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DSO RISK MANAGEMENT STRATEGIES FOR REDUCING RISK CAUSED BY ACTIONS IN FUTURE FLEXIBILITY MARKETS

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Abstract

The lack of visibility of the actions of new actors such as aggregators and customers providing demand side response and other ancillary services will present new risks to Distribution System Operators (DSO's) in both their planning of new investments and in the day to day running of the system. The key question is how will DSO's identify these potential risks, value them and then act on them to safe guard the operation of their network systems and protect their financial performance? This paper presents a methodology / approach for assessing/quantifying such risks, to help understand the impact of various mitigation strategies. At the heart of this framework, lies an Agent Based Modelling tool, which models the interactions of key agents such as aggregators, generators, independent system/market place operators and domestic/industrial customers.

1. Introduction

Additional uncertainty and risk are being introduced into the distribution eco-system, as a result of the introduction of embedded generation (DER's), new market structures (such as flexibility markets), and new actors (aggregators, EV and storage owners, and DSR from domestic and industrial customers). This has a direct impact on the DSO's ability to operate and plan its distribution system operations. This raises important questions for various stakeholders e.g. aggregators and the DSO including but not limited to:

- The DSO needs a better understanding of aggregator actions to be able to efficiently manage its physical risk (flows and voltages). How would it do this?
- What risk management strategies and business models are open to the DSO for its use to manage such uncertainties e.g. – Longer term reserve, Contingency planning etc.

Increased uncertainty would normally require additional "safety" operating margins so reducing risk to the DSO is important objective if it is to increase hosting capacity on its systems at a reasonable costs.

This short paper sets out a new methodology for assessing the uncertainty and risk due to new actors' actions in flexibility markets e.g. aggregators, domestic and industrial consumers etc., providing flexibility. The methodology allows for identification of risks as well as the quantification and valuation of risk to the DSO.

2. State of the Art: Risk Management

Much of the literature talks about standard approaches in the risk management field in generic terms and typically highlights the risk matrix approach i.e. Impact vs Probability of occurrence [1] and embodied in systems like PRINCE2®. Additionally only a few papers since 2007, address risk management methodologies in the power distribution arena. More generally although risk management is a discipline in its own right and some might say it is mature, it is still developing and cuts across many varied disciplines from finance to engineering and natural hazard management. In particular, reference [2] provides a good overview of the asset management based class of risk management techniques/methodologies used in the distribution sector. In addition, approaches can be quantitative, qualitative or a hybrid (semi quantitative). Quantitative approaches provide analytical rigor and are preferred, but can be difficult when soft measures are involved. In addition, quantitative approaches can be quite complex and may be difficult to communicate to a wider audience.

In general terms the risk management industry sees three areas for further development in its methodologies

- Integration of risk management into the business (holistic/whole system viewpoint).
- Depth of methods used to analyse the risks i.e. go beyond the simple risk matrix methodology.

- Inclusion of behaviours into risk management.

In the context of the current direction of travel in the distribution sector in Europe, active domestic and industrial customer involvement (human behaviour), the growth of EV's (commercial and residential), and the introduction of new actors and contract structures increases the complexity of the system and makes it difficult to understand and forecast risk outcomes.

With less complexity it is easier to use in house experts and external consultants to provide a view on what the potential risks might be for the DSO going forward, but this becomes more difficult to predict in newer and fast evolving markets as well as ones that exhibit a human behavioural component. Thus an alternative methodology is required.

3. Agent Based Modelling and Risk

Agent-Based Models (ABM) are computer based frameworks used to study the interactions between people, things, places, and time. They are stochastic models built from the bottom-up, meaning individual agents (Companies, EV owners, Customers Regulators, etc.) are assigned certain attributes that represent the way that they behave. These behaviours can be static in nature (the norm in ABM) or highly adaptive or a combination of the both. It is an ideal technique to model the questions above. A framework that provides a DSO with a view of plausible scenarios or outcomes on their system would therefore be extremely valuable. Essentially our approach tries to make sense of a complex uncertain world through simulation and strives to identify plausible outcomes in terms of business patterns and impacts on business.

