How disruptive is wind power? A lesson from Denmark

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Abstract

Peter Karnøe, a researcher at Aalborg University (Department of Development and Planning) and member of a new research center for Design and Innovation for Sustainable Transition (DIST), is a specialist in the socio-economic analysis of innovation processes and has contributed extensively to the understanding of technological dynamics in the energy sector. His current research on the valuation of wind power is directly connected to his participation in policy initiatives in Denmark. Peter Karnøe is also a member of the Advisory Committee of the Observatory for Responsible Innovation. This short position piece builds on a discussion hosted by the Working Group on Built-in Renewable Energy in Architecture at Mines ParisTech (14 May 2012). Peter Karnøe examines the technical and political conditions in which the value of wind power can be established and re-established, with reference to the Danish case.

The Danish wind power trajectory

How disruptive is wind power? How does it alter and confront existing energy arrangements? The question is worthwhile asking in the light of the Danish experience, as the country stand as a particularly exciting real scale experiment in energy policy. Wind power went in Denmark from a completely marginal source of energy in the late 1970s to an almost dominant source, at least centrally located in today's Danish energy strategy. Political determination has signaled an ambitious 50% target for 2020. But wind power and wind-power technology meet an already-existing technological environment, mostly characterized by a centralized system of electricity production and distribution. Wind power needs to cope with a whole already-set energy arrangement. And this translates into a series of disruptions that require careful consideration.

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What happened throughout the Danish wind power trajectory? How did opposing forces operate in the 1970s? How did different "networks of power" (in both senses of the word) evolve? Concerned groups articulated wind power in a particular manner. Opposition to nuclear power was becoming a crucial element in the 1960s, but it intensified after the 1973-energy crisis. The energy crisis was used by the societal (network) coalition behind nuclear power to advocate nuclear power as the "natural response". The spurred counter-action from the anti-nuclear groups and together groups advocating for renewable energy

and the limits to growth mobilized to shift the dominant agenda. Determination in favor of nuclear power was the main response to this movement. The Director of Electrical Utility Association in Denmark (which was preparing for nuclear power since the 1950s), famously claimed at that time: "you may discuss as much as you like but nuclear power you will get".

The first official Danish energy plan of 1976 focused on a shift from oil to coal dependency, with an emphasis on nuclear power, energy efficiency and domestic energy sources. But the coalition of groups contesting the "established networks of power" managed to penetrate the energy technical and political assemblage, in a mostly experimental manner. For example prominent scientists from the Academy of Technical Sciences made calculation-based reports with scenarios of wind power and proposed experimental testing to part of the official energy policy. However, Christian Riisager, carpenter and prominent wind turbine "hacker" of 1976, was pivotal in the wind power trajectory. Mainly concerned by the electricity bill and motivated by a rather romanticized relation to harnessing energy from the wind, Riisager constructed his own wind turbine and connected it to the grid, without asking for permission. He looked at his meter, the story goes, and noticed it was running backwards. Meanwhile, nothing seemed to break down in the neighborhood. He then went to the local director of the electric utility to request an official authorization to connect to the grid. This socio-technical act had of course important political and organizational consequences. Riisager's action felt into a regulatory "no man's land" as the regulatory framework for power generation did not include the option of grid-connected wind turbines - only for centralized power plants. The Danish Electrical Association of Utilities developed a set of guidelines that granted wind turbines the right to be connected to the grid - and to pay the power producer a modest price for the electricity. This soon became a recipe that started to circulate and stood as a stimulant proof for further initiatives.

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In order to understand the penetration of the existing network of power it is important to follow these sorts of historical details. The Danish energy technological trajectory is heavily path-dependent, but we need to appreciate the path-creation endeavors of actors that attempt to break dependencies. Rather than being the outcome of grand political initiatives, this trajectory is the result of an accumulation and assemblage of socio-technical experiments, struggles and mobilizations. The situation evolved in the 1980s and the 1990s, with new key concerns, new forms of coalition, new regulatory initiatives. The concerned groups against nuclear power and pro-renewable energy jointly with scientists-activists were pivotal in my view, with their capacity to organize political mobilization and technical demonstrations of wind-power scenarios and trajectories.

In 1980s, the reached institutional and technical arrangements for large-scale wind turbines proved rather poor (definitely not a success), compared to the arrangement for small wind turbines (à la Riisager). Utilities, on the other hand, did not fear wind turbines: these

represented hardly anything, and nuclear power was not out of the game yet in the early 1980s. But the wind power coalition grew stronger, technically and politically, especially in the 1990s. Nuclear energy had been politically ruled out in 1985. CO2 concerns came to the forefront in 1990s where Denmark formulated national energy plans in 1990 and in 1996 that was integrating CO2-emissions as a criterion for the policy. For example, decentralized power plants, which were fostered in part by the development of infrastructures for natural gas, constituted a rather hospitable technical environment for wind power, and could be fuelled with biomass. From 1990 to 2000 the share of wind power in the Danish electricity system increased from 2 to 15%.

