (12) Wolsink, 2000; (13) Wolsink, 2007a; (14) Wolsink, 2007b.

Toke, Breukers & Wolsink, 2008) (see Table 3). Returning to Wüstenhagen, Wolsink and Burer's (2007) model, in Portugal political and market acceptance are, thus, assured, whereas communities and stakeholders are mostly ambivalent, but almost powerless against a centralised form of decision-making. This goes to show that when it comes to promoting renewable energies across Europe, "one size fits all" models are inadequate. Political and administrative practices and traditions have a strong bearing on the outcomes of energy policy.

Given the importance of institutional settings within varied national contexts to understand consensus or controversy of civil society attitudes regarding renewable energy, and particularly wind energy, it is suggested that future research could benefit from historical analyses of state and science co-evolution and their relationships with the market and civil society. The case of Portugal illustrates the need for more research on these relationships given much of the explanations for the findings of this study fell back onto some of the features of a heavy, centralised, highly hierarchized and secretive public administration inherited from the past, as poignantly noted by Gonçalves (2002).

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Notes

1 Decree-Law n. 189/88, May 27 1988.

2 Decree-Law n. 168/99, May 18, 1999.

3 Resolution of the Council of Ministers n. 154/2001, September 27, 2001.

4 Resolution of the Council of Ministers n. 63/2003, April 28, 2003.

5 Resolution of the Council of Ministers n. 169/2005, October 24, 2005.

6 Resolution of the Council of Ministers n. 29/2010, April 15, 2010.

7 Decree-Law n. 69/2000, May 3, 2000; Joint Dispatch of the Ministers of Economy and Enviroment and Territorial Planning n. 583/2001, July 3, 2001.

8 Resolution of the Council of Ministers n. 20/2013, April 10, 2011.

9 The National Program of Dams with High Hydroelectric Potential, created in 2007, foresees the construction of ten large scale projects with severe environmental impacts.

10 These nearly extinct traditional structures have gained a new lease on life due to wind farms, since a great number of projects fall under their jurisdiction and they are in charge of negotiating conditions and redistributing benefits (Afonso & Mendes, 2010).

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The Meanings of Practices for Energy Consumption – a Comparison of Homes and Workplaces

Jenny Palm and Sarah J Darby

We examine how building and appliance technologies relate to their use by occupants through practices at home and at work. The aim is to analyse how practices are influenced by buildings and other technologies and by social requirements and to add to ongoing research on how to contribute to a transition to more sustainable everyday practices. Interview, quantitative and observational material are used to compare experiences of occupying and using two different types of buildings, passive housing and large modern research laboratories. We apply the practice theory approach. The passive house case showed that the main project of a liveable, low-impact new building was on a fairly manageable scale, with a viable design and occupants who were prepared to adapt to it. The research lab study showed, however, that the configuration of unsustainable technologies and practices can occur at the design stage, and that most actors had very limited room for manoeuvre.

Keywords: practice theory, low-energy building, tenants

Introduction

Recent years have seen increased interest in ameliorating global warming, and considerable attention has been paid to energy-related emissions. The EU Directive 2012/27 states that, by the year 2020, EU member states should improve their energy efficiency by 20% compared with business-as-usual projections. This applies to all end users, and is to be achieved through measures in all sectors. In the EU, the building sector accounts for approximately 40% of total energy demand. This is one reason why we see increased interest in energy-efficient buildings, and in practices that reduce the demand for fuel and electricity.

A building's design always includes an idea on how the building will be used, according to Gieryn (2002). These kinds of ideas are not necessarily conscious but embedded in norms and social structures. Yet they still have consequences for the occupants of the building. From a sociotechnical perspective, researchers have long emphasized that the ways in which a building is used have great impact on its energy performance (Wilson & Dowlatabadi, 2007; Moezzi & Lutzenhiser, 2010; Gram-Hanssen, 2010). Studies have also shown that users have greater impact on energy consumption than designers and constructors usually estimate (Pett & Guertler, 2004; Steemers & Yun, 2009). In order for our understanding of energy use in buildings to increase, we need to go beyond simplistic references to unpredictable 'user behaviour' to explain weak energy performance (e.g. Gill et al., 2010). Social studies of science and technology have also shown different interpretations and uses of design to be possible, and that intentions and political ideas can be built into design (Stewart & Williams, 2005). Early work on this perspective traced ideas built into technology by designers and producers (Glad, 2012) and, more recently, social learning related to the use of different energy technologies has been acknowledged (e.g. Darby, 2006; Rohracher, 2006; Stagl, 2006; Vergragt & Szejnwald Brown, 2006). Designers and users of modern technology need to think about the contexts in which technology will be used, even if everyday life use offers endless variations. Sørensen (1996) has emphasised that technologies of everyday life form heterogeneous networks of technology hardware, software and the social systems of routines and culture. Shove (2003) has stressed the importance of studying *normal* practices, since much of our resource consumption is embedded in everyday life activities, habits and routines.

More research is needed regarding the actual use of energy efficient buildings, and the ways in which low-energy-demand practices can be developed in an everyday context at home and at work. Not so much research has been conducted on this, and too often it is more or less taken for granted that, for example, technological provisions alone will reduce energy use and greenhouse gas emissions. In this article we will focus on energy use in passive houses and research labs designed for 24-hour use, using practice theory as our analytical framework. The passive house concept is described in more detail below, but the idea is to minimize heating needs by creating an air-tight building envelope and to gain "passively" the heat from the sun, the tenants themselves, and the equipment installed in the house. The four research labs were designed to be used as 24-hour buildings and were built at a time when the university responsible for them had adopted a target to reduce carbon emissions by 20%. The buildings were designed with slightly different technical approaches to heating, cooling and ventilation, as outlined below, but with a very similar approach to function and management.

Practice theory has been increasingly used in relation to domestic energy consumption over the past decade (Gram-Hanssen, 2010; Wilhite, 2008) but rarely applied to energy use in non-domestic buildings. We reflect on energy-related practices in both homes and workplaces, in order to discuss similarities and differences and to find out if a multi-sited methodology approach can shed new light on practice theory and contribute to new lines of questioning. The practice theory framework will be used to examine the implementation of passive housing in Linköping, Sweden and 24-hour research labs in Oxford, UK. Since both passive houses and 24-hour research labs are innovative design approaches, we can expect that they will challenge occupants' practices and that these contrasting case studies are highly suitable for assessing how unfamiliar technology influences practices. The homes and workplaces under discussion are in different countries, but they reflect developments in building design and user practices that may be seen in cool temperate climates generally. As most adults in industrialised countries routinely move between the home and the workplace, adopting what they see as appropriate practices for each, it seems reasonable to consider them together: "the multi-sited approach feels necessary in many circumstances as a faithful reflection of lives lived not in discrete locations, but through various forms of circulation and connection" (Hine, 2007: 656).

Material factors contribute to, and set limits on, the potential to reduce energy use in a building, and the design of new buildings will have consequences for occupants' energy patterns for decades to come. Our research casts some light on how user practices relate to the fabric of a building and the technologies inside it. The aims are to apply practice theoretical concepts to buildings that have been specially designed to be innovative, and to analyse in general terms how practice theory can be used to improve the understanding of energy use in buildings and contribute to demand reduction in homes and workplaces.

Theoretical Framework: Practices Influencing Energy Use

People in their everyday domestic lives are engaged in practices such as cooking, eating, sleeping, shopping and dancing. Also work includes a wide variety of practices. When people are asked about their everyday life, they usually describe the practices they are engaged in (Røpke, 2009).

While the roots of practice theory can be traced back to the Enlightenment, the term itself has more recent origins. One branch of practice theory that has been developed within sociology (our main frame of reference) emanates from Bourdieu (1977) and Giddens (1984), and has been developed further by Schatzki (1996) and Reckwitz (2002). In relation to energy consumption, Shove (2003) and Gram-Hanssen (2010) have made important contributions. However, practice theory is not yet a commonly-agreed theory, and a practice is a dynamic concept. A very general understanding of the concept would be that a practice is a behaviour "in which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood" (Reckwitz, 2002: 250). Practice theory aims to focus on the importance of physical, social and regulatory contexts, meanings, and human action. Context includes systems of provision and available technologies, while human action encompasses behaviour and choice (Spaargaren, 2003). The idea is to study everyday practices not only from a psychological, behavioural or technological perspective, but to look at activities in their social contexts, including for example the constant negotiation with time constraints, financial resources and the needs of others. It is to put the things we do in our everyday life in the perspective of cultural and social networks.

Practice theory is also based on the idea that in the performance of everyday life it is possible to identify clusters of activities, whose coordination and interdependence make it meaningful for practitioners to conceive of them as entities: for example cooking, cleaning and accounting. An organized set of activities is seen as a coordinated entity, or 'cluster', when it is recognizable across time and space. A practice is a relatively *enduring* entity (Shove et al., 2007). A practice is also a set of doings and sayings: Schatzki describes how a collection of sayings and doings forms a level of *tasks*, which in turn may form a level of *projects*. Practices are social, and by performing a practice we connect not only with those we interact with directly but also with all other people performing the practice (Gram-Hanssen, 2010).

Activities are guided by practical intelligibility: what it makes sense for individuals to do. This is what guides practices, and the reasons for performing a practice in a certain way can be based on 'correct' (formal) knowledge or can have totally different grounds, sometimes referred to as tacit or informal knowledge. People simply perform their practices in a way that makes sense for them.

Practices are also an expression of the distributed agency of people and things. A practice usually involves the use of various materials and technologies, although people are not necessarily aware of all the resources that are involved. The 'invisibility' of energy use, in particular, has often been noted (e.g. Jensen & Gram-Hanssen, 2008; Löfström & Palm, 2011; Palm & Ellegård, 2011).

In our view, elements of practice directly affect end-use efficiency, life-cycle efficiency and environmental impact, and the analysis of practices offers a promising tool for understanding how best to improve these. For the analysis of how building design and structure influences energy-related practices in our case studies, we will adopt the framework developed by Gram-Hanssen (2010: 2011), who provides a very useful summary of the issues raised above and interprets practices in terms of *technologies, routines, knowledge,* and *meaning*. In this framework, *technologies* are products or things important for structuring practices. Routines are embodied habits and know-how, i.e. knowing what to do and how to react in a situation. *Routines* include bodily and mental activities carried out by practitioners when they both respond and contribute to sustaining and developing a practice. *Knowledge* includes rules of how to do things and technical knowledge. In some interpretations (including this one), it also includes cultural myths of energy consumption. Meanings accumulate through engaged practitioners and are an important element of holding a practice together (Gram-Hanssen, 2011).

Next, we will focus on how technology and systems of provision shape everyday energy use in homes and in a type of energy-intensive workplace. We compare energy-related practice in each, and discuss how the buildings where people live or work restrict or enable practices that contribute to improved energy efficiency and demand reduction. From this, we can draw out some implications for understanding practices in the context outlined above.

The Case Studies – Background and Research Methods

Multi-sited ethnography is an established research method among anthropologists and sociologists. Marcus states in his article from 1995 that multi-sited ethnography defines its object as the study of social phenomena that cannot be accounted for by focusing on a single site. The idea is to combine multi-sited work with the need for in-depth analysis (Falzon, 2009). So far, research applying practice theory to energy use has been single-sited in the sense that *either* energy related everyday practices at home have been in focus *or* energy related practices at work. There has been a lack of analysis where different sites have been included. The idea in this article is to do that. We will compare energy-related practices in domestic buildings with non-domestic buildings in order to see how such an approach can contribute to energy research using a sociologically-inspired practice theory approach.

This choice of such seemingly disparate building types may seem odd at first, yet it can be a basis for showing how practice theory applies across domains that are traditionally kept separate. (For example, the research literature contains far more material on residential energy use than on energy use in non-domestic buildings, while there is very little research that addresses both and seeks out commonalities and differences.) Le Corbusier, in his 1923 book 'Vers une Architecture', famously spoke of a house as a machine for living in. This may sit uncomfortably with our ideas of domesticity. However, it perhaps becomes more accessible after considering a laboratory as a machine for carrying out research in; and even more so if both laboratories and houses are the products of highly-specialised design techniques. Pollock and Williams (2010) have argued persuasively that single-site and short-term studies can seriously limit what we are able to learn about the evolution of e-infrastructure. We show here how a multi-site approach sheds light on possible developments in energy infrastructure, in a more comprehensive way than if we had stayed within the usual domestic/non-domestic boundaries.

Once we start thinking about buildings as *for* practices, as well as being the product *of* practices and maintained *by* practices, we are on the way to a broader understanding of what happens in buildings and how it can change. (In doing so, incidentally, we find that the concept of energy efficiency can be unhelpfully narrow. Energy efficiency is usually understood as a ratio of the energy *used* for a particular 'service' to the energy input *delivered* for that service. [1] But, as we see in passive-standard housing, the service of warmth is mostly not supplied by kWh of gas or electricity delivered specifically for heating. Most of the warmth comes from the nature of the building itself and the activity of the people within it. Moreover, the activity is related to the occupants' knowledge of how best to achieve thermal comfort. The technical breakthrough of the passive house can therefore be seen primarily as the introduction of a set of new practices rather than as an efficiency improvement.)

One case study concerns buildings in Oxford, UK, occupied by several hundred people at peak times. (The empirical material is taken from Darby et al. (2010) except where otherwise indicated.) These buildings serve as an environment for scientific research in the higher education sector but are, like housing, places where the comfort and convenience of occupants are important. The buildings also form part of a system of accountability, though. In response to governmental goals for carbon emissions reduction, the University of Oxford had adopted a target of 20% reduction by 2010 over 1990 levels, singled out as "precise and ambitious" (Fawcett, 2005). However, that reduction was not actually achieved, as emissions per square meter rose by 15% from 124 to 143kg CO_2 over this period. In the light of the evidence we gathered for this study, this is not surprising: the biggest energy consumers in the higher education sector, and those with the fastest growth in consumption, are the research-intensive universities. Moreover, university buildings used "out of hours" (between 7pm and 7am on weekdays, at weekends and during public holidays) rank amongst the highest energy users of all.

The researchers gathered data on overnight usage of four recently-built 24-hour research labs at Oxford (one of which accounted for over 6% of the university's energy use). They also looked at occupancy and at the ways in which the buildings fulfilled their intended function. Information came from meter data, floor plans, interviews, occupant surveys, and observation. Interviews were undertaken with security personnel, building managers, administrators, lab managers, lab technicians and researchers. Two primary interviews were conducted with each of the four building managers, at the beginning and end of the data-gathering, which lasted altogether about a month. This approach was followed in order to assess the "status quo" of energy management, and to discuss findings with the four people who were most familiar with their operation of "their" buildings. The surveys nearly all come from members of single research teams in each building, (n = 38, 38, 19 and 14). These were carried out in order to gain an indication of researcher views that could complement the quantitative data. All the labs were observed overnight as well as during the day. This allowed the researchers to complement "swipe card" data on comings and goings, to see how much lighting and equipment were in use at night and to talk with night-time users and night watchmen.

