AN INDUSTRY SURVEY: ARTIFICIAL INTELLIGENCE POTENTIAL DISRUPTIVENESS AND USEFULNESS FOR ELECTRICITY DISTRIBUTION

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ABSTRACT

This papers sets forth that artificial intelligence is seen as potentially disruptive and ten electricity distribution activities are identified where artificial intelligence could be usefully applied: network planning, asset management, malfunctions & failures, fault detection, demand response & management, planned maintenance, grid operation, data checking & validation and load forecasting. The observation is that the most useful applications of data checking & validation and load forecasting are found to be low to moderate complexity and low to medium on data and time requirement.

INTRODUCTION

The **subject** addressed is the application of artificial intelligence in electricity distribution activities. Artificial intelligence (AI), and neural networks especially, are identified as potential valuable decision-making tools. However, at the current level-of-understanding, there is considerable uncertainty about how and where to apply artificial intelligence.

The **problem** is identifying the useful application of artificial intelligence in electricity distribution activities. Teams considering AI projects and applications are confronted with a number of questions: **which of our DSO activities could benefit most from AI applications?** How difficult and time-consuming is it to apply artificial intelligence and neural networks? In addition, utilization and application of AI comes with specific requirements for the organization, from data to IT-skills, that have to be addressed.

RESEARH QUESTION

The **research questions** involved are: **where can artificial intelligence be usefully applied in electric distribution activities?** Which applications are expected to be the most useful? Which of our DSO activities could benefit most from artificial intelligence applications? How much time, money and expertise is required for a project? And more general, **how disruptive could AI be for electricity distribution?**

METHOD

The **method** of addressing this problem is through the following steps: (1) the identification of the electricity distribution activities where AI could be applied, (2) identification of potential AI tools and techniques to apply to the activities, (3) matching of activities with AI applications, (4) industry survey amongst world electricity distribution community, (5) estimation of expertise and time required as well as potential value.

Steps one to three are performed with DSO practitioners in an AI working group [1]. Step 4 and 5 and are performed using an industry survey which is held from December 2018 till January 2019. The estimation of value is performed on a qualitative scale, the expertise and time required are combined in a ‘difficulty level’ and presented on a two-by-two matrix.

The **survey** is an industry questionnaire send out to people working and writing about the electricity distribution sector. More specifically, a selection of CIRED authors from 2016 to 2018 has been asked to participate in the survey of which 69 responded. The author selection was random. The questionnaire was sent out once, without reminder. The survey consists of two topics: (1) how CIRED authors view 18 future technologies in general, one of them being artificial intelligence, (2) how CIRED authors view artificial intelligence (AI) as useful to assist with electricity distribution activities.

RESULTS

The AI working group identified 24 activity areas where artificial intelligence could be applied (see table 1). The topics have been described in the table. In addition, the estimates of the team for complexity, data requirement and time effort are presented as well. *The team learned that a clear description of the topic is required to facilitate constructive thinking and discussion.*

The **complexity** is defined as the estimated required level of expertise to successfully complete the project. Data requirement is the estimated quantity of data that is required to successfully complete the project. Finally, time is the estimated working time required by a team that possessed the right level of expertise and has obtained the required data.

Low complexity means a person with a proficient/basic background in AI and computer skills should be able to complete the project. Medium complexity means skilled people are necessary and people with an understanding of the topic, for example electricity distribution. High complexity means advanced skills are required, with very high complexity requiring state-of-the-art skills and deep-understanding and experience.

Low **data requirement** means that, on an order-of-magnitude, a few thousand examples should be sufficient, usually less than a gigabyte. Moderate data requirement is ten thousand of data fields. High data requirement is multiple databases of which some contain tens-of-thousands of fields.

The **time estimate** 'short' indicates weeks to months, from the moment that the team is ready to start and has all required data. 'Medium' means months to quarters to complete the project. Long is quarters to years, with very long requiring multiple years. The time estimate is dependent on the development of AI tools and the progression of knowledge and experience will decrease these estimates.