At the heart of this work is our ABM framework PyEMLab–AGG designed to simulate markets and network conditions under the actions of domestic/industrial and aggregators. This short paper provides an outline of our approach which essentially provides a framework that allows us to:

- Structure and understand the problem.
- Identify specific risks especially those associated with new actors.
- Measure and quantify risk.
- Try out and simulate portfolios of mitigation options.

Agent based modelling has been extensively used in assessing flood management [3] and for assessing risks associated with disaster evacuation routes, and natural hazard analysis in general, but not for risks in the power Industry. By combing and adapting the "SIMULATE" and Dynamic Adaptive Planning approaches in references [4, 5] we have developed a new approach for addressing and mitigating DSO risks in future flexibility markets. In this instance we utilise ABM methodologies rather than system dynamics.

4. Framework Methodology

Transmission and distribution companies are investing billions of Euros to upgrade the network infrastructure across the Europe between now and 2050 as the region looks to play a leading role in the clean energy transition. Unfortunately, in the future,, the distribution companies in are likely to be sandwiched between a numbers of players, old and new e.g. the ISO, Aggregators and Customers, with whom they have no control over, or visibility of their day to day actions. These various players' interactions could have a significant effect on the operations and financials of the DSO businesses and impact the veracity of their future investments. Of course it will be difficult to know the exact intentions of these various actors, but a framework that simulates potential plausible outcomes could provide important information on the potential impact to one's position in the current and future operating environments. Simulating these problems/challenges are best approached as a Multi-Agent or as an Agent-Based Modelling approach (MAS/ABM), where the system consists of agents/actors'/entities that each see the world differently. Interactions between these "agents" will be an important determinant of both physical and financial flows in the power system that the DSO is connected to.

The power system is also evolving and the actors (DSO, TSO's etc.) behaviours are changing. The key questions are:

- How are these behaviours changing?
- How do we model and evaluate that?
- How will could this affect the DSO?
- What should DSO's do to mitigate or enhance potential opportunities?
- Can we develop robust strategy/ positions for the DSO and how would we do that?

4.1. Process/Framework Outline

We have developed a process (Figure 1) that allows us to:

- Structure the problem to answer key questions for a DSO with regard to risk from new actor actions like aggregators.
- Identify and allow us to investigate risks and key elements of the problem,
- Measure and value those risks/uncertainties. Which in turn will allow us to mitigate those risks.
- Understand the mechanics and interrelationships of the key parts of the problem.
- Test alternative technical and commercial solutions (mitigation, risk management etc.) and allows for further understanding of the problem.

The process includes the use of workshops, collection data, and surveys, but relies heavily on the use of an Agent

Based Modelling framework, to simulate the actions of actors that the DSO has zero or partial visibility of (e.g. Aggregators, domestic customers etc.). Note other simulation type environments that can capture behaviour of "causal" relationships and feedback loops e.g. system dynamics could also be used.