The second case concerns a block of semi-detached passive apartments in the municipality of Linköping in Östergötland, South Central Sweden. The municipally owned housing company, AB Stångåstaden, built nine apartments according to the Swedish passive house standards in the suburb of Lambohov. Two types of apartments were built: single-floor apartments with three rooms (73 m^2) and two-floor apartments with four rooms (105 m^2). The four-room apartments have a shower room on the ground floor and a bathroom on the first floor.The ground floor also contains a laundry room with a washing machine, tumble dryer, and central heating unit. The three-room apartments have a combined bathroom and laundry room that includes the central heating unit.

The researchers measured indoor temperatures, and interviewed representatives of the housing company Stångåstaden and tenants living in the apartments. At Stångåstaden, we interviewed the environmental manager, the project manager for the buildings in Lambohov, two "sellers" who showed the apartments to prospective tenants, the area officer in charge until the autumn of 2009, and the new area officer who started work in the autumn of 2009. We also interviewed one or both adults living in seven of the nine passive house-concept apartments. These tenants were interviewed three times, first when they moved into the apartment (February–March 2009), then after their first summer (September–October 2009), and the last time after their first winter (March–April 2010). In this way, we were able to track what they had learned about living in their new homes over a period of just over a year.

We have re-analyzed our empirical data with a focus on how energy-related practices were performed and described by the informants, and also in relation to the chosen theoretical framework. Below, we have divided the sections according to our framework, i.e. how practices are influenced by technology, meanings, knowledge and routines. This is of course an analytical construction and not a reflection of a practice, because practices are performed in relation to all of these.

Technologies Structuring Practices

We will start by focusing on technologies. As discussed in the theory section above, technologies are products or physical things influencing a practice.

The Research Labs

The UK case study examined four buildings (B, C, G, and O). Building B used mixed-mode ventilation with a naturally-ventilated atrium. However the other three used mechanical ventilation only and were, effectively, sealed boxes apart from the doorways. (Several respondents expressed frustration at their perceived lack of control over their working conditions – a common feature of buildings with centralised building management systems, few on/off switches, and windows that cannot be opened.)

G was the smallest building, the only one without an atrium, and had a relatively low base: peak load ratio for electricity usage – that is, there was markedly less electricity consumption at night and over weekends and holidays than during normal working hours. This reflected the relatively low contribution of air-conditioning to the total load.

Humidifiers had been installed in the two newest buildings, but they were switched off after a few months because of the huge expense of running them. It is hard to understand why it was ever thought necessary to supply humidifiers to buildings in the (humid, cool-temperate) Thames Valley. This decision could be seen as an example of influence from other climates and building standards.

The management of research equipment was also an important factor in determining consumption. For example, fume cupboards require constant ventilation and make large demands, but the energy used is minimised if they are kept 90% shut while not in use. Building managers were keen to persuade researchers to shut the fume cupboard doors whenever possible. Refrigerating samples at -80°C posed a problem in one building, as the number of low-temperature fridges increased and the waste heat from them had to be countered by additional air-conditioning.

Table 1 shows some descriptive statistics on gas and energy use, and also the magnitude of baseload power demand (kW) for these buildings, which is particularly striking: this is the demand for HVAC (heating, ventilation, and air-conditioning), lighting and equipment *at its lowest*, when the building has few or no people in it. The ratio of electrical baseload to peak load (when researchers, technicians, and administrators were going about their work) was roughly 75% for building B, while the lowest ratio recorded was around 40%, for G. These figures partly reflect the ways in which the functions of the building continue even when there is no-one there: experimental samples are kept chilled, warmed, or agitated, and IT equipment continues to operate. But they also reflect consumption that is related to the *possibility* that people are in the buildings, in particular heating, cooling, ventilation, and lighting.

Table 1. Annual gas and electricity consumption and internal area, with approximate electricity base load.[2]

Building	Gas kWh/m²	Electricity kWh/m²	Gas / occupant (kWh/yr)	Electricity / occupant (kWh/yr)	Approx. electric baseload (kW)
B	194	395	7,842	15,992	500
C	395	379	11,618	11,144	600
G	244	273	3,525	3,946	60
O	334	480	11,215	16,130	600
CIBSE[3] (2004) benchmark for 'typical' science lab	132	175			
CIBSE benchmark for 'good practice' science lab	110	155			
HEEPI (2004) Benchmark for university bioscience and medical labs	121	250			

For comparison, an average British household at the time used approximately 14,000 kWh of gas and 4,000 kWh of electricity per year - roughly 6,000 kWh of gas and 1700 kWh of electricity per capita. Each occupant of buildings C and O was therefore using substantially more gas in the workplace than at home, although they were unlikely to spend more than one-fifth of their time there. Electricity use per occupant was even more striking. These figures demonstrate a difficulty with "individualising" environmental impact, when so much of it is associated with collective activities.

The Passive Housing

In the Swedish passive house case, all apartments were connected to a district heating system for hot water and for supplementary heat on cold winter days. The passive house concept minimises heating needs by creating an air-tight building envelope to reduce heat leakage (Ornetzeder and Rohracher, 2009). The house passively gains the heat from the sun, the tenants themselves, and the equipment installed in the house. In addition, the passive house has mechanical heat-recovery air exchange, so that the fresh air that comes into the house is heated by the outgoing indoor air.

Regarding the energy use of the building envelope, Stångåstaden had installed more heating capacity than is allowed according to traditional passive house specifications. District heating was installed not only for hot water but also for supplementary heating. Because of this, the apartments did not need to use electricity for supplementary indoor heating, which is otherwise common. However, simulations indicated that the energy demand for space heating was only 19.5 kWh/m^2 per year and thus meets Swedish passive house specifications that allow a maximum of 25 kWh/m^2 per year (Karresand et al., 2009).

Appliances are closely related to electricity consumption, but in a passive house they are also important for achieving a pleasant indoor environment, as explained above. Various household appliances were installed in the apartments. The kitchens were each equipped with a dishwasher, refrigerator, freezer, stove, and ventilation fan. The laundry room was equipped with a washing machine and a tumble dryer; the dryer and the washing machine were classified B and A+.

The performance of the Lambohov houses in terms of energy use and indoor climate was evaluated, based on a combination of measurements (in 2009-2010) and simulation. The space heating energy demand varied between 5–25kWh/m^2 over a year, depending on weather conditions (Molin et al, 2011). Temperature levels in the kitchen/living room in the heating season varied typically from 20 to 24°C and the temperature was never below 18°C in the annual measurements. According to the annual measurements, the tenants preferred a temperature of ~23°C in the kitchen/living room.

In summer conditions the kitchen/living room temperature was above 26°C for 500 hours, which indicates that the residents could have used more free-cooling through window openings. Looking at the annual heat balance, the apartments had more cooling need than heating need when outdoor temperatures rose above 20°C.

The measured overall energy performance of the buildings was found to meet the design values in terms of energy use, 21kWh/m^2 which is within the limits for Swedish passive houses as noted above. (For a more thorough discussion on the measurement results, see Molin et al. (2011).)

Meanings – "Official" and Occupant Perspectives

Meanings accumulate through engaged practitioners, and we therefore had a particular interest in how the building occupants in Sweden and the UK perceived living and working in these specially-designed buildings. We also analysed how the homes and labs had been designed with a set of meanings that were not necessarily the same as those that influenced the daily practices of their occupants.

The Research Labs

The labs are full of research equipment, with strict health and safety requirements. How do they compare with buildings with the same sort of "meaning"? As Table 1 shows, consumption in all four buildings was well beyond "typical" benchmark figures in use at the time. We do not know to what extent this was due to shortcomings in construction or to the ways in which the buildings were used, including the 24-hour operation. Construction and usage are linked to some extent, given that design is influenced by the building owner's concept of purpose, while the physical components of a building allow some practices while discouraging others.

We do know that the buildings were completed two to four years before the study began, that is, during a period when climate and other environmental considerations were increasingly significant. Yet estimated consumption figures that were available for buildings C and O at the design stage show that these buildings were not *designed* to be in the "typical" range, let alone to represent "good practice". One scientific discourse seems to be at odds with another here: it looks as though it was considered acceptable to break scientifically-derived conventions of good practice in order to conduct scientific enquiry in buildings that would be seen as prestigious. From a practice theory perspective, this is hardly surprising. An account of technical processes and scientific logic is only part of the building performance story , and it needs to be complemented by accounts of routines, meanings, tacit and explicit knowledge, and rules.

The meaning of a 24-hour building immediately seemed questionable to the researchers. All four of the 24-hour buildings normally had very low occupancy between the hours of 7pm and 7am, and hardly anyone worked there beyond midnight. Occupancy at 8pm on the nights observed was no more than 8% of staff in the most highly-occupied of the buildings (C). By 11pm, occupancy was nine individuals in building B (out of a total of around 325 staff), 8/578 in C, and 1/200 in G. By 3am, these figures had reduced still further, to three, two, and zero respectively. In building O, swipe card data showed very little use of the building beyond 10pm, although there tended to be more at the end of each month, when some staff had to meet reporting deadlines.

Spending an entire night in building B (which had the highest base load electrical demand in relation to overall load – see Figure 1) felt to one of the observers "like spending a night in the hospital, because the building never goes to sleep". The lighting was almost all automated and centrally controlled, and most of it was on all night (Figure 2). Yet this perception of energy wasted at night (based on *visible* energy use) does not necessarily correlate with what we know of the makeup of the base load. A survey conducted by the university estimated that lighting in the building accounted for approximately 18% of total electricity use. Less obvious centrally-controlled energy uses, such as air handling, were likely playing a much greater role. However, failure to manage lighting more effectively contributed to a sense of helplessness among staff in building B.

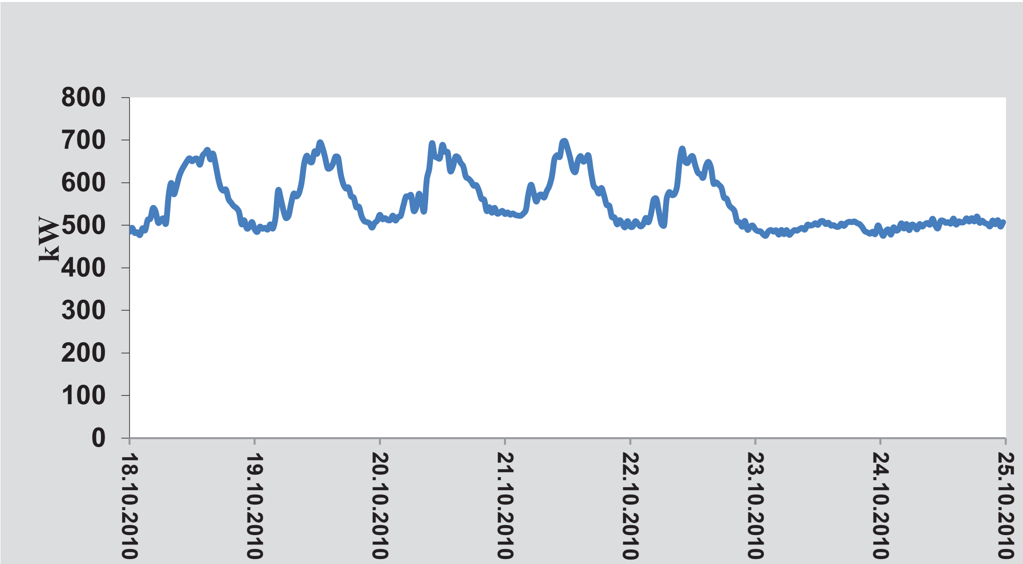

Figure 1. Electricity demand at half-hourly intervals during a week in term time (building B).

Many respondents felt that with so much electricity wasted through lighting, individual attempts to save energy would be somewhat futile. Even if the lighting became more efficient (for example, LED lighting has been installed in building B since this study was conducted), the symbolic message would be the same unless steps were also taken to allow for manual control or more effective automation. The automated systems in buildings B and O were particularly complex and difficult to control, and the building managers (BMs) sometimes needed to bring in outside contractors to repair them, which could mean waiting for months. These were clear indications that the promises of "smart" control and automation, attached as they often are to descriptions of prestigious buildings, were not being realised

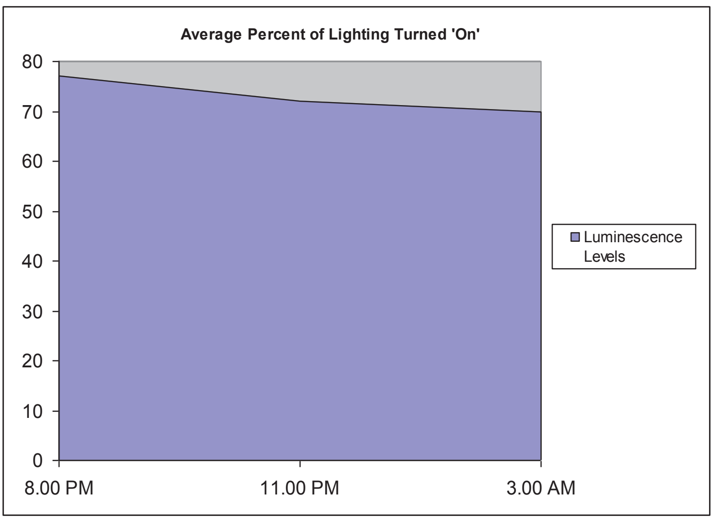

Figure 2. Night-time lighting in building B.

either in terms of efficient management or occupant satisfaction.

Interestingly, perceptions of whether energy was being wasted varied depending on the time of day when the occupant was surveyed. Almost three quarters of the 30 daytime occupants surveyed felt that energy was being wasted, in contrast to only two of the eight night time occupants surveyed. This raises the question of what constitutes "waste"? At what level does electrical indoor climate control become "waste" for a researcher working on [what she perceives as] a ground-breaking experiment at 2am? And how often is it *necessary* to work overnight in a lab? From our respondents, the answer seemed to be that this is very rare: even some chemistry experiments can now be monitored from home. While approximately three quarters of the 38 researchers surveyed said that they did work after hours, less than a quarter said that they do so habitually. The majority of "late workers" stated that even when their lab work ran late (after 7 pm), they did not stay in the building overnight. While the concept of a 24-hour building might sound flexible and empowering, it seemed to be that a "14-hour" building might have achieved all that the university intended at the design stage.

There were diverse views on what facilities were needed to perform research to a high standard, and on whether environmental impact is a proper concern for researchers. At one extreme was the view held by one research administrator, that *"The main purpose of this group is to do research, not save energy".* However, (implicitly) good research outcomes were linked to energy services, and she was not satisfied with the building from that point of view. The building was too complicated, and she complained that

> the temperature is never right ..., the air-conditioning doesn't provide a nice environment to work in, the temperature is drastically different in some areas compared to others. Why are we heating and cooling space at the same time!?"

At the other extreme, energy management was seen as being on a par with health and safety considerations, as an integral part of the way in which responsible researchers should operate. Almost all our respondents were pleased that the university was addressing a major sustainability issue.

One researcher made the point that there was a problem with the design process for buildings, claiming that "*They want cheap, big, smart-looking buildings, plus they oversize the [heating and ventilation] plant to be on the safe side. Energy-saving features aren't the first thing that the university asks for*." While there were financial incentives for the university to reduce energy consumption, there was far more of an imperative to bring in fresh research funding than to reduce costs. A prestigious building was intended to help this process, attracting researchers by offering cutting-edge facilities. One department reported that putting a picture of their new building on their website led to a 50% increase in applications to study there. We see, again, how meanings affect design and day-to-day practices, and how a building can be configured using one set of meanings in such a way that it is difficult to operationalise another set, those related to reducing environmental impact.

