Maersk McKinney Møller Institute

Center for Energy Informatics

Digital Twin for the Smart Energy Market

PhD student:
Nicolas Fatras
Supervisors:
-SDU: Bo Nørregaard Jørgensen; Zheng Ma
-U. of Chinese Academy of Sciences: Xielin Liu; Hongbo Duan

Background

Energy markets worldwide have been experiencing a decentralisation since the 90s, driven by various factors: incentives for competition to drive prices down, multiplication of actors through emergence of DERs, change in consumption patterns [1]…

The complex stakeholder relationships in such energy markets vary from region to region, as exemplified on the right by the electricity markets for Denmark and China. Although not exclusively, these two countries shall represent the main case studies throughout this project , as both are very relevant to future energy markets, through important shares of renewables for the first, and the shear size and growth of its market for the latter.

In parallel to this increase in market complexity, binding socio-environmental constraints have been fixed for the decades to come in light of increasingly important sustainability concerns.

In order to drive these changing ecosystems to the sustainability objectives, the governing market mechanisms and policy regulations have to be adapted to the local conditions.

However, the complexity of the systems analysed is such that no human-based analysis can cover all the aspects of the problem at hand. Therefore network modelling tools are essential to solving the problem at hand.

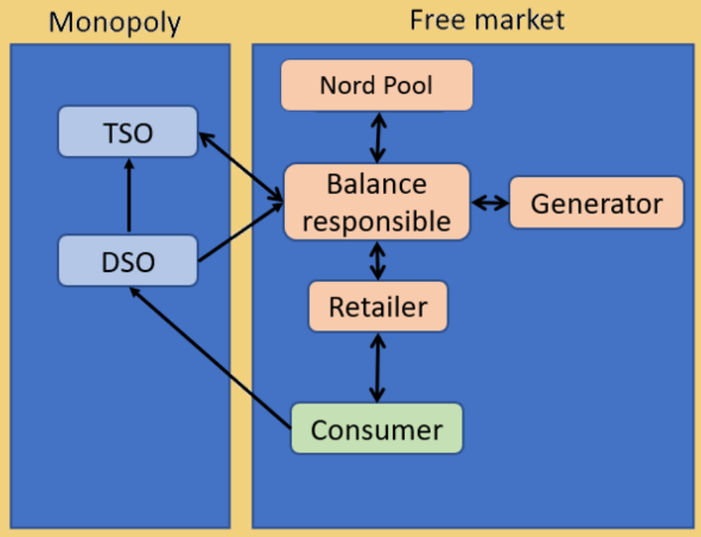

Figure 1: Danish electricity market framework (adapted from [2])