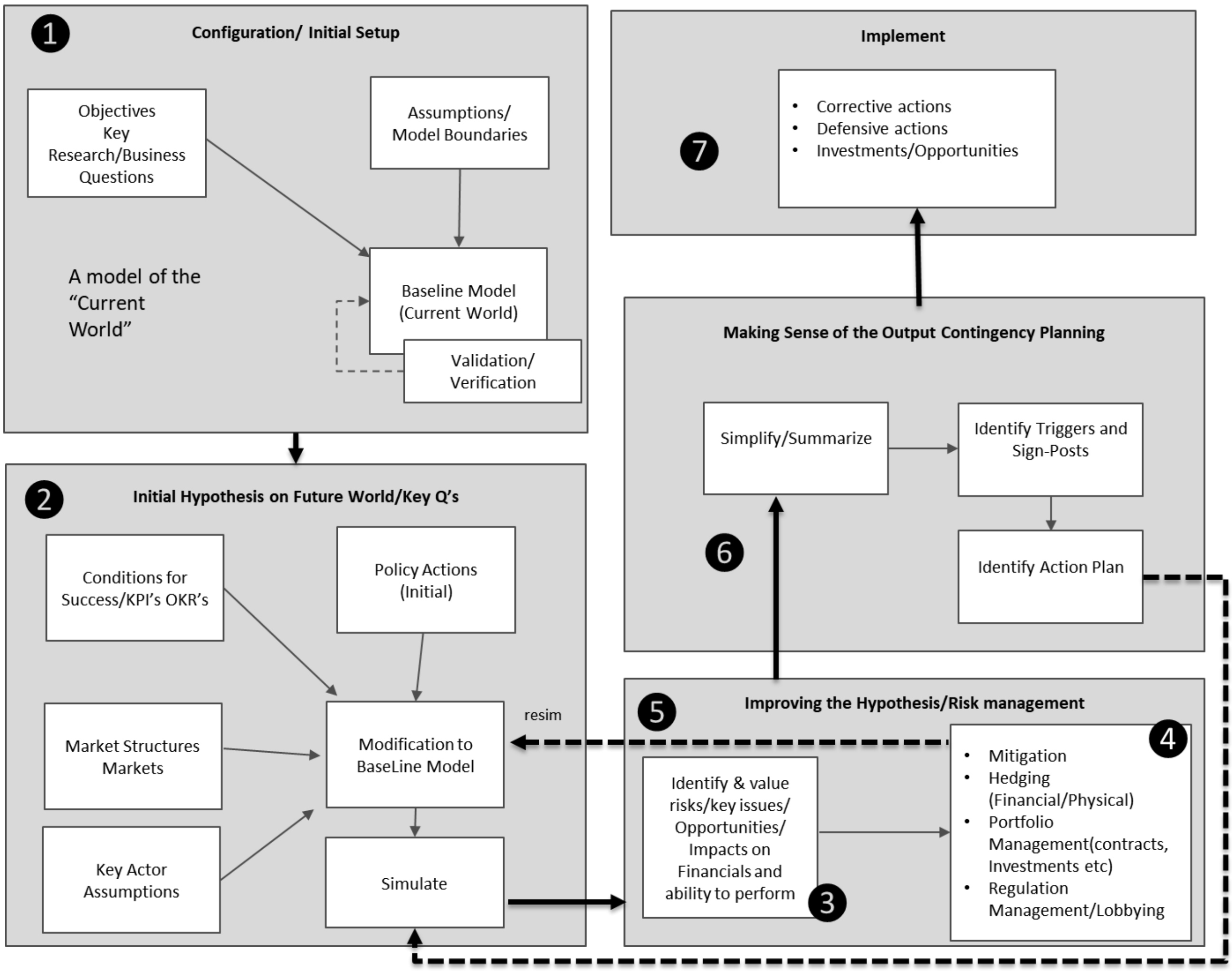

Figure 1: Risk Assessment Methodology using an ABM Simulation Environment

The process starts by creating a base simulation model to model as the current environment, and agreeing objectives for the exercise ① (numbering on Figure 1). Known outcomes or data are used to validate the model. The second part of the approach② extends the model created in ① to represent future distribution operations and would include new actors as appropriate. After the simulations in stage ② risks can be identified and mitigation strategies developed. These could include: curtailment, novel contract structure, Active Network Management and so on (stage ③). Models of these options are then made and used to re-simulate the model developed in stage ②. This provides us with output that can be used to assess the impact and of the suggested portfolio of mitigation options and to redesign them if necessary. The "final" simulations using mitigations/investments in stage ④⑤ provide us with synthetic data that we can use to analyse the output of the simulations. Much of this output is difficult to understand, so a key part of this part of our approach is to "make "sense of this complex data". We have developed methods that use a combination of statistical and machine learning techniques that allow us to extract "patterns" from complex simulations⑥. This allows us to better understand the key drivers and "levers" of the simulations. We have found this helps both in simplification of the output but also in validating the model. The results from this modelling and discussions with stakeholders are used to identify and highlight important triggers/Signposts, and can be used to help you implement appropriate mitigation and hedging strategies⑦. Although the phases are discussed sequentially, this is not a linear process; steps may be repeated using information/insights from other stages.