The Passive Housing

In Sweden the municipally owned housing company AB Stångåstaden built the passive apartments as a test project, wanting to know whether the "*market is ready for passive houses*" (interview, project manager). Stångåstaden representatives said that tenants in the passive apartments need to be energy conscious, willing to learn how the heating system works and willing to adapt to the specific functions of a passive apartment. A project manager for example said:

> "As a tenant, you need to be aware that if the outdoor temperature is minus 30°C one morning, then it might not be possible to have an indoor temperature of 20°C."

The Stångåstaden representatives all believed that extra information was needed when introducing tenants to the passive apartments. Extra information was prepared and folders on the passive house concept were distributed when the apartments were shown. When the tenants moved in, the project manager made a personal visit and informed them about the heating system and the passive house concept. He claimed that the heating system was easy to handle: the tenant just turns a knob to the preferred temperature (interview, project manager).

All tenants mentioned similar motives for choosing their apartment. Everything is new: living space, design of the apartment, low running costs, good communications, schools, day care etc. Most of the tenants did not specifically look for a passive house but got the information through their contacts with Stångåstaden. One of the households explained:

> " We looked at Stångåstaden's website to see where there were apartments available and we found these in Lambohov. When we then talked with Seller B she explained that the apartments available were of both conventional and of passive house standard. So we didn't actively search for passive houses, it was more of a coincidence."

Five of the households did however emphasize environmental reasons as important incentives for the decision to move into the apartment. One expressed this in connection with an instinct to be environmentally-friendly, saying that *"It gives you a good gut feeling to live in a passive house"*. One household wanted to try out "new technology" as they put it, to see if it actually worked, and they wished to live in a new "climate smart" building rather than an old less energy efficient house. Besides environmental incentives, several mentioned financial incentives and hoped that a passive apartment would also give a lower energy bill. The tenants said that they probably would need to learn how to live in their new apartment, and that they were prepared to adapt their behavior. For example, they would keep the front door shut and wear slippers.

The meanings assigned to passive housing were therefore not dissimilar between the landlord and tenants, and there was a realistic acceptance that some adaptation and learning were required. The technology alone would not achieve everything in terms of comfort and energy saving.

Knowledge of how to Produce Thermal Comfort and Operate Appliances

In this section we will focus on the households' and building managers' knowledge on how to produce thermal comfort. The knowledge category includes rules of how to do things as well as technical knowledge.

The Research Labs

The building managers (BMs) played a crucial role in maintaining these technology-intensive buildings and had unique access to the building management systems. All were highly qualified, and three had previously worked as researchers themselves. It took time (about two years) for the BMs to become fully familiar with their buildings, and some major adjustments were made during that period to limit consumption.

Energy management was only one of their many responsibilities, though. Their main task was maintaining a safe, pleasant working environment for researchers and other staff. In practice, this often meant tweaking the management systems in order to keep most of the occupants happy for most of the time – satisficing rather than optimising (Leaman and Bordass, 2001). This was likely to be far more complex than maintaining a pleasant environment in a home, as there were so many people to be kept content. One BM had the challenge of managing a building for six departments, each with its own administration and requirements.

Building managers varied in the extent to which they encouraged users to conserve energy. One showed how a safety-based induction programme for new researchers, backed up by random checks on the operation of fume cupboards, could help to contain demand for electricity. He was strongly backed by a head of department who was keen to reduce the environmental impact of the building. It was in this lab, building C, that it was easiest to see how a number of apparently small changes in routine, initiated mostly by the BM, had added up to a significant reduction in energy demand over a period of two years.

The extent to which control, decision-making and knowledge were shared emerged as a significant factor in building management. For example, three of the four BMs were *not* able to make decisions on some aspects of their facilities, notably in operating the HVAC systems, which were contracted out. We found that the BMs often worked in relative isolation from their peers; they supported the idea of setting up a forum in which they could learn from each other.

Energy was not necessarily discussed at the senior management level for each building, and many respondents stressed the importance of leadership. They commented that when heads of department and university decision-making bodies stress the significance of energy, it becomes more likely that researchers will pay attention, and that BMs will have more authority to implement changes in practice.

The Passive Housing

In the passive house case, the tenants are also managers of the systems. A passive house has a technology construction that requires action from the tenants. Usually the tenants' activities and appliances are described as part of the building's *heating system,* and the information given to the tenants on arrival gives guidance only on how to keep warm. But this does not help the tenant in deciding what to do about cooling in summer. In Sweden, residential buildings usually do not have air conditioning. In general, the tenants thought that their apartments became too hot on sunny days, though not unbearably so. They also said that the heat remained in the building, making it difficult to cool the apartment down. One had measured an indoor temperature of 33°C and had discussed installing an air conditioner.

The householders said they knew how to regulate the temperature, but one household never touched the thermostat because they said they needed more specific information on how to adjust it. Three claimed that they knew how to adjust the thermostat but that it did not matter, because there was nothing to be done if they wanted to cool off the apartment.

During the winter four of the households complained about problems with temperature differences inside the apartment, as they could not adjust the temperature individually in each room (which you normally can if you have radiators in the rooms). The bathroom and toilet were described as either too cold or too warm, and all the households had the toilet door on the second floor open all the time, either as a way to keep the toilet from becoming 'ice cold' or to allow the 'heat' from the toilet to get to the rest of the apartment. One household was planning to buy a fan for the first floor to blow the heat down to the ground floor. These conflicting perceptions baffled the researcher, who found the toilets in all the homes to be about the same temperature.

Another household said that, compared with apartments they had lived in before, this was better because it was the first time they knew how to adjust the indoor temperature themselves; heating systems in earlier apartments had been like 'black boxes' to them.

Some of the tenants also become experts and learnt how to manage the technical systems in the house. They complained of dry air during the summer and had experienced technical problems with the ventilation system. One was not especially upset, saying that they could accept some minor problems like this in the beginning. But another system stopped working when the winter was at its coldest, and the occupiers thought that the biggest problem was that no one understood their system:

> "So even though we report the problems to the on-call person, they don't know much about the system. No one does. No one knows how these systems are connected and work or how you are supposed to adjust the settings. So in the end, I and my partner needed to learn more about the system ourselves, look at the Internet and so on."

This household became technically expert and learned how to handle the system. Another household experienced several problems with the heat exchanger and contacted the housing company several times, but never got any help. They did not accept the explanation that the extremely cold weather had contributed to the problem and eventually learned how to repair the system themselves. A third household was worried that the system might stop working at night and that their kids would *"wake up to six degrees in the morning"*. They lacked technical knowledge and felt that they had changed their routines drastically as they dressed the children at night and used extra blankets.

Changing Routines for Improved Energy Management and Comfort

Routines are bodily and mental activities carried out by practitioners and include habits and know-how. Changing routines for the use of appliances and equipment are often mentioned as important for improved energy efficiency, and this was an issue that appeared also in our case studies.

The Research Labs

In one of the labs, the BM reported that £35,000 a year had been saved by switching off four 35kW autoclaves overnight and at weekends. He had had to persuade researchers that they would still be able to carry out sterilisation when they wanted, without more than short periods of waiting for the equipment to be ready. This had involved occasional adjustments to their routines, but perhaps more significant changes in their ways of thinking about the task of sterilisation.

Many respondents felt that there could be a much better job of turning off unused equipment, which of course raised the issue of responsibility. It was possible to find work areas where all of the computer monitors, desk lamps and lab lighting had been turned off at night – that is, everything that was under the researchers' control. But this was often not the case. A researcher commented that *"lab machines are left on because you don't know late at night whether someone else will want to use it, and if it's switched off it takes ages to switch back on."* Many items were left on around the clock largely because someone *might* want to use them – an indication of conflict between individual and group wishes and priorities.

The Passive Housing

The householders thought it was difficult to find routines to lower indoor temperature in the summer. Those who had awnings used them, while the others only had window blinds to block out the sun. Three households said that they kept their windows open when they were at home, even though they were told not to. One household told us that:

> "But we have the window open and we keep it open at night. But they say that you shouldn't do that in a passive house. You should not air out the house, but only open up [i.e. the windows] when it is as hot outside as inside."

The householders had especially been told to be careful with opening the windows. But that was because they moved in during winter time and obviously thought that this information also applied to the summer. The householders understood that they just had to stand the heat, and recalled that Swedish summers are not that long.

All households in the passive apartments discussed ways they used to keep the indoor temperature at a comfortable level in the winter. Common practices were to leave a lamp on at night, light a candle, turn on the washing machine and tumble dryer, turn on a light, and turn on the TV. One household said they preferred to put on cardigans and slippers and avoided using appliances to heat the apartment.

One household had tried raising the thermostat to 22°C, in order to have an indoor temperature of 20°C. This, however, resulted in extra expense for the family when the supplementary district heating system turned on. Instead, they used the TV, washing machine and dryer to heat the apartment, but did not discuss the fact that this also resulted in increased costs for the family. They found that it was more difficult to achieve an even temperature in the winter than in the summer, because in the summer they could at least air out the apartment by opening the windows. In the winter, they had no way to increase the temperature quickly.

One household had started to open the windows apartment routinesly, even in the winter:

> "We open up [the windows], because we have noticed that in this air-tight building the air is different. If we are both taking a shower in the morning, then it is like we need an extra fan because the air becomes moist and sticky. Then we need to open the windows in both the bathroom and bedroom."

When it was coldest, this household went home to the wife's mother. They also baked a lot, used many candles, and let the child sleep in their bed to keep her warm. Despite these efforts, they thought that the child had become unwell because of the cold apartment.

Discussion

There are clearly differences between the case studies in terms of construction standards, expectations, climate, occupancy, and usage patterns. There are also similarities. Both sets of buildings were designed to be "different", and to be prestigious "forerunner" buildings using new technologies. Both were tenanted rather than owner-occupied, and the occupants of both lacked control over the whole system, needing backup from either the housing association or the university. Both also required some expert knowledge in order to achieve comfort and carry out activities.

In both cases we have seen that the buildings are designed in ways that influence the practices of the residents. Table 2 summarises some characteristics of each type of building, in categories recognised in the variant of practice theory we have referred to earlier (Gram-Hanssen, 2010).

The table indicates the interrelatedness of everyday living and working practices with the practices of designing and constructing a building and setting it to work. For example, once a building designer has made the conceptual leap to believing it is possible to be comfortable in a home without traditional heating, a new set of practices begins to be adopted by builders and residents, and by other designers. Builders are guided in their practices by user expectations as well as by architects' designs; users have practices (such as night-time working, control of lighting, tactical

Table 2. Passive housing and research labs in relation to practices.

	Passive housing	**24-hour research lab**
Technology	The passive house itself, with district heating available as back-up; appliances that can be used for "waste" heat as well as for specific purposes	The lab building is a sort of machine, controlled primarily by the building manager; HVAC and research equipment are operated for the convenience of many researchers at different times of day.
Meanings	A house does not have to have a customary heating system; a washing machine becomes a source of ambient heat; a passive house is heated by active people – and can be cooled to some extent, by disobeying the normal rules and opening windows in hot weather.	The lab is a site for complex, expensive research work; can also attract new researchers. A researcher is entitled to workspace and functioning equipment, around the clock. A prestigious building has fully-automated climate and lighting control. There may now be reputational risk from a building that is seen as wasteful of resources.
Knowledge	How to produce and maintain thermal comfort; how to gain access to advice and assistance	How to produce thermal comfort and good working conditions for many people at the same time (BM). How to operate research equipment. When and how to apply restrictions on working times, practices, equipment or building services
Routines	Timing the use of appliances to coincide with need for extra warmth; altering clothing Accepting limitations to and shortcomings in thermal comfort	Timing and nature of work; use of equipment; consideration of energy issues at departmental meetings; maintenance of health and safety

use of appliances for comfort) opened up or closed down by the practices involved in building development.

The studies indicate that building energy management involves factors that are both physical (building fabric and equipment) and social (the rules by which these operate). We have seen how the people in charge of controlling a home or a large workplace after some time work out ways of "satisficing", achieving "good enough" living or working conditions for the occupants. This can be interpreted as a period of learning how to manage hardware and software, during which the limits of the building design can be tested. It is interesting that in both case studies, this period lasted longer than a year. Sometimes occupants discover that the recommended building technology framings can be ignored or subverted. For example, it is not only possible but good to open the windows of a passive house on a Swedish summer evening in order to cool the house. Or it is possible to make working conditions more pleasant in an over-cooled workplace by smuggling in an electric fan heater.

Low energy buildings are designed with particular characteristics and these do not emerge from nowhere, but from the aspirations and norms of people in particular social groupings. Practice theory, by taking meanings, knowledge and routines into account, brings these aspirations and norms into the story.

These case studies have shown the significance of both individuals and organisations in developing energy efficient practices: Stångåstaden housing association and its staff, architects, and the people who approve designs for new buildings; managers and their concerns for the viability and reputation of their organisations. The studies also show some possibilities for promoting more sustainable energy related practices through learning from experience, and they show how changed practices can be carried out by many actors: householders, building managers, technicians and researchers and energy advisers, in addition to managers and designers. Practice theory, especially as it has been developed in relation to sociology by researchers such as Schatzki and Shove, allows options for change to be identified and discussed but tends to stop short of dealing explicitly with organisational and relational issues. These form an optional further step, and an essential one in terms of learning. In the short term, the case studies show how 'single loop' learning (Schon, 1983) is taking place, as people discover how to manage their buildings more effectively or to carry out particular practices. In the longer term, they show how critical it is that post-occupancy evaluation feeds back to the people responsible for the design of new buildings (Leaman et al., 2010) – a form of 'double loop' learning. An important development for the socio-cultural branch of practice theory is to connect it to different aspects of learning (Hasu 2001; Gherardi 2006), and to try to internalise the study of knowledge/learning, meaning and routines into technology design and operation, extending the boundaries of the traditional systematic approach. The incorporation of social science modules in engineering courses is an example of this; so is post-occupancy evaluation.

Summary and Conclusions

Concepts from practice theory – technologies, routines, knowledge, and meaning – have been applied to an account of how people have been learning how to interrelate with technology in new passive houses and new purpose-built research buildings. We have also aimed to develop sociological practice theory through a multi-site analysis of practices relating to energy infrastructures and the built environment.

The Swedish residential case study showed how a combination of technologies and satisficing became the 'new normal' for residents, after a process of trying to make those technologies work for them, and adapting their own practices. The design of the building with its technology mattered, but the main project of a liveable, low-impact new building was on a fairly manageable scale once people had some time to work out meanings, build knowledge and develop new routines. The goals were not entirely achieved, but seemed within reach, given more attention to knowledge-building and practices.