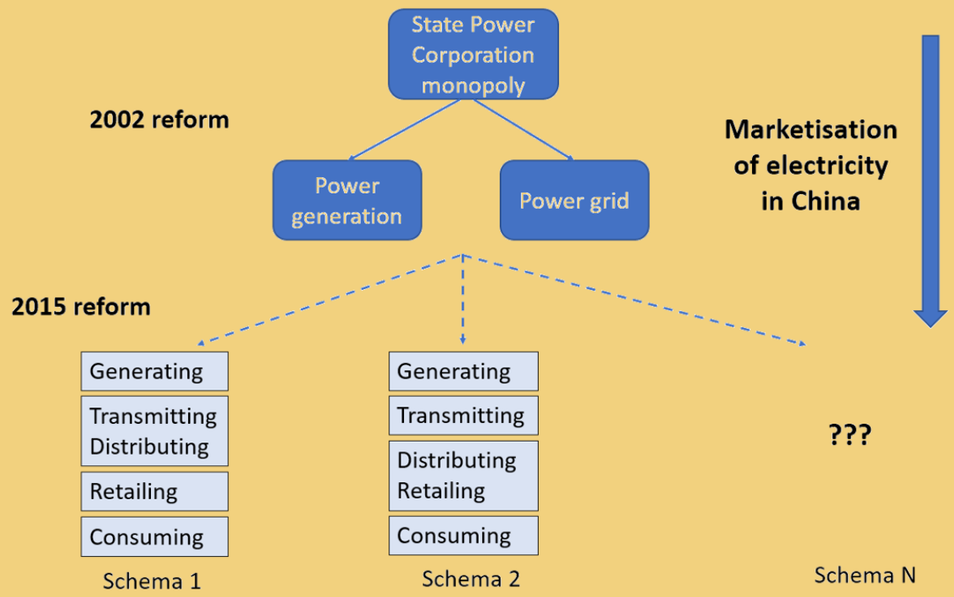

Figure 2: Chinese electricity market framework (adapted from [1])

Aims and Objectives

Contribute to the development of a digital twin for the smart energy market , to facilitate consumers' engagement in the transition towards a sustainable energy ecosystem.

This will be achieved through the following objectives:

- Understand the main impact factors in a smart energy market
- Set up and run simulations to test these impact factors in various case studies
- Develop a generic model framework of the smart energy market, customisable to different energy ecosystems

Stakeholders benefiting from digital twin:

- **Consumers** (industrial and aggregated households): better quantify risks and benefits of adopting innovative energy supply solutions
- **Policy makers**: implement policies at different time-scales while better understanding impacts
- **Energy suppliers**: offer energy solutions better tailored to the market's needs, thereby improving the financial viability of their projects

Methodology

Simulations will be Multi-Agent based (MAS) using the software AnyLogic, in order to extract overall system properties from the aggregation of individual behaviours in a bottom-up approach for complex systems.

The quality of such models is highly impacted by the input data provided, which fits nicely with the generalisation of IoT and Big Data nowadays.

Once the model framework is set up, there are a multitude of new technologies, market mechanisms and regulation scenarios to test, as shown for example by the complexity of the Denmark residential electricity price structure in Figure 3.

Due to large amount of variables to test, the combination of the simulation models with AI (machine learning, artificial neural networks…) becomes interesting to help design policy and market mechanisms experiments.

This combination of simulation models, Big Data and AI results in a Digital Twin which can be used to design Smart Energy Markets in various ecosystems.

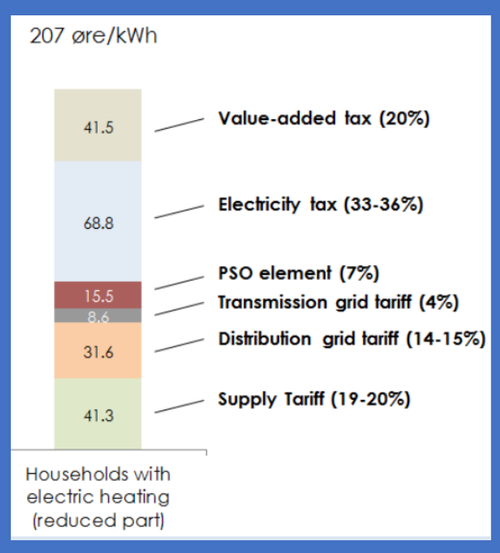

Figure 3: Example of Danish electricity price structure [3]

References

[1] N. Lei; L. Chen; C. Sun; Y. Tao. "Electricity market creation in China: Policy Options from Political Economics Perspective". Sustainability, vol. 10 – 1481, 2018.

[2] K.B. Laage-Petersen ; M.H. Bjarrum . "The Danish Power Sector: Liberalization and regulation of the Danish power sector". Florence Online School, Jun. 2017.

[3] L. Kitzing, J. Katz, S. Schröder, S.T. Morthorst, F. Møller Andersen "The residential electricity sector in Denmark: A description of current conditions". DTU Management Engineering, 2016.

Project funded in collaboration with SDC (Sino-Danish Center)

Contact: nifa@mmmi.sdu.dk