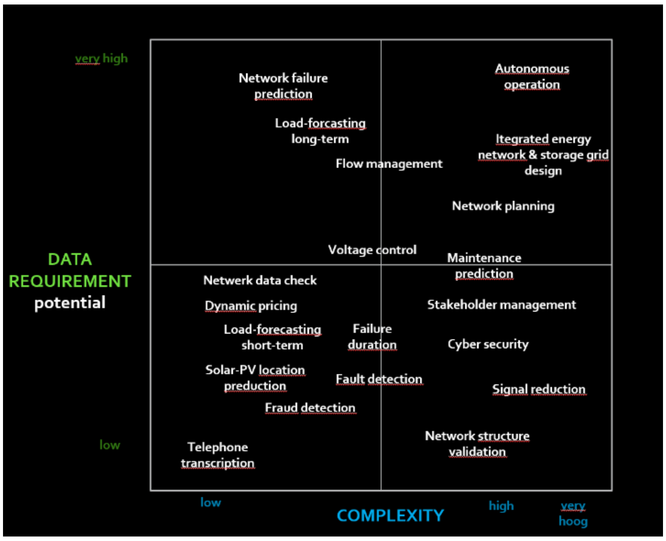
Table 1: artificial intelligence for electric distribution activities

Topics	Description	Com-plexity	Data required	Time
Telephone transcription	Phone call to text file with standard language recognition	Low	Low	Short
Data check	Data fields are checked for different data fields (error detection)	Low	Moderate	Short
Unraveling load measurements	Classify whether there are generators behind the meter and predict which generator with which power. By recognizing patterns in the data and linking them to descriptions.	High	High	Short
Meter measurement	Analysis of electricity metering	Low - Medium,	Moderate	Short
Voltage control	Predicting what the tension will do in the coming day, hour, quarter, minute and responding proactively.	Medium	Moderate	Medium
Flow management	Describe and predict the load (load) and act proactively on this (operation) and make plans.	Medium	High	Medium
Load-forecasting: short-term	Predicting grid load (load) over 1 year, in a day, in 15 minutes.	Medium	Moderate	Medium
Load-forecasting: long-term	Predicting grid load (load) over> 1 year.	Medium	Moderate	Medium
Solar and wind new installations expected	Predicting future deployed solar and wind capacity size and location.	Low	High	Medium
Resource planning	Prediction of resource required in time plus recommendation for planning of people and equipment.	Medium	High	Medium
Fraud detection	Identify fraud and classify type of fraud.	Medium	Low - Moderate	Medium
Fault detection	Identifying fault and classifying the type of fault.	Medium	High	Medium
Maintenance planning	Prediction of expected maintenance over time plus recommendation for planning.	High	High	Medium
Malfunction time duration	Prediction of expected failure duration	Medium	High	Medium
Energy storage location and size (planning)	Recommendation of storage in terms of location and size and type in the grid.	High	Moderate	Medium
network structure optimality	Compare plans of optimal network structure and current network structure.	Medium	Low	Medium
Signal reduction	Classify relevant data for operator and display them.	Very high	Low	Medium
Asset security	Identify an unsafe physical event (event) or threat and report it.	Medium	Low - Medium	Medium
Cyber security	Identifying an unsafe digital event (event) or threat and reporting it.	High	Medium	Medium
Network failure prediction	Prediction of expected network failure (and classification of type of failure).	High	High	Long
Network planning structure (design)	Plans for optimal cable and pipeline structure.	High	Low	Long
Multi-network design including storage	Plans for optimal network structure, including energy storage on different scale levels.	Very high	Very high	Very long
Autonomous network decision-making	Make recommendations for network operation and perform this operation autonomously (i.e. without human intervention)	Very high	Very high	Very long

Authors like to share the following experience from practice: the time required to obtain the right data can take from a few weeks to a few months ranging from the proficiency of a data team. There are quite a number of cases where the required data is not yet available or even collected. The right data means the required *type* of data, in a useful *format* with the right *accuracy and reliability*.

The results range from relatively simple topics such as telephone transcriptions (translating from speech to text) to very complex topics such as autonomous operation of the grid. The outcome from this assessment has been put into a two-by-two matrix ranking data requirement and level of complexity (see figure 1).

Figure 1: impact of artificial intelligence (AI)



These results are from the AI-working group. The next step is to expand the analysis by asking the electricity distribution sector, as organized in CIRED.