By contrast, the research lab study showed limited room for manoeuvre in very highly technical buildings, once the design decisions had been made. Some occupant practices were able to change, but control of the indoor climate and much of the lighting climate was centralised, automated and highly complex, while energy management was not seen as a priority by many of those responsible for overseeing the research carried out in the buildings. Although so much was at stake in these buildings in terms of reputation, finance and environmental impact, there was little sign of a feedback loop from which architects, design committees and the higher education sector could learn for the future. The findings from this case study indicate why it can be difficult to reduce energy use without changes to the ways in which scientific research is practised. They illustrate the configuration of unsustainable technologies and practices that can occur at the design stage, and the way in which the significance of the 'core business' of the labs can overwhelm energy considerations.

The contrast between 'passive' (low-energy-intensity) and 'active' (high energy-intensity) buildings is striking. Learning for sustainability seems to be facilitated by the former far more than by the latter. Specialised buildings need specialised design, but the process tends to leave out consideration of meanings (what does scientific activity mean in the 21st century? what is comfort at work?); routines (how much provision for 24-hour work is really needed, and how can it be provided most effectively? how much control should be delegated to teams and individuals?); and knowledge (who needs to understand how to construct, maintain and operate a building in an ecologically sound way, and how can they best be trained?).

The analysis shows that practice theory offers a means of interpreting what happens in the course of designing, constructing and inhabiting buildings that are intended for residential or for highly-specialised uses. It helps to show why the environmental outcomes for a relatively simple 'passive' building (ultra-low-fuel, with active occupants) are not far from expectations: the building is designed for both comfort and 'environmental' purposes, the meaning is fairly uncontroversial, and the adaptation required from occupants is modest but achievable. It also helps to show why the environmental outcomes for very complex 'active' buildings (high-fuel, passive occupants) have been so disappointing: here, the design is tight (for very specific purposes), but the meanings are more contested among many occupants, and even the building manager may not be able to make many significant adaptations. However, this application of a practice theory perspective in the field of energy studies, with an emphasis on active learning, illustrates how there is still room to extend the vocabulary and scope of practice theory.

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Notes

1 For example, see http://www.iea.org/topics/energyefficiency/

2 Energy figures were calculated from utility bills for the financial year August 2009-July 2010.

3 Chartered Institution of Buildings Services Engineers

Keeping Systems at Work: Electricity Infrastructure from Control Rooms to Household Practices

Antti Silvast and Mikko J Virtanen

This article discusses the reliability of electricity supply and the management of its uncertainties from a systems theoretical point of view. We begin by outlining recent Science and Technology Studies (STS) literature about energy systems, infrastructures and practices concerning their use and argue that many current discussions hold promise in two directions: one concerns the brittleness and uncertainty of the electricity system that is seen as an ongoing achievement, the other is about broader structuring factors and contexts that should also be acknowledged when researching such systems. With an aim of developing this two-part focus, the paper advances systems theoretical considerations about the electricity infrastructure and proposes an analysis tool to study the necessary reductions of complexity of the infrastructure in two emblematic settings. The sites are infrastructure control rooms on the one hand and households on the other hand. The article concludes by discussing the different reductions of complexity by electricity users and electricity experts through using the theoretical point of view presented in the article.

Keywords: actor-network-theory, ethnography, systems theory

Introduction

Systems are a classical concern of STS research on energy issues, starting from the historian Thomas P. Hughes's (1983; 1989) work on electrification and the invention and expansion of *large technological systems*. A *system*, according to Hughes (1983: 5), "is constituted of related parts or components […] connected by a network or structure". Parts and components in an electricity system include physical artifacts like lines and transformers as well as organizations, scientific works, legislation and natural resources (Hughes, 1989: 51). While some are "social" and some "technical", the key to their inclusion in the system is control: when the parts are "under control" (often centralized), they belong to the system, when they are not they are merely in its *environment* (Hughes, 1989: 66). According to previous research on organizations that manage these systems, large technical systems are marked by institutional inertia and resistance to change especially when it is unanticipated (see e.g. Silvast et al., 2013: 5; Fuchs, 2014).

Recent scholarship has expanded these considerations about relatively closed systems in several ways, as summarized in a review essay by researcher Erik van der Vleuten (2004, 401-406). As he notes, scholars have drawn more attention to how large systems are attached with cultural symbolic meanings, to societies becoming increasingly dependent on such systems, to the growing complexity of the systems and the issuing systemic risks and vulnerabilities, to interrelations between other processes like nation-state building and urbanization and large system growth and to "second-order" systems that are systems of several "first-order" large systems. While these discussions are heterogeneous, they seem to agree that large-scale electricity systems are not as closed from outside contexts as originally foreseen.

Starting from systems as relative closures and ending with how these systems figure and change in society, many current STS works about energy systems and infrastructures indeed seem to hold promise in two directions. The first is to stress that infrastructures like electricity are fragile, uncertain and practical achievements; the second concerns wider systemic, cultural, and societal contexts that are viewed as highly important though not always manifest in concrete situations and their practices. STS scholar Susan Leigh Star's (1999: 381) ideas on how infrastructure "both shapes and is shaped by the conventions of community of practice" offers an example of the first direction, as do recent openings about the complex ways in which household practices are intertwined with infrastructures like energy and water (Shove, 2003; 2010; Wilhite, 2008). Some commentators have framed the entire electricity network as a "brittle assemblage" (Bennett, 2005: 446) and a "precarious achievement" (Graham, 2009: 11). Lea Schick and Brit Ross Winthereik (2013: 84) summarize by describing emerging, "smarter" electricity infrastructures as "always rich and complicated entanglements of humans and technologies, discourse and materiality, nature and politics".

Others – inspired by actor-network-theory (see Callon, 1986) – expand such a premise to the functioning and risks of energy systems in general: the systems do not hold together by themselves as their breakdowns aptly demonstrate (Bennett, 2005; Graham, 2009). Current energy policy, too, leans on similar ideas in many occasions. The European Commission (2011: 2) vies for "smarter" electricity grids because they can "cost-efficiently integrate the behavior and actions of all users connected to it". Similarly, reports on major electric power failures have repeatedly stressed that human operator errors, failing coordination, and consumers' "wasteful energy practices" pose risks to the systems and their reliable functioning (OECD & IEA, 2005; 2011).

These observations on activities, actors, habits, and decisions as building blocks of systems are important. They also have resonance in political and societal arenas beyond particular failures and breakdowns: accordingly, the long-term sustainability of energy systems may be significantly improved by shifting the attitudes, behavior, and choices of energy producers and users (see Shove, 2010). However, different kind of actors, not necessarily as "flat" as the ones outlined above, might be as important for the discussions. Leigh Star (1999: 381) draws on this notion when she argues that infrastructures are embedded in "other structures, social arrangements, and technologies". Infrastructure researcher Paul N. Edwards (2003: 197), while acknowledging the "user heuristics" of infrastructures, has paid a great deal of attention to the part that political economies, governments, and enduring institutions play in shaping these technologies. A similar point is made by energy scholars Harold Wilhite and Elizabeth Shove, respectively: while interested in situated household practices of energy use, they position these practices along "changing socio-cultural contexts of everyday life" for Wilhite (2008: 125) and "clusters of practice" and "organizing principles and engrained habits" for Shove (2003: 408).

A summary of these arguments is relatively straightforward: both wider systemic issues and their practical manifestations are relevant and interesting for STS scholarship on energy systems. A broader way to say this is that the uncertainty of the systems holding together and more durable factors should not be seen as contradictory perspectives or as each other's alternatives. Motivated by these considerations, this article advances an interest in the structuring of those activities that constitute the continuous management and the use of infrastructures. We develop terminology and a set of operationalizations as an analysis tool to elaborate a conceptual vantage point on large infrastructures and demonstrate their use by presenting a study about electricity system management and use in Finland.

The research objective comprises two closely related ends. The first objective is theoretical-conceptual and develops a perspective on electricity infrastructures and their societal embeddedness from a systems theoretical point of view. In so doing, we aim at establishing a conceptual approach that enables us to explore both electricity experts and energy-using lay persons by means of the same theoretical framework. Our theoretical objective is consequently to conjoin these perspectives in our conceptual work: on the one hand, the possibility of observing infrastructures' system-likeness and their manifold connectedness to their environment and, on the other, the focus on concrete practices in which the infrastructures are continuously produced and maintained as well as consumed.

The second part of our research objective is based on an analysis of diverse empirical material. We start by inquiring into the ways in which electricity technicians manage the electricity infrastructure continuously and in real-time in special infrastructure control rooms. We then analyze the concrete effects and experiences of electricity reliability at the consumer level. The analysis uses the conceptual approach that was developed in the first part of the article. We pay particular attention to the necessary maneuvers, which we term as reductions of complexity, that actors make in their own contexts: electricity experts are responsible for a reliable critical electricity supply, while the end users experience a functioning electricity supply as an indispensable part of everyday life. The research question is: *what kinds of stableness emerge by studying an electricity infrastructure from the vantage point of its situated reductions of complexity?*

The structure of the remaining article is as follows. The next section outlines our theoretical-conceptual approach, and the subsequent section of the article contains the methodology and the materials. The analysis is in three different sections, divided to the empirical sites. The article concludes with a discussion section, where we tie together the conceptual and the empirical parts of the article.

Uncertain Infrastructures: Contours for a Systems-Theoretical Methodology

It is uncertain that assemblages such as modern infrastructures hold together and function appropriately. The ever-present uncertainty is due to their complexity. This underlying train of thought, which constitutes our vantage point to understand infrastructures, comes from the German sociologist Niklas Luhmann. Luhmann's (1993: 87) proposal for a generic definition of *technology* as "a functioning simplification in the medium of causality" bears implicitly the general idea of uncertainty. The uncertainty has to be actively tamed. In other words, the simplification has to be produced and continuously maintained: technology is a result of an active and successful process of *technicalization* (Luhmann, 1993: 87-88). This view goes close to the philosophical concept of a *machine* (e.g. Deacon, 2011: 90). A machine has been designed to attain a particular function, it has a specific design, and to reach this end in a predictable manner, its controlled closure must be actively maintained. The causal effects that are relevant to a technological system or a machine are therefore first identified as accurately as possible and are then made subject to control. Those effects that are not identified and those that are identified as problematic and non-controllable are in turn excluded and kept outside the system, if this is possible.

The perspective can be presented through the functioning of a simple electric engine. When an engine is working accurately and predictably, its input current and the functioning of its internal parts, like magnets, coil, and coal rods are subject to control, as is the internal temperature of the engine. However, managing even such a simple system requires a number of continuous and relatively complex duties, such as providing a standard level of electric current, excluding unwanted environmental factors like moisture and maintaining the parts of the engine. Considering the generic definition of technology above, one soon notes how a causal closure is only a relatively momentary achievement: in fact, all factors affecting the functioning of the system on different timescales can never be exclusively controlled. A degree of uncertainty is inherent in the functioning of all technologies.

Assemblages that are considerably more complex, large-scale, and societally interconnected, such as the electricity network, can likewise be considered as systems based on a relative closure. Bearing this in mind, we define the electricity network *as a causal (relative) closure, which is built on continuous management and permits the distribution of electricity in a controlled and predictable manner.* The adequate functioning of the network, the distribution of electricity, and the maintenance of its equipment, together with the system's manifold environmental effects, continuously shape the network and its parts. The potential, constant change creates conditions in which causal effects can slide beyond control and this in turn requires persistent management of the processes that may have an impact on the network's functioning. The network holds together because it is actively and unceasingly held together.

These are not new considerations within STS. For example, that the electricity network requires continuous performing to stay afloat is almost the same point that Bruno Latour has made about the focus of sociology: accordingly social scientists study "associations that have to be constantly reshuffled in order to gather once more a collective that is threatened by irrelevance" (Latour, 2005: 160). Inspired by Latour, political theorist Jane Bennett has explored the electricity network as a brittle "assemblage" of "actants" that "produce effects, or even initiate action" (Bennett, 2005: 446) – ranging from electron streams and economic theory to energy consumption lifestyles, legislation, and beyond. Furthermore, she stresses that the specific assemblage of the electricity network's actants that "will be actualized at any given moment is not predictable with confidence" (Bennett, 2005: 457). Urbanist Stephen Graham (2009: 11) endorses Bennett's view of electricity networks as uncertain assemblages: "Such a perspective underlines that any coherence that the electrical assemblage achieves as an infrastructure must never be assumed or taken as permanent and inviolable. [...] [T]he grid is always precarious achievement ready to untangle at a moment's notice through a myriad of possible causes."

It is clearly the case that such an *assemblage* (Bennett, 2005) or a *collectiv*e (Latour, 2005) can only become durable through constant effort and coordination among human and non-human. Though focused on history of large systems and their expansion more than their maintenance, Thomas Hughes's classical work on electrification offers similar examples. For instance, the builders of early electricity systems strove "to increase the size of the system under their control and reduce the size of the environment that is not" (Hughes, 1989: 66) and attained this by "absorbing" new equipment as well as organizations into the system whose boundaries were marked by control.

So far so good, the relative closure of an infrastructure, a collective or an assemblage has to be actively maintained. But are all the components of these compositions, encompassing everything from electrons to electricity market, to be investigated as mutually symmetrical as the *credo* of actor-network-theory (see Callon, 1986) goes? This is where our paths diverge slightly. Latour's (2002: 125) methodological emphasis on "flat concept of society" as a microscopic starting point is to be geared towards freeing empirical research from any aprioristic (and normative) presumptions of social structures, order, change, strata, and so forth (cf. Lash, 2009). We do not postulate any of these big classical categories as a priori starting points for our study at hand either. But we do our bests to tune up our observation to see also grades of stableness, durations, repetitiveness and thicknesses in our research topics and materials. We would thus like to add to Latour's (2005: 165-172) advice that instead of considering societal structures, contexts and dimensions "we have to try to keep the *social domain* completely *flat*" (Latour, 2005: 171), that *to start with the flatness doesn't have to end with one*. Some stableness and duration in ways of conduct, in techniques of using artifacts and even in the functioning of artifacts themselves might emerge. In other words, the ever-present complexity of societal occurring does become somehow tamed, and thus some structuredness is constantly created and also dissolved. How this actually happens in particular settings is, nevertheless, a matter of empirical study.

We aim at combining these general sociological ideas with our conceptualization of the electricity network as an uncertain infrastructure. Our conceptual framework describing these phenomena draws on Luhmannian systems theory, but in a rather unorthodox manner. We utilize a systems theory informed starting point to approach and conceptualize the various ways of structuration as *continuous reductions of complexity* (Luhmann, 1989: 12). In this regard, two clarifications of our interpretation of systems theory have to be made. Firstly, and in concord with Latour's view, neither systems nor institutions or structures are taken as pre-empirical a priori entities, nor are they thematized as static and binding. Furthermore, they are not grasped as extra-empirical entities deduced from Luhmann's conceptual apparatus either. Entity-centeredness is replaced by a relation-scheme: "A system [...] is the result of interactions of its parts, not the other way round" (Nassehi, 2005: 180). In other words, systems are not investigated as, and through, static pigeon-holes (*Setzkasten*) out there to which empirical phenomena more or less comprehensively fit. Instead, a topology of incessant connections and disconnections is put to use: systems are observed as constantly evolving "real-time machines" (*Echtzeitmaschinen*) to use a metaphor of one of Luhmann's successors (see Nassehi, 2003: 159-187).

