Summary

In this research the modernization of electricity networks in the Netherlands has been explored and explained from the perspective of (1) the alignment of the institutions and technology and (2) the innovation system. The objective of the research was to determine the important variables in the modernization of electricity networks in the Netherlands from these two analytical perspectives and to determine under which conditions these variables become important in modernization.

Research approach

The conceptual framework in the alignment perspective is a co-evolutionary approach (e.g. Nelson and Sampat, 2001; Perez, 2002; Tunzelmann, 2003) predominantly based on the theory of coherence (e.g. Finger et al., 2005; Künneke, 2008). An important aspect in this theory is the concept of critical technical functions that have to be safeguarded institutionally and technically in order to maintain an aligned system. Another aspect relates to the technical alignment of the different technologies in a bigger structure referred to as a large technical system (e.g. Hughes, 1987). We determined the relationships between modernization and alignment with a historical analysis, dividing the time between the start of the first power system and the present power system accordingly in a number of periods, based on important modernizations. Additionally, we used a layered approach to structure the important institutional variables and to determine a 'logic' of the institutional system.

In the Innovation Systems perspective (e.g. Freeman, 1987; Lundvall, 1992; Nelson and Rosenberg, 1993; Braczyk et al., 1998; Malerba, 2004) we also used the institutional layers to structure the identified important institutional variables and to determine a 'logic'. The institutional variables in the period prior to liberalization are compared to the institutional variables since liberalization. We conducted interviews and a survey to capture the interactions between the institutional variables in the different layers and assessed the impact of the institutional variables on innovation. This approach also enabled us to determine which layer is important for innovation.

Results and conclusions

Alignment perspective

We identified examples in which the alignment of the institutions and technology acted as an important driver to modernization, such as with the concession scheme for provinces and the Obstruction Act which were directed at long term capacity management and which drove the modernization, i.e. electrification of the Netherlands. We also observed historical examples that demonstrated that the misalignment of institutions and technology played an important driving role in the modernization of electricity networks. For example, the misaligned situation of German windmills jeopardized the Dutch electricity network and resulted in modernization of the network by the implementation of phase shifters. Hence, we conclude that both misalignment and alignment can act as an important variable impacting on modernization. We discussed whether there are circumstances or conditions under which modernization acts as a driver to the (mis)alignment in the system. The condition for modernization to be a driver for alignment is in cases where the technical adaptation is already to some extent readily available at reasonable costs. The misalignment might also be answered by an institutional change. However, institutional change might be more costly or too time consuming. Aligning different actors with different objectives might be costly in time, money and effort. In urgent cases it would be more appropriate to choose for an available technical solution.

Next to modernizations in which the system became re-aligned, we identified cases in which modernization of the network acted as a driver for misalignment of the system. An example is the modernization by international interconnections which, together with the German windmills, resulted in a misaligned system. Another example is the installation of increasingly big generation plants which resulted in a substantial need for network adaptation, referred to as a technical re-alignment.

A regularity that was observed in our historical analysis relates to the network expanding to larger scales by means of interconnections: from a local to a provincial system, from a provincial to a national system, and finally from a national to an international system. Not every technical function could be easily forecasted with the growth of the electricity system. Some technology specific functions were not to be foreseen based on previous electricity network modernizations and unexpected misalignment issues resulted from that. This observation implies that with current modernization efforts, still unexpected issues can arise that would jeopardize the electricity system. This understanding is important and deviates from the standard engineering and policy making approach which focuses on the single domain of either technology or economics respectively and which is based on the idea that the system can be easily designed. Our approach shows that the electricity network should be understood as a complex socio-technical system with intricate interrelationships between the technical and institutional domain.

We determined an evolution in the logic of the electricity system from institutions directed at small scale local level in the first period of electricity system which developed into institutions directed at an integrated electricity system in the current period. From the analysis we learned that the national government has always been at a certain distance from the electricity sector with

as a most remarkable example the prominent role of the provinces instead of the national government in electrifying the Netherlands in the 1910s-1930s. Although we observed that the sector at certain instances is able to solve alignment problems itself, we also observed instances were the national government stepped in to restore alignment. This indicates that per situation it should be determined at which institutional level any misalignment should be coped with. In other words, the context of the specific alignment issue is of utmost importance in determining the appropriate institutional or technical measure.

Innovation system perspective

The application of the innovation system perspective has resulted in an inventory of important variables impacting on innovation. The interviews provided us with an enhanced understanding of the variables in modernization prior to and since liberalization. Examples of prominent variables that impact on innovation are the authority within an organization that can promote innovative activity (e.g. the CEO of the company), the culture of reliability, the share of engineers and the R&D facilities. In general we found that variables such as the culture of conservatism, the current tendering rules, the incentives for the shareholders and current regulation do not have a positive influence on radical innovation. Regulation and tendering procedures are very much focused on cost efficiency and conventional technology. We also found that to cover the risks that are accompanied with innovations more often than before extensive contractual arrangements between the technology supplier and the network company are used. With these contractual arrangements there is a tendency for technology suppliers to only provide conventional and proven technologies. This influences radical innovation negatively. It was concluded that there is a shift from long-term radical innovations to short-term incremental innovations after liberalization. The idea that liberalization increases innovation is therefore not confirmed with this research.

From the logic of the institutional layers we learned that the central government does not steer the innovation as companies in the sector are intrinsically, in their culture and actor organization, tending towards innovation. In other words, the logic is based on self organization with regard to innovation although among policy makers there is a persistent line of thinking with regard to central planning and design. The logic, however, shows that instead of central planning and design the central government should facilitate the self regulation with regard to innovation and allow parties in the electricity sector to find the most appropriate technology. So it is not the end results which should be dictated by government policies, but the process of innovation that should be facilitated by government policies. The government should be able to intervene in cases that parties cannot fulfil their duties with regard to innovation. In order to allow for more radical innovations we suggest that the central government might opt for a more steering role as current innovations tend to be more incremental.

If we want to increase the innovation activity of the sector we should focus on the important variables impacting on innovation as identified in this study. Policy makers and innovation managers in companies can construct innovation policies based on the key variables in the process of innovation, but should be aware that variables might work in combination with other variables and that intricate relations exist. These interrelationships, furthermore, suggest that the combination of variables might be more persuasive in explaining innovative activity than individual variables. The identified institutional variables are also highly interrelated across different institutional layers. Thus a logic combination of institutional variables, possibly at different layers, is needed to fully understand the drivers in the modernization process.

Closing remarks

Considering the above, there might be a need to accompany the institutional change to safeguard a well aligned system. In order to achieve a successful liberalized electricity sector there should be incentives to stimulate these technologies that allow for the development of a substantially decentralized electricity system. This suggestion combines both our analytical perspectives of alignment and innovation system. Radical change of the system is only needed if we want to accommodate more DG and to arrive at smart grids. The question is whether the demand pull for such radical change is large enough for the electricity sector to step in with innovations of network technology. The answer to this question should contribute to formulating a vision with regard to whether and how the government should direct its policies towards facilitating this radical change.