Industry survey of electricity distribution sector

The electricity distribution community, as represented by CIRED authors, have rated how CIRED authors view 18 future technologies and their potential disruptive impact on the electricity system. The scale in the answers are from 0, no impact, to 5 very large impact. The results are presented below in two tables.

The first table presents the technologies in a box-and-whiskers-diagram where the average is the middle line/point, the mean value is the x symbol. The box describes the upper and lower quartile (i.e. 50% of values are within the box) and the lines showing the variability. Single dots outside the lines represent outliers in the values. The second table presents the average value of respondents as well as the 0,2 and 0,8 quintile of results (see figure 3).

Artificial intelligence scores a 3,5 on the 0 to 5 scale. This puts it at relative position 7 of 18 rated technologies. Interesting, there is a large variation in responses, it appears there is no consensus on the potential of the technology at this point in time.

The technology seen as potentially most disruptive are electric vehicles, scoring a 4,3 out of 5. *Interestingly, there is little variation in the responses showing 80% of all respondents view it as 4 or higher.*

Figure 2: potential disruptive impact on the electricity system of 18 new technologies (Box plot)
0 = no impact, 5 = very large impact

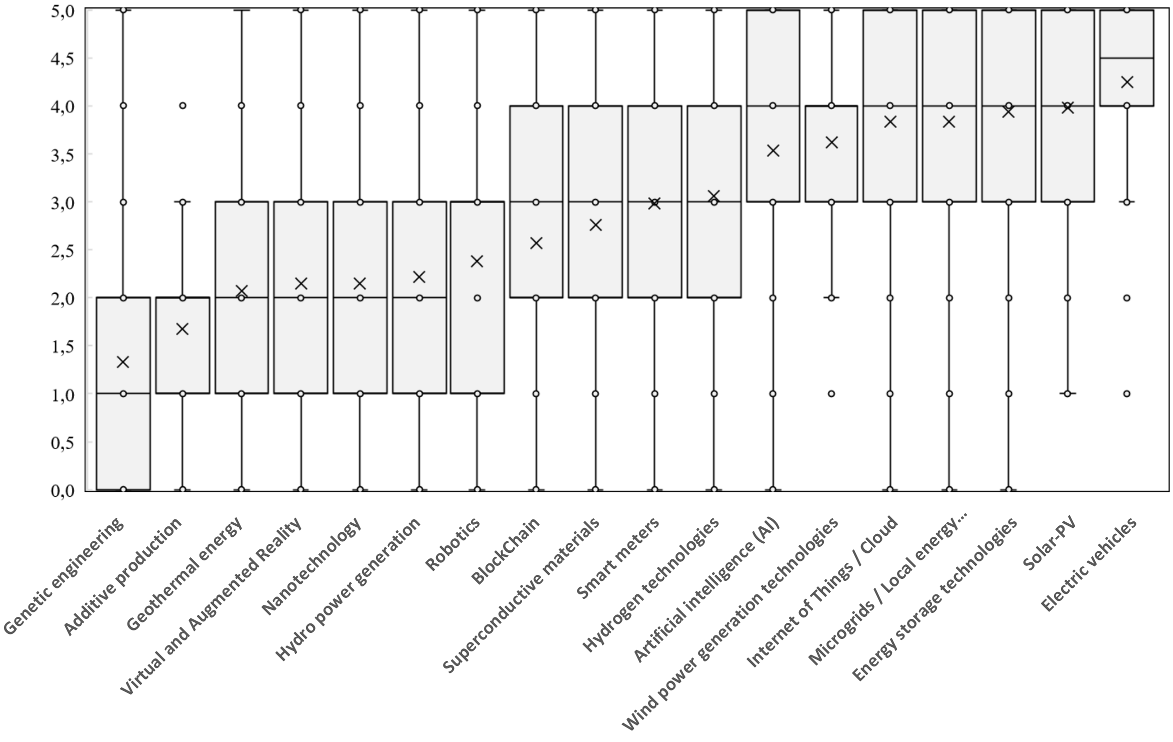
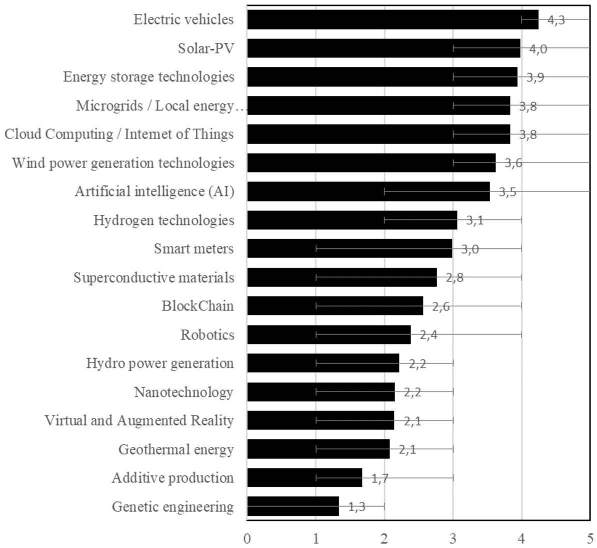
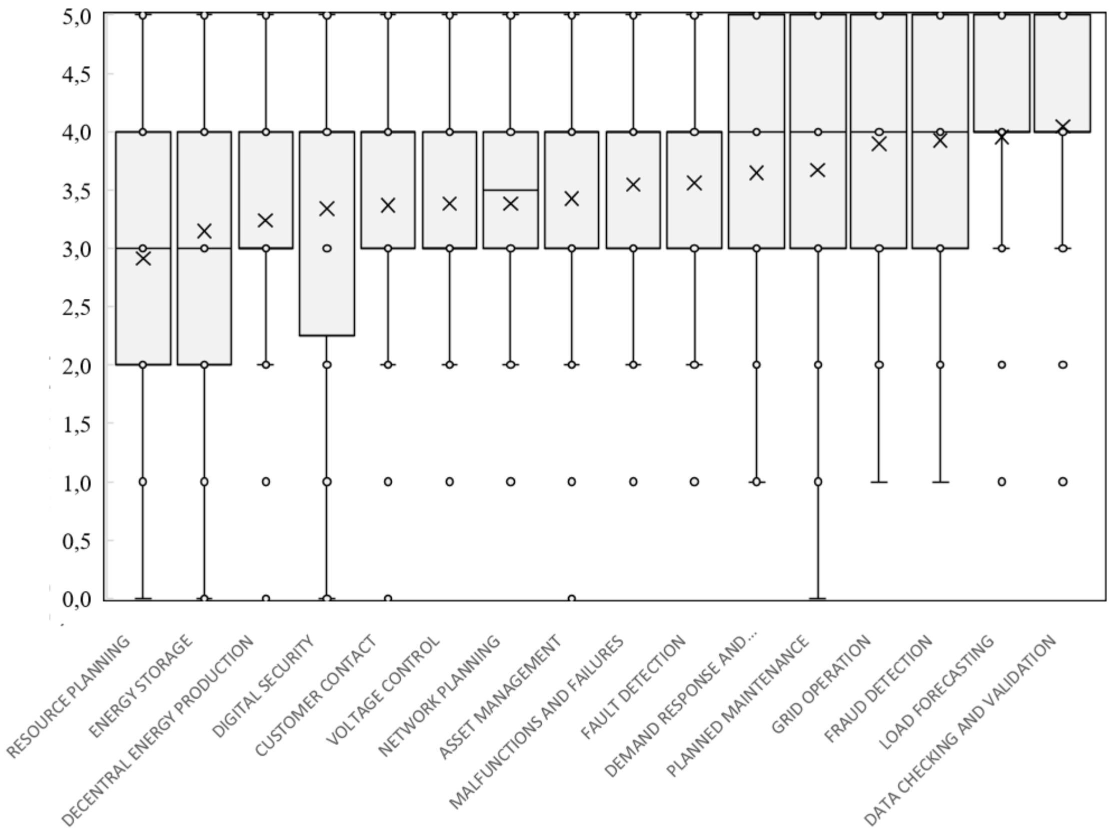


Figure 3: potential disruptive impact on the electricity system of 18 new technologies
0 = no impact, 5 = very large impact



Solar-PV, energy storage technologies, microgrids and internet-of-things / cloud are the four technologies which are scored highly on disruptive potential (3,8 to 4,0).