Secondly, our notion of a system as constantly maintained reduction of complexity is not compatible with an idea of systems constituting on some a priori "levels". Rather, the infrastructure holds together only via constant mundane tasks in concrete settings where different logics merge: in control rooms and electricity stock exchanges as well as at the homes of end-users. Put methodologically, instead of focusing on the maintaining of only one structure, electricity network as an "infra-structure" in our case, we try to pinpoint local and subtle structurednesses created and maintained in constant practice, and manifoldly intertwined with keeping up the large-scale infrastructure, the electricity network. These concrete ways of complexity reduction, which are not necessarily empirically "flat" but possibly also embedded and contextually bounded, is the main target of our "systems theory informed qualitative social research" (Nassehi & Saake, 2002: 81).

Materials and Methodology

The rest of our article is based on multi-sited empirical work carried out among Finnish electricity consumers and experts.[1] On this point, we interpret the materials by building on the theoretical premises laid above. Starting with the observation that the electricity infrastructure both consists of and combines multiple actors, logics and components only some of which can ever be included by a *technicalization* at the same time, the analysis focuses on different, concrete ways of complexity reduction found in the materials. However, this general starting point has to be calibrated towards a more subtle methodological apparatus for observing localized practices. In this regard, and to get soundly on grips with different logics and the richness of ways and variations of complexity reductions, empirically merged in concrete practice, we fine-grain our conceptual approach. This is done by analytically dimensionalizing the idea of reduction of complexity. We utilize Luhmann's (1995: 75-81) original tripartition to factual, temporal, and social dimensions as a background and source of inspiration. As we are focusing on concrete empirical practice of real people and artifacts, observed mainly semi-ethnographically, instead of focusing on circulation of communication in different types of systems in strict Luhmannian sense, we experiment to stretch this divide a bit. The focus is on the feasibility of the methodological concepts in relation to our empirical data consisting of control room workers and lay people. A preliminary reading of the data has also affected our conceptual choice at this point. Consequently, we split our observation of empirically interwoven practices, during which complexity gets constantly reduced, to *structural, temporal* and *personal dimensions.*

On the *structural dimension*, the focus is on matters of fact, on concrete topics which have to take care about and reacted upon. Hence binding structuredness with features of duration and externalness come to the fore. This “structural exposure” is done by asking questions of *what* and *why*: what is concretely at hand; what is out there that can’t be easily changed, and upon which has to be reacted? The why-questions are actually questions about the relatedness of the tasks at hand to other tasks and demands, and can thus be formulated as questions of why is the task at hand to be done (now)? On the *temporal dimension*, our focus is on the time structuring of the practices. By asking *when*-questions, we observe the temporal structuredness of complexity reduction: (different) time frames, postponing as well as repetitiveness and successiveness of different tasks. Lastly, in regard of the *personal dimension*, the persons in question with their unique knowledge and experience are of our interest as well as attributions of tasks and responsibilities to different persons and groups. We start by asking *who*-questions to find out how complexity gets reduced in relation to the persons in question: who takes care of certain tasks, how different roles are related to each other and how distinctive identities are constructed. Furthermore, we also ask *how*-questions: how do the persons manage to take care of the tasks concretely? Attention is paid to the relevance of personal (tacit) knowledge, experience and skill as well. Also variations in the ways of taking care of concrete tasks and concrete mundane practice vis-à-vis technological devices, manuals and other scripts are of interest in this regard.

Two main actors and sites were identified for the study based on their important role in earlier scholarship on electricity infrastructures and reliability: first, electricity *control rooms* where electricity systems and energy markets are managed in more or less real-time allowing “interaction, communication, and coordination across organizations through various technologies and methods (e.g., computers, markets, telephone calls, meetings)” (De Bruijne, 2006: 89; see also Roe & Schulman, 2008); and second, going further than a focus on market trading and technical maintenance, *households* whose expectations, interests, routines, habits, and energy-using practices have been recently raised a key issue of energy systems by many STS scholars (e.g. Shove, 2003, 2010; Wilhite, 2008; Rohracher, 2008). At the same time, comparisons of these two actors have not been that common and our generic framework presents one possible new vantage point for a comparative analysis. The following presents the main themes which were found in the data by analyzing the structural, temporal, and personal dimensions of those practices that the research subjects put into effect.

Electricity Reliability and Systems – Multiple Viewpoints

On the Energy Trading Floor

The field work and the expert interviews for the first part of the article happened in restricted sites, two electricity control rooms in a Finnish city. In one of these rooms, energy stock brokers operated in the free energy stock exchange 24 hours a day, 7 days a week. In the other, the technical operation of the local electricity network was taken care of by monitoring, adjusting, and if necessary maintaining the various components of the network. We start our analysis with the market room.

Structural Dimension

The duty of the market control room was to participate in the Nordic common energy market, *Nord Pool*, whose headquarters is in Norway and which combines energy market players in Finland, Sweden, Norway, Denmark, Estonia and parts of Germany. The *pool*, as the electricity industry characterizes it, “is a kind of a stock exchange that gathers daily the sale offers from electricity providers for each half an hour and determines the system’s market price” (SENER, 2000: 10). The example concerns the UK and the granularity of the stock exchange is one hour in the Nordic countries, but the idea is similar. The pool is a wholesale market of electricity where companies that generate electricity once a day place bids and offers for each hour of the day. Based on how these bids and offers play out, the owner of the stock exchange then calculates for each hour of the day a “system price” that determines the price that these actors pay for electric energy (Nord Pool Spot, 2009).

The seven brokers in the control room, working in shifts around the day, were responsible for making these transactions happen with the city’s electric energy. In practice, they balanced energy levels on two electricity markets. Firstly, they used the *Elspot* market for managing the supply and demand of the days ahead (Nord Pool Spot, 2013a). This market is accessed through already mentioned techniques called bidding and offering: communications about how much energy in megawatt hours the company is willing to buy or sell for a certain wholesale price.

A second energy market that was founded a decade ago and has gained more importance over the years is called Elbas (Nord Pool Spot, 2013b). Rather than concerning the day ahead like Elspot, Elbas is a real-time, hour-ahead market place that has operated in Finland and Sweden since 1999, Germany since 2006, Denmark since 2007 and Norway since 2009. The market works through bids and offers like Elspot.

These markets provide an important structuring dimension to electricity control room work. Based on interviewing the workers of the energy market control room and observing their work, it appears that the key characteristic of Nord Pool trading on the screen is its discipline. Bidding and offering on the Nord Pool obliges workers to follow a number of routines: completing electronic forms on computer monitors and submitting them by a certain hour, as well as following the Nordic market situation on a minute by minute, if not a second by second basis. One of the operators stressed how energy trading used to be “much more casual” over the phone. He continued that the “work has become much more exact” after the introduction of Nord Pool and others agreed: they were not as financially accountable prior to today’s market (Silvast, 2011). What is important here for the present argument is that the market appears as simply being “out there” to these workers, a durable entity whose rules, routines, and disciplining techniques like bids and offers need to be followed all the time. There is more routine than there are attempts to think about them in detail: in practice, the reflection of the market tools would only provide minimal input to the work that is all about fulfilling the bids and offers on time each and every day.

As a practical matter, the energy markets are accessed through software visible on several control room computer screens. Like one of the authors has argued elsewhere (Silvast, 2011), this software assumes that all energy traders are anonymous and rational economic decision makers; and perhaps then a reality is created where the control room workers become these non-human actors at least when they “screen” electricity through market bids and offers. On another note, it also seems that computer monitors, computer software, and market bids and offers can extend or “distribute” (MacKenzie, 2008: 16-19) the cognitive capabilities of the control room workers. For each hour of the day, two numbers (quantity and price) is adequate to make sense of a large distributed electricity network and a market that comprised hundreds of companies from tens of different countries. Such market provides an original and specific structure to the control room work, although more intuitive human skills and capabilities also remain important, as we shall see soon.

Temporal Dimension

The markets, as indicated, produced their own temporal dimensions too. To start with the spot orders, they were made to the energy stock exchange once per day, at 13:00 Finnish time (12:00 Norwegian time due to the time difference). One of the workers explained the day-ahead Elspot bid and offer as follows:

> In the morning shift we make the next day's prognosis, where the power plant's generation power is defined based on the weather situation and from there the electricity. From there on we also send to Norway (to the energy stock exchange) the order, which has for each hour the information on which price we are willing to sell and buy (energy).

At 13:00 each day, the company then sends their "order" to the Nord Pool stock exchange: the prices for which it is willing to sell and buy energy during each hour of the following day. However much skill this required, the necessity to do the order at a specific time was instituted by the energy markets.

Another relevant temporality of the work was shaped by the real-time market, Elbas. As Nord Pool Spot (2010, 2013b) the operator of the Nordic stock exchange has noted, the more or less real-time trading of energy fulfills several functions: not only can economic agents engage in just-in-time trading that increases their revenues, but the real-time market may also help manage "incidents" such as shutdowns at nuclear power plants and fluctuations of the wind power.

Similarly, all the operators in our study emphasized the ever-changing contexts of day-to-day practice and the real-time market certainly seemed to raise this intensity. Even if not much happens but the worker's main task is to *stay alert*. One of the workers aptly summed energy trading as watching a camp fire: "You have to be constantly keeping up a small flame. That is, you mustn't fall behind the energy stock exchanges." Here, again, the energy market creates the conditions of possibility – and a specific kind of compressed timeframe – for actors to manage electricity and its always-on reliable provision.

Personal Dimension

The operators were titled as technicians and most of them were trained in energy generation technology, which is a vocational degree. About half of them, in correspondence with their new duties, received a brief course as brokers after the energy market was liberalized. The work seems clear enough based on its designations: the workers observe monitors and use them in accordance with the requirements of the respective room.

However, when interviewed, the informants made it clear that the work is not merely about following computer monitors and interacting with them in hourly and daily rhythms. Instead, the working required special skills and capabilities. Both ordering energy for the day ahead and adjusting it hour-by-hour provide useful examples. The ordering, for its part, is shaped by the difficulties of predicting the weather, requiring the finding of a "comparison day" that has had similar temperature and consumption patterns as the coming day. The same days of the week are preferred: working days tend to have slightly different energy consumption than the weekend. But only part of this process of ordering could even be reflected. Instead, as one of the experienced workers reported, he could draw on his “gut feeling” to foresee the energy demand on any one day of the week:

> Tuesday, Wednesday, Thursday, they could be similar to each other in the middle of the week, then you have Friday, Saturday, Sunday, even Monday, they are little bit different. But that starts from your guts in a sense, that you somehow suspect that they have some small difference.

Hunches and intuitive moves were it seems as important for the real-time trading, which invoked images of what one of the workers termed as managing a “living infrastructure”:

> The process is alive all the time. And we try to keep up with the district heating network and as a counterweight to it. It’s alive all the time. When we make some guess about the temperature and what could be the consumption, it’s a living process even though there have been similar temperatures in the past. It’s alive and production is alive too.

He is referring to the weather here, which impacts people’s demand of heat which then impacts the local power production: the Nordic weather might suddenly become colder and alter the level of power and heat co-production in the city’s own plant by increasing the demand of heat. Or the city’s street lights could come on, which creates a marked shift in the required level of electricity production. Hence for another worker, “this work is always about making adjustments, there is no crystal ball. You cannot do the electricity stock exchanges beforehand so that it goes dead-on. This work changes from moment to moment.” Such ever-present shifts keep the skills and experience of a worker important, even as, at the same time, many structural dimensions and temporal dimensions of the work are instituted by the international free energy markets.

Technical Maintenance Room

A further structural dimension of the management of electricity infrastructure was suggested by architecture on the field. As mentioned, there were two control rooms in place of one in the studied company, mostly with different workers that had received differing training following the liberalization of the energy market. To better understand this arrangement, we have to briefly visit the concept of infrastructural *unbundling* before accounting for the control room working practices.

Structural Dimension

Urbanists Stephen Graham and Simon Marvin (2002: 141) provide the following general definition of unbundling: “Central to the notion of unbundled networks is the concept of `segmenting’ integrated infrastructures into different network elements and service packages. Segmentation involves detaching activities and functions that were previously integrated within monopolies and opening them to different forms of competition.” In other words, unbundling means the separation of monopolistic provisions from market-based provisions in order to support competition that is seen as “fair”. One main issue behind this practice is called *vertical integration*: if utilities like electricity are vertically integrated – that is, if the same company manages several steps of the energy supply chain from production to distribution as is typical in a monopoly – the result may be that this company has an "incentive" to "discriminate against competitors as regards network access and investment" (European Parliament & European Council, 2009: 10). To mitigate such suggested "discrimination", many bodies including the European Parliament and European Council (2009) have proposed mechanisms of unbundling: setting up legally, functionally, or organizationally separate entities to manage the systems of electricity supply and those of electricity production. Nord Pool Spot (2009: 4) explains the two distinct responsibilities that are created by unbundling like this:

> The commercial players are not and cannot be responsible for the security of supply. If a South Swedish retailer, for example, has bought electricity from a North Swedish producer, the North Swedish producer cannot guarantee that there will be electricity in the plug at the retailer's customers. What the commercial players deliver to each other and the end users are only the prices (and the bills). Hence, the commercial players deliver financial services only. The commercial players work in the domain which is changed when the electricity market is liberalized: the financial domain.

Hence, the actors on energy markets are not responsible for dealing with risks and security. However, there is a "non-commercial" side of electric energy as the stock exchange calls it (Nord Pool Spot, 2009: 3). This "non-commercial" operator transmits and distributes the electricity from one region to another from the producers to the retail customers.

In the case of the control rooms, the aspirations for unbundling – which had only existed briefly at the time of the study in 2008 – had already created highly specialized working tasks for the two control room workers. The two control rooms were neighboring and only separated by a wall. According to the principle of unbundling, the operators were not supposed to "know" about each other's activities. In practice, they could have easily talked with each other through an open door or in the kitchen that they shared.

The operators had the same title and a similar training, as already mentioned above; they were also of similar age and had worked in the same control room prior to the energy market restructuring of the 1990s. At the time of the study, however, only one worker still operated both the control rooms as a broker and a technician. For the others, the tasks were separated according to the room.

In practice, the technical control room work involved a number of main recurring tasks. First, continuous monitoring of the voltage, current and temperature of the components of the electricity network was carried out on several computer screens. Second, when new components like lines, transformers or power stations were installed, the control room operators needed to change the switching of the network. Third, the management of a repair team might have been required when a component failed and triggered an alarm. The structural matters that this rooms deals with are then much to do with the electricity network itself: its frequencies, voltages, and components that need to be continuously watched and maintained in order to stay always on. The difference that this creates in relation to the market room is also that of temporality.

Temporal Dimension

Each of the above control room tasks shows a slight variation of a similar rhythm. The first task above is about routines of monitoring that continue all the time. However, the second task was also seen similarly because, as one of the operators noted, the remote testing of newly installed components was "most typical routine in a working day". The temporality of the third task, the response to an alarm, is seemingly different and most obviously concerns on-the-spot responses.