These good days for wind power did not continue. A governmental shift led to a strong wind power skepticism (and climate change skepticism), and that characterized the political developments in the 2000s, when for example ambitious off-shore wind farm agreements reached in the 1990s were meeting a dead-end. Further, in the face of a liberalization and so-called more "responsible economic policy" and assessment of the Danish wind turbine trajectory by the Economic Council concluded in a highly contested cost-benefit analyses that that societal investments in wind power had not been economically responsible due to the low societal return on investment. Consequently a conclusion circulated that "wind power is too expensive". But things started to change in favor of wind power as the climate change and wind turbine skeptic prime minister in a public speech in 2008 (before the COP 15 in Copenhagen) said: "I am sorry - I was wrong about the climate change". This stimulated governmental evolutions and enhanced a new national compromise on wind power in the 2010s, quite importantly. Wind was granted a central position in the Danish energy strategy, and the new National Energy Act was approved in Parliament in 2012.

Conditions for a shifting valuation of wind power

Since the 1970s the wind power penetration in Denmark shifted historically from "impossible innocence" to "disruption at work". Why disruption? Isn't the becoming of a "network-of-wind-power" just a matter of political will and of liking or disliking wind power? Well, the argument is well-known: higher shares of wind power mean higher costs in the electricity system (as long as externalities are excluded from fossil fuels). Electricity is defined by a "load balance" set at a specific frequency, 50Hz, in real time. Power generation needs to meet consumption on a fine-grained matching basis. Fluctuations in power generation are not by any means restricted to wind power, though wind power is admittedly greatly intermittent. The larger the share of wind power in a particular grid, the more the "load balance" will depend on a source that cannot be fine-tuned: the utility cannot ask for more or less wind. And, consequently, the more standby power will have to be available in that grid (coal, for example). Hence the

disruption: the material violation of the electricity system when wind power is massively plugged-in. Wind power disturbs the load balance, and may result in massive amounts of "discharged electricity".

One conclusion is to say that wind power is impossible: that is the standard talk. But what this conclusion does not take into account is what I term the material grounding of valuation. The value of wind power depends on the valuation matrix that you use, which is grounded in the dominant technical arrangement and, in particular, on the existing grid infrastructure. There is a transition challenge, which precisely affects how valuation is done and how the value of wind power is considered.

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In a "Grid 1.0" regime, we are in a load balancing "turning-up-and-down" logic, with an Edison-Tesla configuration, with centralized power generation, with consumers generally passive in load balancing. This is a hostile territory to wind power, which is costly and disruptive on that model of generating and preserving load balance. But the framing of the cost burden depends on a shift in the material grounding of valuation. A "Grid 2.0" regime introduces a paradigm-shifting load balancing, a "volatility" logic. This "volatility logic" is based on a power generation mix with 50% of wind power and on smart complementary generation, storage and consumption technologies, and new transmission lines (micro-grids), which also enhance consumer agency in load balancing. Such a "volatility logic" transforms consistently the material ground on which the valuation of energy technologies ought to be based. This is a path towards the "normalization" of "disruption", by just considering the value of wind power within a socio-technical environment that puts wind power at its center, and not in the margins. My point is that there are competing visions and struggles to re-arrange the socio-technical components of the energy system in order to avoid discharged electricity. This requires the technical and regulatory re-building of the energy system toward s a "smart energy system" that is creating flexibility to meet volatility. This is in my view the direction that Denmark is demonstrating.

The policy challenges to the commitment to wind power have strongly to do with the way we modify the conditions of valuation. Political commitment to favoring wind power has disruptive consequences on the material arrangement of the system, pricing methods and political regulation, and these disruptive consequences have to be assumed at face value and organized in a responsible manner. However, regarding responsibility, there are also "limits to wind power" as concerned groups protest against new wind power installations - just like for nuclear power facilities - in Denmark. Wind power move from being marginal to becoming the central actor in the energy system, which does not give the right to "run over smaller actors". There is also clear evidence that shows how democratized co-ownership of large-scale on-shore and off-shore wind farms in Denmark has transformed interests of concerned people.

This new arrangement relies greatly on a heavily active, responsive and reflexive consumer. It therefore opens the black box of the kind of citizen-consumer that needs to be configured, and, with this, the condition of energy as a public service in a common world. The disruptive experiment is therefore an anthropological experiment and a political one, and definitely a necessary one in my opinion. And the experiment ought to be an open one. The ways of configuring an "active" consumer are manifold. You can rely on an exacerbation of the culture of consumer choice, exposing users to all sorts of signals, in particular price signals that demand decision-making. But you can also rely on automation protocols that shift decision-making to collectively assessed rules embedded in appliances and apparatuses.

Does this means that the value of wind power is politically malleable and socially constructed? Yes, if you take into account the material, technical aspects of that malleability and that construction. The key notion here is not path dependence, but path creation defined as the shifts required to imagine and realize new techno-economic and socio-political assemblages. A path-dependence thinking will favor the existing energy technologies and of the existing methods and concepts we use in order to account for their value.

The French nuclear trajectory was also strongly path-dependent. The nuclear program, which also met opposition, did achieve framing its material grounding of valuation, and the corresponding infrastructure, that posited nuclear power as the more rational and cost-efficient alternative within it, and therefore fostered that path. If the Danish utilities had agreed on a nuclear reactor type in the 1960s (which they could not), for example, they very well could have developed that path too. I really believe that path creation as opposed to path dependence is the right way to consider these new developments. There is nothing structural that makes a path stronger in principle, but a path surely becomes stronger and more irreversible as it is undertaken by various actors and possibly institutionalized in "networks of power". This teaches us about how technological paths are locked-in but it also indicates keys for locking them out. The Danish case is also about how society itself became re-organized and re-shaped by the energy technological path. This makes evolutions highly unpredictable. We are in a highly experimental terrain.

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