Figure 4: impact of artificial intelligence (AI) on electricity system (Box plot)
To what extend do you view artificial intelligence (AI) as useful to assist with. 0 = not useful, 5 = extremely useful



Genetic engineering ranks as least disruptive. *This is unsurprising, and it presents a sort of check questions in the survey.*

Next, the survey asked how useful artificial intelligence could be for 16 electricity distribution activities.

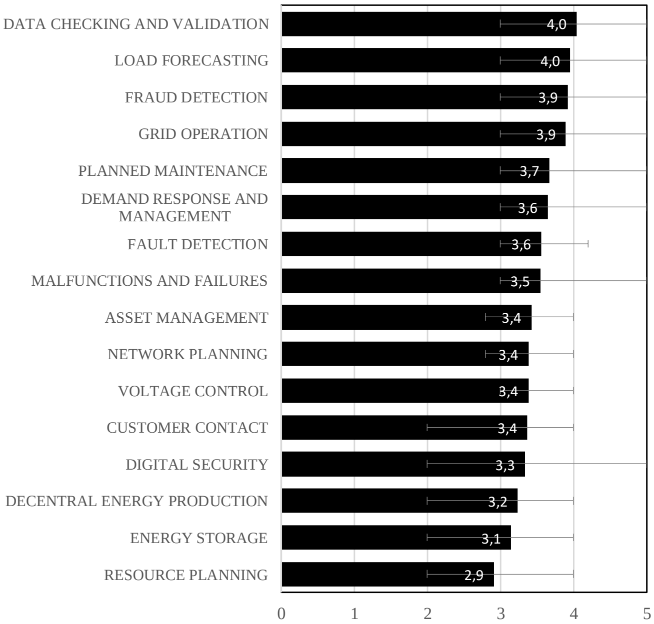
Survey on artificial intelligence usefulness

The second half of the industry survey covers the following questions: 'To what extend do you view artificial intelligence (AI) as useful to assist with the following activities?' The **most useful activity areas for artificial intelligence load forecasting and the checking & validation of data** (see figure 4). This is in line with the AI working group outcomes.

Fraud detection and grid operation are, on average, almost as useful, however there is less consensus in the answer and variation is higher. The next most useful technologies are planned maintenance (3,7), demand response and management (3,6), fault detection (3,6), malfunction & failures (3,5), and network planning, asset management, voltage control and consumer contact with a similar score at 3,4.

Resource planning is seen as area with the least usefulness of AI, but is still a 2,9 score. Energy storage (3,1) decentral energy production (3,2) and digital security (3,3) constitute the other activity areas.

Figure 5: usefulness of artificial intelligence for electricity distribution activities
0 = not useful, 5 = extremely useful



CONCLUSIONS

The main conclusions are that **artificial intelligence is seen as potentially disruptive (3,5)** and ten electricity distribution activities are identified where artificial intelligence could be usefully applied: network planning (3,4), asset management (3,4), malfunctions & failures (3,5), fault detection (3,6), demand response & management (3,6), planned maintenance (3,7), grid operation (3,9), data checking & validation (4,0) and load forecasting (4,0).

The industry survey indicates that **the most useful applications for artificial intelligence is data checking & validation and load forecasting** are found to be low to moderate complexity and low to medium on data and time requirement.

The technology seen as potentially most disruptive however are electric vehicles, scoring a 4,3 out of 5. Interestingly, there is little variation in the responses showing 80% of all respondents view it as 4 or higher. Solar-PV, energy storage technologies, microgrids and internet-of-things / cloud are the four technologies which are scored highly on disruptive potential.

Acknowledgments

Authors gratefully acknowledge the cooperation of the AI working group at Enexis DSO and to the CIRED authors who participated in the industry survey.

MISCELLANEOUS

The following definition of artificial intelligence is used: the designing and building of intelligent agents that receive input and instructions from the environment and take actions that affect that environment [2]. An intelligent agent is one that acts so as to achieve the best outcome or, in case of uncertainty, the best expected outcome. Authors endeavour to apply artificial intelligence to the task of network design.

REFERENCES

[1] Van der Mei, A.J., Doomernik, J.P., *Artificial Intelligence for Microgrid Planning and Operation*, paper 0303, April 18

[2] P. Norvig, S. Russell, 2016, *Artificial Intelligence a Modern Approach*, Pearson, Harlow, England.