But even the third case was not a clear-cut non-routine, disruptive event to these workers. One operator had not counted how many alarms there had been in a single day, but an event list on a computer screens showed 36 pages of events for that particular day. Not all of these events set off an alarm as some are "invisibly" solved by automatic fail-safe devices. When an alarm occurs, the task is to first report the details of the fault to a computer system, then determine whether a maintenance team is needed and if it is, to send the team into the field and coordinate the field work in relation to the information on the control room computer screens.

A factor that considerably structures these on-the-spot behaviors is working rules and protocols. The steps taken are discussed in the following:

> Interviewer: Are there many rules that are followed even though situations change?
>
> Operator: Well, of course there are security and other sets of rules about what should be done. You have to go according to them. And every operator has to have the same point of view about those things. That doesn't change according to who sits here.

Thus, the working practice of the room follows strict sequences of actions when "security" is considered. The time frame, duration, and pace of the work and its rules and decisions get standardized through such standards.

Personal Dimension

The worker who compared the market room to "keeping watch of a camp fire" was able to work in both of the control rooms. The distribution control room, in turn, he said, "is like being a tin soldier. Things don't happen all the time, but when someone calls you have to be ready on the spot." What he saw hence was a market place that has to be constantly "made" by economic actors. The electricity grid, in its turn, was managed primarily through reactive monitoring and maintenance tasks.

The previous examples demonstrate the matters dealt with in the maintenance room and their relatively straightforward character. The control room work is to do with the distribution of electricity through reliable components, not the price of this electric energy as that was dealt within the other control room. To this end, the room has setup highly structured routines and protocols that are followed to attain "security", as the workers termed it. In addition, as the energy industry is liberalized and competitive, the network maintenance was outsourced and hence workers get billed for the maintenance work. Considering personal dimension, however, it would seem that personification is not seminal for the work of this room. What is at stake is that the billing for the work should be fair and transparent and deviations from the safety protocol are against the norm.

Nonetheless, the informants still emphasized how skills and in some cases even improvisations may be necessary, as a purely practical matter. As one of them told:

> In principle electricity work is usually highly standardized. If everyone follows the standard, then it is highly structured. There is a problem, however, that when you go to a work site, the situation might vary greatly. And then comes

> your own adaptation about how you want to do things.

So the actual work site introduces uncertainty that requires special skills. Another broader source of uncertainty is given by the complexity of the managed systems and the difficulty of finding which many possible processes had led to their failure.

A participant observation of practical fixing of a fault showed that only some activities involved a standardized control of risks and uncertainty. The observations also uncovered independent decisions, team work, skills, help from computer systems, practical rules of thumb and knowledge of the local region. Indeed, even the problem that was identified and anticipated by the technician shifted gradually as the situations unfolded: a customer's blinking lights becomes a possible dangerous ground fault to the control room worker, requires maintenance that could cause power failures to other customers, but is finally discovered to be a sagging line and not a ground fault. In another case written to a fault report, a blackout occurs and a loud bang has been reported from a near-by construction site but a careful investigation on the field reveals that the problem that caused the failure was a twig and the bang was unrelated to this problem. Such logic deals with incidents little by little by adjusting working habits. Formalized prevention of hazards then receives significant assistance from working experience and localized experience.

Households

The previous sections were concerned with the operations of two control rooms in formal energy organizations. The question about finding structural and temporal dimensions was relatively straightforward in these cases: organizations have to deal with markets of various temporalities and follow set rules, routines, and protocols. However, the theory outlined in this paper is more general and can be applied to other sites, including households that are viewed as central in many STS energy discussions (e.g. Shove, 2003; Wilhite, 2008). We also apply the framework to homes during the remainder of this article.

Structural Dimension

When considering households, the identification of structural dimensions almost immediately starts to seem like a complex task. Part of this is because households are not formal organizations as we discuss below, but another matter is wider-ranging. To draw on scholarship on infrastructure and energy uses and practices (Star, 1999; Shove, 2003; 2010; Wilhite; 2008), the electricity infrastructure is "structured" for homes in various manners. It is structured, first of all, by being embedded in and utilized by other household technologies like lighting, cooking, media, and computing, by everyday habits with their long durability, and by clusters of practice such as using electricity to do other things like typing on a computer during the night. More broadly speaking, patterns of electricity consumption also receive structures from cultures of using electricity in the cold Nordic countries and Finland in our case. Finally, the traits of these patterns are affected by more durable institutions and arrangements such as the regularity and resolution of household energy billing, prohibitions to cut electricity for example during very cold months, and compensations from electricity supply failures in homes.

When reflected, the number and scope of such matters can indeed easily become overwhelming. However, it is also important to stress that the households that were interviewed and surveyed did not seem to think about such issues all the time or even that often, not even in the context of failing electricity that was the original research problem of the study. Rather, most of them shared the idea that a capable person manages to be without electricity, at least for a short while, as long as this person acts responsibly and has prepared for a blackout.

For example, an interviewee, a retired woman, told about the wood stove that heats her old house and emphasized that she would have "no worries" during a blackout:

> Personally I have no worries, there is a wood stove here as this is such an old house. But then the neighbor's house doesn't have wood heating, so they started to complain [during a long blackout] that it was starting to be a bit chilly.

This woman did not suffer from a crisis during a blackout. Rather, she managed to continue key everyday habits – at least those that require heating – even though the electricity supply was interrupted. She knew from repeated experience that the wood stove would keep the house reasonably warm. Indeed, almost no interviewees were particularly concerned about blackouts. Instead, they explicitly stated that not all blackouts were harmful events. One interviewee said that blackouts have not caused her any harm personally, while another might even accept one further blackout a year.

On some level, it seems that everyday practices were simply allowed to stop during an electricity blackout. A similar positive view of a "primitive" non-electrified moment was shown by a 35-year-old woman female interviewee:

> Of course the blackout offers a possibility to light the candles and spend a kind of primitive moment without computers and televisions. You're forced to sit on the couch with people and talk.

A blackout therefore encourages a positive attitude to doing things differently.

The respondents of the survey had similar thoughts as they thought they could cope for many days without using electricity for appliances (Table 1). We can see, for example, that the lack of credit cards, washing machines, dishwashers, cleaning, computers, the Internet, summer heating, saunas, housekeeping, and gardening only started to significantly worry these people after one week.

Another indication of the low "visibility" of the electricity infrastructure as a structure is provided by dimensions of the network that a power cut revealed to the subjects. When asked about what a blackout indicates to them (Table 2), most people considered general society-wide impacts of electricity failures, the opening of the market and the pricing of electricity, the imagined causes of blackouts, and their own preparedness and consumption. Countering the notion

Table 1. How many days households (N=115) thought they could cope without different electricity-using appliances or functions.

Days	Appliance or function
1-3	fridge, freezer, toilet, heating in the winter, all water (warm and cold)
4-6	cooking, media appliances, lights
7-9	batteries (e.g. mobile phone), credit cards, washing machine, cleaning
10-12	computer, dishwasher, Internet, heating in the summer, electric sauna
12-	housekeeping and gardening

that a technological failure highlights what caused it – thus opening the "black box" – the experiencing of a blackout in a year made explanations concerning the causes of blackouts seem less important to the subjects. At the same time, a blackout made explanations concerning the open electricity markets and their pricing more relevant, even if according to idea of unbundling (see above) the competitive energy and security of supply are separate issues managed by different organization. Finally, whether having experienced a blackout or not, many key factors on the structural dimension like politics, legislation, and the structure of the electricity network appear in the bottom of the list in Table 2. This too is understandable: one cannot stop using electricity after the power comes back on, so it would not always make a difference to think about structural issues in depth in everyday life contexts.

Temporal Dimension

The people that were studied did not underestimate the effects of all electricity blackouts. But in order to raise concern the electricity failure had to have a significant effect, for example, frozen foods melting, water in pipes freezing, or the contents of the hard disk drive disappearing. These situations can be usefully framed as issues of temporality. First, a blackout should not interrupt everyday habits on a very regular basis. Second, a blackout should not occur at a time when people have planned to do something that really requires functioning electricity. And third, a blackout should not impact on tangible objects which are the result of time and investment – such as the contents of the freezer or a computer's hard disk drive.

We can consider the deep freezer as an example: a blackout may destroy the contents of the freezer and, hence, very suddenly undo the investment of gathering the contents in the first place. Other practices need to occur at a certain time and place and can be vastly affected by blackouts: for example, as remarked by a women in her 30s, she would not want to have a blackout when she needs to hand in her thesis or, more mundanely, to go to a party or watch a television series.

One interviewee had even more persistent problems with electricity blackouts. Practically all the appliances of

Table 2. What blackouts uncovered to households (N=115).

% of respondents	had blackout in a year	no blackout in a year
societal impacts of blackouts	79	75
electricity market opening	74	59
own electricity consumption	70	52
electricity price	67	69
own preparedness	65	44
causes of blackouts	63	72
damages to your home	59	47
utility customer service	58	46
own electricity contract	55	54
the number of blackouts in different regions	51	54
the structure of the electricity network	38	35
energy politics and legislation	30	35

this woman in her 40s were electric, from regular appliances to air conditioning, water fountains and unusually for 2005, an electric car. Altogether she had almost 150 separate appliances that required electricity, which she counted when she was interviewed over the phone.

The problem was that this consumer lived in a rural area, as classified by the electricity utility. In comparison to cities, according to this classification, such areas have relatively more open-air electric cables. These open-air components are particularly subject to weather, trees, and animals which damage overhead cables and transformers and cause short, but frequent blackouts. This was precisely the issue in the woman's house.

The interviewee stressed that blackouts cause multiple actual harms and not only infrequently but on a day-to-day basis. Such constant harms often cannot be understood by people who do not "live surrounded by the latest contemporary technology". She remarked that such people may talk about the way in which blackouts symbolize a halt. Infrequent blackouts may be acceptable and even have positive aspects, but as frequent occurrences, blackouts can become unbearable:

> For us a blackout is not just an interruption. Instead, it is difficult to cope with a situation where every morning the phones may start ringing at five in the morning, so that the whole family wakes up. Because this is a new house, everything is automated. And if there's a blackout and for some reason a program is erased, then certainly it's a nuisance that you have to spend an hour entering the data again. For a person who doesn't have this equipment it's just a matter of resetting the digital clock. But we live in a house where everything works with electricity and modern technology is complex.

Blackouts were thus a major inconvenience to this person and her family. It was taxing to constantly think about blackouts and she wanted her technology simply to work without having to reset it every morning. In regular use, electricity does not structure the time of everyday life into separate events: with always-on electricity, the idea precisely is that lights and appliances can be used all the time without giving electricity that much consideration. It is the breakage to this durable temporal logic that proved particularly worrying to this subject.

Personal Dimension

Both of the above sections have already hinted at the importance of personal factors in people's assessments of electricity distribution failures. However, this did not necessarily mean reflective decision-making like obtaining new energy-efficient purchases or willingness to postpone consumption for the sake of the electricity network reliability. Indeed, most respondents tended to emphasize that a blackout does not cause marked damage or harm. People coped with blackouts rather than being highly reflective about them. One thing that signified this was an emphasis on simple mundane skills like finding the switch board, candles, and a flash light. A woman in her 30s, a kindergarten teacher, noted that she coped with blackouts well while children might not cope. A retired woman already quoted above emphasized she would have "no worries" during a blackout, but that her neighbors would. A similar emphasis is apparent in the survey (Table 2) where a blackout, most often, signified to people the importance of own consumption and own forms of preparedness as well as damages to their own home.

The personal dimension is also visible in the ways in which households explained blackouts in interviews. The subjects were not unaware of the catastrophic potential of blackouts. One interviewee thought about what would happen if the temperature was minus 25 degree Celsius in the winter, whereas another thought that a blackout "makes you observe the whole system's vulnerability and you start to feel sort of stupid, as you are so dependent on electricity". However, these types of catastrophic effects were not mentioned in connection with any blackout that the interviewees had personally experienced. Catastrophic considerations of infrastructures, it seems, are simply not very tangible when making sense of actual harms. This also made preparing for blackouts difficult for a woman in her 40s:

> Somewhere in the back of your head you have these fallbacks, like what if. And you think about buying an emergency heating system and about whether you should get one. But then when the electricity starts up again and is not interrupted, it's easy to forget about it.

The reflective, active, and thorough consideration of one's own energy use seems to be the exception rather than the rule. When asked about what causes a blackout, nearly all interviewees concurred: in addition to natural acts, the most common perceived reasons were the liberalization of the energy markets, trees growing next to electricity lines, and the downsizing of energy network maintenance. Even if electricity supply disturbances revealed a material network that is normally hidden from view, it seems that people consider the causes of failures to be "scapegoats" that are easy to comprehend. Rather than seeing how the systems work, people considered whether the institutions that deliver electricity are trustworthy.

The blackout – originally, a complex system-level failure of an infrastructure – was hence reduced to more mundane and comprehensible explanations in the everyday frame. Such explanations kept the electricity infrastructures hidden rather than opening up their functioning to debate.

Discussion

This paper advanced an interest in different dimensions of the electricity infrastructure and the management of its reliability. The paper acknowledged the importance of starting the analysis of an infrastructure with a Latourian "flat" concept of social domain. However, and importantly, the paper also tried to demonstrate how such an analysis that "follows the actors" does not necessarily have to end with flatness. Rather, the purpose of the paper was to tune our sociological observations to see grades of stableness, durations, receptiveness, and thicknesses from the situated, practical vantage point.

To this aim, to find structuredness among flatness, we drew upon systems theoretical considerations inspired from the work of the sociologist Niklas Luhmann and his colleagues and successors. This theory was utilized from a specific, rather unorthodox premise: the concern was not directly with themes popularized by Luhmann such as subsystems of society, their interrelations, and their "autopoietic" ("self-creating") communications. Rather, the systems theoretical vantage point was calibrated into a research methodology about how people engage with the electricity infrastructure and manage its complexity and uncertainties in workplaces and homes.

Our key sensitizing concept was that of *locally contextualized, embedded reduction of complexity*. Three such reduction dimensions were operationalized for the analysis: the *structural dimension* of factors external to the situations at hand; the *temporal dimension* of varying time frames; and the *personal dimension* of experience, local knowledge, and skills as well as roles and identities. The difference between the categories is relative and they overlap in practice: for example, different structural dimensional factors, like market places, have their own temporal variations. Cases about special electricity infrastructure control rooms and homes – both important in recent discussions in STS and organization and workplace studies – were analyzed to demonstrate the framework and its use.

The results from the analysis of these sites and their concrete practices show important outcomes for a comparison of different sites. In the electricity control room whose workers trade electric energy in an open energy market, the Nordic energy market posits important external factors on the structural dimension that discipline the control room work and create certain binding temporal dimensional time frames like once-per-day ordering and once-per-hour trading. Nonetheless, it seems that the control room workers' personal skills, experience, and local knowledge remain important (see also de Bruijne, 2006; Roe & Schulman, 2008). This is because they managed what they saw as an ever-changing "living" infrastructure and matched various temporalities from day-ahead prognoses to a more or less real-time trading.

In the second control room that deals with technical distribution of electricity, the electricity network technology creates various external constraints to the work as do safety protocols and both trigger special kinds of maintenance and monitoring routines. But it was also clear that the systems maintained would not hold together would it not be for the local experience of the control room workers and their skillful adjustments in ever-changing work conditions.