5. Case Study Results

Using data from a Virtual Power Plant learning-by-doing Project (SIES 2022) [6, 7], based in Scotland, ABM simulations of the effects of aggregation on the DSO have shown that large impacts on distribution system could occur at certain nodes (Figure 2 and 3). Note Imports and Exports to the pilot plant are shown and that for 15% of the time, large difference in dispatch patterns (what was expected by the DSO vs what happened), were seen. This potentially represents a large risk to the DSO.

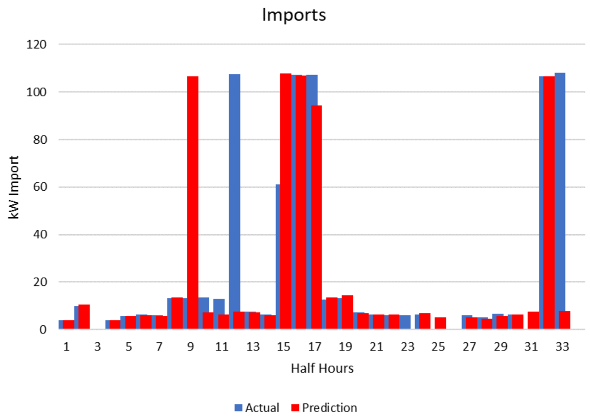

Figure 2: Aggregator Impact on DSO forecasts – Imports

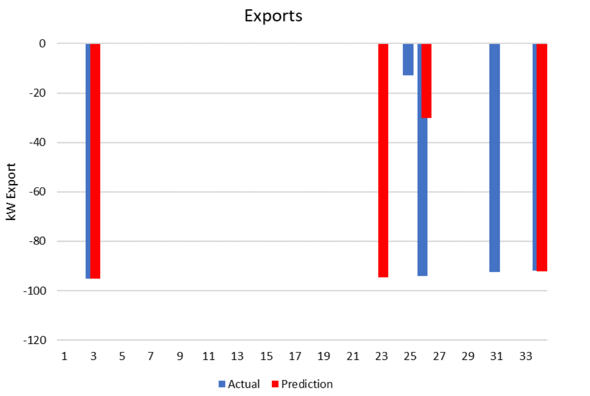

Figure 3: Aggregator impact on DSO forecasts - Exports

Our approach therefore is able to highlight both short-term (Flows and Prices) and longer-term (DSO investments) risks. Although not shown, the simulation also presents market price impacts and can be used to simulate price incentives or contract structure effects on the system operation. Mitigation and risk reduction alternatives can be formulated and used to simulate the effect on the DSO's position via the simulation framework, therefore providing the DSO/stakeholder with an approach to rank alternatives. We are currently developing models of these risk mitigation alternatives to simulate the risk and will be included as future work (both physical and financial). Mitigation strategies such as curtailment, additional flexibility reserves, active network management (ANM), and novel contract structures etc. could be formulated in this environment and used to assess their effectiveness.

6. Conclusion

Using an ABM tool as the basis of assessing complex interactive behaviour in a future flexibility markets, we have developed a risk framework for assessing DSO risks and their impact on system operation. Initial simulations to value and quantify risk have been carried out and the next phase of the work is involved in developing mitigation strategies to be incorporated into the wider simulation environment and framework.

7. References

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