At the same time, households are a key concern for many recent STS discussions on energy systems and infrastructures and provide a critical addition to our analysis and interpretations. The structuring factors in an organization like an electricity utility are relatively clear to an analyst, often also to practitioners themselves: in many instances, such factors have even been engrained in job descriptions, professional roles, and wider rules like those concerning "unbundling" some specific "interests" of infrastructure provision from different "interests". The time frames shaped by these factors – like those triggered by markets whose trading emerges every even hour or once per day – seem likewise typically apparent to an organization and its members dealing with them on a routine basis.

However, energy-using households seldom have similar organizational frames nor is expertise typically at-hand to domesticate issues created by markets, failures, or other matters. To lay people, the majority of the structural dimensional factors of electricity seem not to be reflected and remain simply "out there", and this stays accurate even when the electric power goes out, according to the analysis in this paper. Power failures were seen as temporal matters as was shown: through their regularity, their time of occurrence, and their impact on time use. Yet, it is plausible that other temporal dimensional occurrences of energy systems remained hidden – the key temporality of electricity simply being that it flows continuously to home. The use of electricity and the reduction of the complexity of a failure then becomes by and large a personal matter to members of households. It involves issues like their skills, installed electric equipment, situated preparedness, and explanations that hide the electricity infrastructure rather than opening up its functioning to debate.

The observations on households are important not only for showing what knowledge was gathered in this analysis. They also contribute to perspectives on current strivings for creating more rational electricity consumption and informed energy consumers. The active consideration of electricity and its reliability, which experts do continuously in their organizations, seems to be the exception rather than the rule in households. In other words the demand for rational electricity consumption seems to increase the complexity of everyday life, which is something people would rather avoid.

The organizations that keep systems at work, studied in this paper, offer one way to elaborate this result concerning households further. First of all, the notion that a reliable system would not hold together without continuous maintenance is certainly accurate in the control rooms based on the analysis (Bennett, 2005; Graham, 2009). But the rooms also show that for work practices to become effective reductions of complexity, they need to involve some structuring factors and time frames. Not everything was and maybe even can be "flat" for people that manage a large-scale electricity network. Indeed, one part played by the energy markets and security standards, though their effects and functions could be discussed and even critiqued from various other angles (e.g. de Bruijne 2006; Roe & Schulman, 2008), is that they offer specific structure and a temporality to what seems like highly demanding working practice.

This conclusion may shed some new light on energy consumption practices, too. Many commentators have drawn attention to personal dimensions of energy use and to how the practices of energy consumers' or even citizens' might be shaped and altered: for example by energy rationing, price signals, and information campaigns concerning more rational energy use. While such measures are important, one could pose another follow-up question based on the framework in this article. What are the structural dimensions and temporalities for lay persons to manage challenging energy issues and what kind of institutions would be needed in their support? Various arrangements are doubtless possible, but they could serve two functions in daily life. The arrangements could reduce the uncertainties of electricity distribution and at the same time, also buffer lay-people from constantly thinking about these uncertainties.

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Notes

1 The materials include interviews with two Finnish electricity control room operators (12 interviews) and households (9 interviews), participant observation in the two electricity control rooms, and an electricity consumer survey (115 respondents, response rate 21 percent). The control room informants were found through the other author's field work in the Finnish electricity sector, particularly through personal contact with the managers of the workers. The questions posed in the control room interviews concerned the anticipation of electricity blackouts and the management of their damages as risks, and were divided into sub-themes

about working practice, free energy markets, and security in the control rooms. The control room operators worked for one electricity company in Finland and were male in their 50s or 60s with the exception of one younger female worker. The questions for the households concerned experienced blackouts and imagined blackouts in homes. The household interviews were found through various means including a housing association, personal contacts, and "snowballing" new respondents from those subjects that had already replied. Both female (7) and male (2) respondents were included in the household interviews from the greater Helsinki region. The household survey was posted to the customers of two electricity companies in Finland, one a city and other a rural region. The structure of the survey included four sections: the household impacts of electricity blackouts, the preparedness against electricity blackouts, lessons from electricity interruptions, and attitude questions. The survey responses covered all adult age groups and both men and women were represented – however, the majority was male, more than half were over 60, and most lived in an electrically heated detached house.

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Andrew Barry: Material Politics: Disputes along the Pipeline. Wiley-Blackwell: Oxford. 2013. xiv + 244 pages.

Andrew Barry's genius as a writer is that he teaches you something new about something that you thought you already knew. If you are a member of the small world of science and technology studies (STS) and you did not read Plato's *Republic* firsthand while at university, then you were probably introduced to Plato's analogy of the large sailing vessel in Langdon Winner's famous essay "Do artifacts have politics?" First published in *Daedalus* (Vol. 109, No. 1, Winter 1980), reprinted in *The Social Shaping of Technology* (MacKenzie & Wajcman, 1999), and then adapted for his masterpiece *The Whale and the Reactor*, Winner (1986: 31) shows readers that "[a]ttempts to justify strong authority on the basis of supposedly necessary conditions of technical practice have an ancient history." Ocean-going vessels, the story goes, "by their very nature need to be steered with a firm hand, … [for] no reasonable person believes that a ship can be run democratically." For Winner, the physical make-up of the ship and the realities of voyage on the high seas create circumstances that, in effect, require that the artifact have certain politics – in this case, centralized control. However, after reading Barry's *Material Politics*, it appears that artifacts may no longer have politics, at least, not the way we thought we knew they did.[1]

Let us anticipate a fair criticism of our set-up thus far: is it not the case that substituting Winner's "artifact politics" with Barry's "material politics" is just clever, post-modern word-play? If that were the case, then Barry's book would deserve an outward expression of disapproval on account of this sloppy and ultimately unforgiveable fault. However, that is not the case. Despite the perceived similarities, Barry's title is not a play on Winner's old idea, furthermore, Barry does not cite a single work of Winner's nor does he utter that tiresome old phrase "technology is politics by other means". After showing readers that materials are not the stable fodder for building infrastructures, Barry convinces us that materials play an always lively and often unpredictable role in political disputes. However, Barry's guidance does not stop there; he takes us one step further. We also learn that when companies preemptively employ policies to enhance the outward appearance of transparency – and, if they are lucky, rationalize the pipe-laying process while limiting downstream complaints from locals – they do not, upon reflection, obviate what they think they will. Barry (p.182) enlightens us:

> … while limiting the scope and intensity of controversy [is anticipated and is also the explicit purpose of transparency], this does not occur as anticipated. For as the case of [Baku-Tbilisi-Ceyhan (BTC)] demonstrates, the production of information – in the form of the evolving archive [i.e., the host and home for all matters transparent at British Petroleum regarding the BTC pipeline] – had the effect of multiplying the surfaces on which disagreements can incubate and flourish.

Where better than to stake his (academic) claim than on an oil pipeline? Barry capitalizes on the massive amount of public information, evidence which became available and simply bled from the full-on collapse of the Soviet Union, about the 1760km BTC pipeline connecting the Caspian Sea and the Mediterranean. According to the acknowledgements, the book was born from Barry's (p.x) selective reading of these materials as well as some "modest" "fieldwork along the route of the pipeline."

Returning to the main thrust of our review: if your main source of knowledge about the BTC is based on aperçus, asides, and casual readings of the global media, then you would likely agree that most seemingly political debates surrounding the pipeline tends to invoke either economic prosperity or energy production. Gaging the effectiveness of the pipeline is a straightforward matter of "how much profit can be earned?" and/or "for how many years can the fuel supplied by the pipeline sustain our energy needs, given current consumption patterns?" Beyond those two obvious questions, relatively little is said about the BTC.[2] In essence, public discussion of pipelines tends toward a kind of semi-ethico-utilitarianism.

In *Material Politics*, however, Andrew Barry, armed with a particular definition of politics, tackles a much broader and far more interesting set of disputes and controversies associated with oil pipelines. Before we go further, we would like to position this book on the bookshelf. To readers who are looking for historical portrayals of the noble race to secure oil futures, for example, like Alastair Sweeny's (2010) *Black Bonanza: Canada's Oil Sands and the Race to Secure North America's Energy Future* or Andrew Nikiforuk's (2010) *Tar Sands: Dirty Oil and the Future of a Continent*, you will be disappointed by this book because Barry's ultimate goal is academic; his comments, related to the role of material as well as the realities of transparency, are made for the disciplinary homes of human geography and social theory. Also, this book is not a book about the rise of "New Russia," which you might enjoy reading about in Marshal I. Goldman's (2008) *Petrostate: Putin, Power, and the New Russia* or David E. Hoffman's (2011) *The Oligarchs: Wealth And Power In The New Russia*. Barry's book was published by Wiley-Blackwell as part of the Royal Geographical Society with the Institute of British Geographers (RGS-IBG) Book Series, and academic books in that collection are of the "highest international standing" with the overt aim to "promote scholarly publications that … change the way readers think about particular issues, methods, or theories."[3] Thus, while most undergraduates will be able to read and absorb the book, we agreed that readers should arrive with an earnest interest in pipelines and/or a learned background in environmental studies, (human) geography, or STS. Still, the book is far from pedantic. In the introduction, for example, Barry (p.4) kindly notes for movie buffs: "[p]rior to its construction, the BTC pipeline had figured in the plot of the [19th] James Bond film, *The World is Not Enough*."[4]

While a joy to read from cover-to-cover, we agreed that once readers happen upon "Transparency's Witness," they should be pretty-well sold on the book. In chapter 3, Barry introduces a key component of his argument: transparency. "The implementation of transparency," he writes, "is said to provide the basis on which the information necessary for the proper function of free markets would become readily available" (p.58). In this respect, transparency has three functions. First, transparency allows investors to make rational choices about the strength of commercial and public organizations. Second, transparency serves as a boundary between the legitimate and illegitimate market. Third, transparency fosters public accountability by requiring reliable information and communication between decision-makers and stakeholders. In short, transparency is a "technique of governmentality[;] a device intended to articulate actions" (p.59).[5] According to Barry, transparency leads to disputes:

> about the process by which public information is generated.... [and] transparency points inevitably to the existence of a domain of activity about which it is thought that information has not yet been or might never be made public, whether intentionally or not (p.60).

To illustrate, before constructing the pipeline, the BTC company wanted to appear "open" and ethical to gain public support. In fact, in order to receive funding from the International Finance Corporation (IFC), the BTC Company was expected to comply with the IFC's information disclosure and consultation policies (p.100). Part of this agreement was to make information about the pipeline available to "affected communities" (i.e., a term used to describe communities directly "affected" by pipeline construction based on proximity to construction sites, and subsequently entitled to compensation) as well as members of the "concerned public" (i.e., anyone wishing to inquire about the pipeline). The company claimed to accomplish precisely this by having accessible computers with data projectors and free copies of information available to anyone who went to the Baku Enterprise Center and other European Bank for Reconstruction and Development offices. However, visitors claimed that "they were watched by BTC security" and that police guarded entrances to various offices requiring every visitor to register (p.101). Moreover, disputes about the pipeline erupted over the way in which consultation with "affected communities" had occurred. In the town of Haçibayram, Turkey, company representatives claimed to have consulted the village prior to construction. However, the village (whose inhabitants are nomadic) was actually deserted at the time of the supposed NGO Fact Finding Mission. Further, according to the Muhtar (elected head of Haçibayram), he had only once met with representatives from the pipeline and no one in the community had ever been contacted by telephone (p.108).

In the end, while Barry spends a good portion of the book criticizing the BTC company's development of the pipeline, he also does a good job of remaining relatively unbiased and showing that questionable activity (i.e., micro-corruption) was no less common among members of affected communities. For example, and the book is chocked full of these beautiful little insights, Barry writes, "in some locations, trees or flowers were planted near to the pipeline route in anticipation of compensation to come" (p.168). Barry tells of walnut trees being planted along the pipeline or beehives being moved closer to pipeline construction pathways and every time this seems to have been in anticipation of higher compensation packages for affected communities. We agreed, Barry did a good job of showing that when financial incentives were present, no one affected by the construction of the pipeline – corporation or individual – was immune to material politics.

Our only concern, which sits uncomfortably in the mouth like a dirty penny, is that Barry's excellent use of cases to illustrate material politics may have been too carefully selected. You see, the BTC pipeline is so long and constructed over so many years, it seems possible that Barry carefully selected specific cases that may or may not have been representative of material politics on the whole. After all, out of 1,000 complaints, what percentage were walnut-related or, for that matter, beehive-related? We cannot determine the representativeness of his examples because he does not report on their empirical prevalence. We cannot determine if his vibrant illustrations are also valid explanations.

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Notes

1 On balance, however, it might be argued that the death knell of this phrase was published in 1999 by Steve Woolgar and Geoff Cooper or, in the same year, in the opposite direction but with the same effect, Bernward Joerges's final attempt at defending "do artifacts have politics?" (Joerges, 1999) and wrestling some residual use from it.

2 Of course, exceptions exist, especially in the public realm; for example, Svetlana Tsalik's *Caspian Oil Windfalls: Who Will Benefit?* (Tsalik, 2003).

3 Quotations are from series editor's preface.

4 As an odd coincidence, Goldman (2008) mentions Bond in his opening lines too.

5 Long-time readers of Barry's work no doubt see this as an extention of his 2001 book *Political Machines*.

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Laura Kurgan: Close Up at a Distance: Mapping Technology and Politics. Zone Books: New York. 2013. 228 pages.

Back in 1992 Denis Wood declared we are 'map immersed', so much of our lived realities are mediated through maps. Only a decade later we are better described as 'map saturated' or map enmeshed. Maps permeate our lives from car navigation systems to weather forecasting. From agriculture to the internet, our ways of moving, being, and consuming are dependent on the spatial organisation of information, that is on maps. This cartographed reality is reflected in the panopticism of the 'Big Data Revolution' and the mega-mapping projects now underway that map the entire universe, the human genome, the brain, all activity on earth. NSA's surveillance regime is in effect mapping all human interactions. Google has come to realise that its real role is to re-present to us the details of our lives through maps.

There is a burgeoning literature analysing the ways in which maps, knowledge and power are deeply imbricated; ontologies and epistemologies, temporalities and spatialities are revealed as co-productions of historical processes defining, mapping and naming reality. There is also a massive efflorescence of cultural production around maps and mapping, artists, geographers, activists, indigenous groups, GIS and Google Earthers are all turning to cartography as a form of resistance or aesthetic expression on the one hand, or as new modes of knowledge management and market expansion on the other, while at the same time new forms of spatiality and connectivity are demanding revised forms of mapping.

Yet we are also variously described as suffering cartographic anxiety, labouring under cartographic illusions or being captured in the map. We appear to be stuck, seemingly unable to get outside the map to meet Foucault's challenge 'what is philosophy…if not the endeavour to know how and to what extent it might be possible to think differently instead of legitimating what is already known?' (Foucault, 1992: 8–9). Brian Holmes, for example, suggests it is impossible to 'escape the overcode', the entangling mesh of linguistic, taxonomic, political, digital and technological infrastructure that supports the contemporary cartographed reality (Holmes, 2009).

The ineluctable saturation of our lives in maps results, in part, from the expansion of mapping capacity, both technical and cognitive, provided by GIS, ICT, satellites, the internet and Web 2. This vastly augmented capacity to organise and re-present data, text, and materials spatially, enables the location and geocoding of every aspect of reality, at every scale from the smallest particles to the collision of galaxies, along with every detail of our daily movements, our genomes, and our desires. Cartographed reality is set to complete a transformation of the embodied and enacted coproduction of life and the environment from a process of movement, interaction and becoming into a seamless web of seemingly objective, placeless and timeless information. Arguably this is why we cannot escape the overcode, datafication provides the source material for the latest phase of accumulation and enclosure in cognitive capitalism.

Given all this, it is difficult to be enthusiastic about Kurgan's book, *Close Up at a Distance: Mapping Technology and Politics,* that promises much for her projects exploring the new mapping technologies of GIS and GPS, but makes little reference or connection to the whole flocks of scholars who have thought deeply and critically about our thoroughly cartographic lives (e.g. Harmon, 2009; O'Rourke, 2013; Pickles 2004). Critics and artists whose work is available at the click of mouse on Kurgan's GPS connected computer.

Why does each new generation continue blithely assume they have invented something new, when in actuality its been worked-over extensively in the past. The fear of influence is understandable in the young and unsure, but it is also a form of ignorance. The complaints of an old fart maybe? But when I look at the acres of print devoted to mapping and the new technologies, that are simply ignored in this book, it makes me wonder. Why does each generation have to work things out for itself, doesn't anything accumulate or resonate down the years? Or is it something else?

One possibility is that the world is not as united and connected as we have been led to believe – the working contention of the book under review here. Territories, disciplines, audiences are divided, knowledge and its production practices are messy and localised, and that any coordination and connection depends on human agency and a great deal of collective work, including work by the authors and publishers of new books.

Another possibility is that Kurgan has gone native and is captive of the military mapping technology she purports to criticize. She explicitly makes the claim her work is special and different:

> Central to the ways these projects unfolded and to the fact that they do not simply analyze, but in fact employ, these technologies, is this claim: we do not stand at a distance from these technologies, but are addressed by and embedded within them. These projects explicitly reject the ideology, the stance and security of "critical distance" and reflect a basic operational commitment to a practice that explores spatial data and its processing from within. Only through a certain intimacy with these technologies– an encounter with their opacities, their assumptions, their intended aims– can we begin to assess their full ethical and political stakes. (p.14)

This is a very strong claim and is very like the methodology of participant observation that typifies a good deal of anthropology, sociology of science and especially practising critical cartographers. However she does not appear to grasp the epistemic practices that go along with that; practices involved in constituting an author as authoritative: need to be self-reflexive; or the difficulties raised for example by Audre Lorde that 'The Master's Tools Will Never Dismantle the Master's House'. Kurgan claims to reveal the biases, and spatialities that modern mapping technologies open up by actually using those technologies in art projects. And indeed many of her projects do force a critical examination of the new cartographic reality. The problem lies more in her exposition than in her projects.

She makes no mention of Tom Van Sant's geosphere image which says it all, and gives only a passing mention to Denis Wood's *Power of Maps*. Denis Wood's work is foundational, but especially relevant is his 'Map Art' article that surveys the huge 'map as art' field ignored by Kurgan and argues:

> Art maps are always pointing toward worlds other than those mapped by normative mapping institutions. In so doing art maps unavoidably draw attention to the world-making power of normative maps. What is at stake is the nature of the world we want to live in. In pointing towards the existence of other worlds – real or imagined – map artists are claiming the power of the map to achieve ends other than the social reproduction of the status quo. Map artists do not reject maps. They reject the authority claimed by normative maps uniquely to portray reality as it is, that is, with dispassion and objectivity, the traits embodied in the mask. (Wood, 2006: 5–14)

If escape from the overcode is to be possible and other worlds are to be made real, it is going to take a united effort across all areas of endeavour and imagination, and a recognition of the mapping practices of cultures that are not enmeshed in a western cartographic reality (Woodward & Lewis, 1998).

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Helen E Longino: Studying Human Behavior: How Scientists Investigate Aggression and Sexuality. University of Chicago Press: Chicago & London. 2013. 249 pages.

Review 1

Helen Longino's *Studying Human Behavior: How Scientists Investigate Aggression and Sexuality* demonstrates the relevance and validity of scientific pluralism as a mode of understanding scientific study of human behavior. Previously, in her *The Fate of Knowledge* (Princeton University Press, 2002), the author demarcated her stance on social epistemology as the epistemic framework in which her version of a philosophical scientific pluralism fits well. The present book clearly puts these principles to work. The result is a fascinating yet easy read, reporting empirical research on how various sciences study and explain human behavior. Throughout, the book is well written and well thought. Based on exhaustive observation and careful analysis of scientific practices and discourses, it offers insights on five distinct scientific approaches to the study of sexuality and aggression.

The book restores, defends, and maintains openness to pluralism (p.2). Its author's aim is not to engage the nature/nurture debate, nor judge which one of the scientific approaches is best in explaining the phenomena they study. Instead, the focus is on what each approach contributes within the limits of its strengths and weak points. In addition she considers the interplay of politics and popular mass media in influencing advancement and directions in scientific discourse.

The book has two parts: one devoted to the analysis of specific scientific approaches to studying sexual behavior and aggressive behavior, the second to the epistemic, ontological, and social life of behavioral science in general. The five scientific approaches to the chosen behavioral phenomena (sexuality and aggression) studied are: quantitative behavioral genetics, social-environmental approaches, molecular behavioral genetics, neurobiological approaches, and integrative or systems theoretical approaches. These entail explanations that the author characterizes (in line with Ernst Mayr) as proximate. Approaches based on ultimate explanations, such as sociobiology and evolutionary psychology, are omitted from the study.

The method of the book is to review both empirical studies and theoretical polemical writings on the chosen behavioral phenomena. Quantitative scientometrics is applied to demonstrate difference in citation structures of distinct approaches. Epistemic, ontological, and social life of behavioral science is re-contextualized into a larger frame, in the latter part of the book. The book ends in discussing the interrelation of scientific explanations and the social outcomes of politics based on these explanations. Referring to the not so rare counter-factuality of science based policies, the author recommends the pluralist approach to the assessment of the import of behavioral sciences. On basis of the evidence presented in her book, this recommendation is clearly justified.

At crux, scientific explanations rely on the theory dependence of causality. The empirical data studied by Longino offer a chance to describe causal spaces of different approaches. Longino shows brilliantly how the chosen approaches, be they on the nature or on the nurture side, have their Achilles' heel in the justification of their choice of theory. The integrative or systems theoretical approach illustrates, perhaps, the most intriguing phenomenon of all: the less detailed the model, the firmer its conclusions, the more detailed the model or the system description, the less explanatory power will be assigned to any single factor.

The book is clearly and concisely written, an easy read for beginners of STS, social epistemology, or scientific pluralism studies, but also interesting and thought provoking to learned people, and not without aesthetic qualities in its prose. Helpfully there is an exhaustive name index as well as a precise subject index of the approaches studied and the relevant public debate. Warmly recommended as basic literature to STS classes as well as a good read for professionals of STS!

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Review 2

Contrary to the trend in mainstream of philosophy of science Helen E. Longino's book *Studying Human Behavior* analyses a popular field of science. For this, she proposes a pluralist approach implying that a "[g]enuine understanding of human behaviour requires not a new comprehensive paradigm so much as an understanding of the scope and limitations of the various approaches employed in its investigations" (p.206).

In my reading, the book presents two different and contrasting messages. I try to convey these by offering two perspectives on Longino's book. First, I present the scope and limitations of the book in a disinterested style similar to Longino's own. After this, I provide a pluralist-pragmatist reading following her proposition in the eighth chapter of the book.

Scope and limitations

The book first presents an impressive overview of five 'families' of scientific approaches to human aggression and sexuality. This overview is complemented by philosophical reflections on how to deal with scientific knowledge of human behaviour, once we realize that the various traditions do not add up.

Each of the two parts of this well-written book is around a hundred pages. The first part presents five named approaches: Quantitative Behavioural Genetics; Social-Environmental Approaches (mainly quantitative psychological and sociological approaches); Molecular Behavioural Genetics; Neurobiological approaches; and approaches that seek to combine these approaches to so-called integrated views of aggression and sexuality. These chapters are each organised in four corresponding sections: an overview section; a section on methods adopted in the approach; its scope and assumptions; and a conclusion. This composition provides a useful grid for orientation within the enormous range of scientific research that each chapter displays. It will be particularly helpful for students and scientists of neighbouring fields.

However, the book fails to explain why exactly its five (largely quantitative) approaches were selected, and not others. Because it presents such vast amounts of research, the book conveys the impression of being comprehensive, of covering any important literature that investigates aggression and sexuality. However, works that are highly influential in the social sciences are missing, such as Judith Butler's (1990) theory of sexuality, and Randall Collins' (2008) approach to violence – to name just a single work in each of the areas of human behaviour concerned. Such work is not even mentioned on the few pages in which Longino briefly sketches "human ecology/ethology approaches" (p.117–121). This is a pity as these could indeed counter Longino's complains of studies of human behaviour, such as that their "focus on homo- and heterosexuality obscures the range of erotic phenomena that constitute human sexuality" (p.208).

The question of 'the best' approach is attended to several times throughout the first part, although part one concludes by noting that this is probably the wrong question to ask. Longino emphasises that all approaches are limited in some ways.

Part two carries the title "Epistemological, Ontological, and Social Analysis". It begins by showing the incommensurability of the five families of approaches covered in part one. In a revealing chapter Longino analyses the 'spaces of causality' of each approach. She shows that what counts as behaviour, what is measured, and accordingly what can possibly be identified as causes of behaviour varies across the approaches. Defining behaviour is extremely difficult, the book emphasises. Most of the approaches analysed understand behaviour as a property of individuals. Even analyses on population-level tend to take populations to be an aggregation of individuals. Yet, as an object of research, aggression "splinters into different measurable indices", that "are held together [only] by a folk understanding of aggression" (p.177, my insertion).

Through citation analysis Longino inquires what happens to knowledge of human behaviour once published. Some areas of research (the GxExN model) were cited in scientific journals, in popularising media and even in philosophy. References to other research (such as Gottlieb's developmental systems approach) mainly appeared in scientific journals, and in a four-to-one ratio of theoretical to empirical content. With few exceptions little cross-approach citation was found within the scientific literature. In the general press, scientific knowledge of behaviour gets reshaped. It is "subject to interpretation and selective reading as it moves from the laboratory and field to policy deliberation, mass media and public hearts and minds" (p.192).

In the book's "Brief Conclusion" Longino attends to the "three major points" of her study, concerning the partial interrelations of approaches to human behaviour, the difficulties in defining behaviour and the communication of research findings.

A pluralist-pragmatist reading

Another way of reviewing *Studying Human Behaviour* is by reporting the disconcertment (Verran, 2001) I experienced while reading. It happened in chapter eight. Well into chapter four or five, I came to find the first part becoming a rather tedious read: approach after approach portrayed as consensual areas of knowledge; study after study, presented in a sort of distanced style. Longino's approach seemed to mirror the approach scientists would themselves take in accounting for their results to an outsider. Focussing on limits, the discussions of the approaches almost exclusively followed an additive logic, emphasising which areas each approach would fail to cover.

And then chapter eight! The analysis of causal spaces that I found so revealing is followed by a discussion of monist, pluralist and pragmatist approaches to accounts of scientific knowledge. Monist approaches contend that proper scientific knowledge of a phenomenon is complete and comprehensive. They share the view with moderate pluralists that diverging scientific accounts are a sign of a scientific area that has not yet been fully developed. By contrast, substantial pluralists take some phenomena to be characterised by an "ineliminable plurality of theories" (p.137). Third, pragmatists hold that knowledge varies with the practices in which it is embedded.

I had unequivocally read the part of the book as conveying a monist or moderate pluralist perspective, based on the recurring emphasis of the partiality of each approach, and their failures in covering this or that aspect of behaviour. However, after a longer discussion of different versions of pluralism, Longino claims that hers is a pluralist approach "supplemented by a form of pragmatism" (p.149). According to this way of accounting scientific knowledge, only "a flawed model of scientific knowledge… separates pure knowledge from its application and supposes that "pure" (a.k.a. "basic") research can provide comprehensive knowledge of a phenomenon that can then be applied to or drawn on for the solution to practical problems." Scientific knowledge, Longino continues, "cannot be separated from the conceptions of what we want the resulting knowledge for" (p.149). Yet it is apparent that the rule Longino is proposing here, does not apply to the first part of the book, in which Longino succeeds very well in presenting scientific knowledge absolutely disembedded from reflections on what we want the resulting overview over approaches for. After she meticulously examines how behavioural scientists' choices in developing their approaches limit their analyses, she is less attentive to exactly those issues when it comes to her own approach.

Being sympathetic to Longino's pluralist-pragmatist ideas I had accepted the need to reinterpret my response to the first part of her book: Probably, I thought, the five approaches were accounted for in a disinterested, distanced style due to Longino's (implicit) conceptions of what she wanted the resulting knowledge for, i.e. to convince scientists of human behaviour, and probably also philosophers of science, of her approach to scientific knowledge. Such a rhetorical 'trick' may indeed be necessary if one seeks to convince such scholars to lend an ear to a pluralist-pragmatist. It was with deep admiration for Longino's paradoxical and, thus, consistent application of her pluralist-pragmatist stance that I turned the page to continue reading chapter nine. This was when the second surprise hit me. Chapter nine starts out by stating that 'ordinary concepts' of behaviour are vague and value laden, and thus not suited for scientific investigation. Accordingly, the challenge is to develop "clear and unambiguous behavioural categories and criteria" (p.152).

The book continues with this apparent amnesia of chapter eight until its end. In the conclusion Longino points to the 'illusion' that "a discrete phenomenon is being identified, but the variety of operationalizations and the instability across measurement methods gives the lie to such hopes" (p.206). I fail to recognize how a diagnosis of scientific approaches as 'illusions' can be compatible with a pluralist-pragmatist stance that departs from the idea that ""pure"… research can provide comprehensive knowledge of a phenomenon".

The disconcerting experience around chapter eight that I felt when reading derived from the tension between the phenomenon behaviour and the representation of behaviour. In my understanding the reconsideration of the relationship between phenomenon and representation is a necessary consequence of Longino's pluralist-pragmatist stance as explained in chapter eight. Without it, we end up in an endless regress of seeking for the universally best representation, ignorant of the fact that also our own knowledge production is situated and attempts to solve practical problems. We might stare ourselves blind focusing on what from a 'view from nowhere' is missing in each approach, or we may end up as this character in Lewis Carroll's *Sylvie and Bruno* from 1894:

> That's another thing we've learned from your Nation," said Mein Herr, "map-making. But we've carried it much further than you. What do you consider the largest map that would be really useful?" "About six inches to a mile." "Only six inches!" exclaimed Mein Herr. "We very soon got to six yards to the mile. Then we tried a hundred yards to the mile. And then came the grandest idea of all! We actually made a map of the country, on the scale of a mile to the mile!" "Have you used it much?" I enquired. "It has never been spread out, yet," said Mein Herr: "the farmers objected: They said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well. (Carroll, 1894: 524, ref. Smith, 2003: 75)

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