Exploration of digital platforms and artificial intelligence in the Dutch electricity system

A Dutch perspective on application, risk and supervision.

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Authors:
prof. dr. Koen Kok
Tijs Wilbrink MSc
Bart van der Holst MSc
Gijs Verhoeven MSc
dr. ir. Roel Schiphorst

MANAGEMENT SUMMARY

The electricity sector is vital to society, but it is also one of the most complex systems created by mankind. Moreover, electricity is one of the key energy carriers of the energy transition. Two major sources of renewable energy (those from wind and sunlight) provide energy in the form of electricity. Moreover, the transition paths of a number of sectors run through electrification (such as transport, industry and heat). Artificial Intelligence (AI) is a key technology in this transition. Agentschap Telecom (Radiocommunications Agency Netherlands) is one of the supervisors of AI. This report provides insights into the expected changes resulting from the application of digital platforms and AI in the Dutch electricity sector, the corresponding risks, and possible approaches for Agentschap Telecom (Radiocommunications Agency Netherlands). The main themes are the (future) management of decentralized units of supply and demand for grid stability. Three research methods were used: literature research, interviews and sessions with experts (workshop).

Answers to the research questions

What role do digital platforms currently play in controlling the electricity supply and how are such platforms constructed?
The role of digital platforms in controlling the electricity supply will increase sharply in the next five to ten years. A number of digital platforms are currently active, such as Tesla's Autobidder platform. The growth of these digital platforms goes hand in hand with the growth of switchable distributed energy assets, such as electric cars and solar panels, and the associated increasing value of predicting future demand, supply and, among other things, congestion. Digital platforms are now mainly active in the power reserve markets, with the domain of charging electric cars being most actively pursued. It is likely that a dominant platform will emerge in the next decade. Many of the currently active digital platforms have been developed and introduced into the market by (semi-)public organizations.

What does the current use of AI applications for controlling the electricity supply within these digital platforms look like? Which applications are crucial for controlling these platforms and how do these applications influence each other?
Controlling digital platforms within the electricity supply can mainly be found in the flexibility of the electricity grid, especially with regard to regulating capacity (Automatic Frequency Restoration Reserve (aFRR)) and congestion management. In absence of regulations, the use of decentralized units for aFRR can actually lead to congestion in the distribution networks. This usually takes place out of sight of the regional network operators, because large parts of the distribution network are not locally metered in real time. But, more importantly, the regional grid operators have a limited legal framework within which they can solve congestion in their grids by directing connected units. In specific cases, aFRR providers can even steer towards congestion through their digital platforms for extra revenue.

How will digital platforms develop in the next 5 years? How does the previously described use of AI change in this regard? Both in the type of AI application and in the location and interaction between the various applications. Describe using scenarios.
The development of digital platforms is set out in five different scenarios in this report (chapter 4). These scenarios range from unwanted network effects due to unilateral

algorithms to the emergence of monopoly positions, and from automated speculation on trading platforms to an autonomous distribution network. AI is already being applied in these domains and will be more widely distributed. The Energy working group of the Dutch AI coalition confirms this point of view in its desired development agenda for algorithms in the electricity system.

What important risks are there with regards to the continuity and availability of the electricity supply as a result of the current and future use of AI in 5 years? Systemic risks and cascade effects due to the use of AI must also be included. How can the different risks be weighted relative to each other in a risk model?
The main risks identified are (1) speculation on intraday trading platforms without considering the transport and distribution network. (2) The emergence of monopoly and oligopoly positions of digital platforms may lead to lock-ins that range from the outsourcing of charging infrastructure due to information advantages, to the occurence of congestion due to simultaneous switching of charging or discharging capacity. (3) Experts interviewed are unanimous on risks of conflicting incentives causing congestion, public values of energy supply being compromised, and the feasibility of emerging public values such as controllable technology.

How (goals and set of instruments) can Agentschap Telecom as a supervisor and executive organization limit these risks?
Supervision is especially important for digital platforms that switch in the electricity supply in real time or close to real time. Coordination with other regulators in the energy sector is essential. The Dutch Autoriteit Consument en Markt (ACM, Authority for Consumers and Markets), Agentschap Telecom and the Dutch Autoriteit Persoonsgegevens (AP, Data Protection Authority) are active in the energy sector. Coordination prevents overlap and gaps in supervision. Organize broad learning capacity around the effects of digitization in the energy sector. Consider building new competencies such as running simulations to test the reliability of algorithms. This is elaborated upon in more detail in the chapter Conclusions and recommendations.

Contents

1 INTRODUCTION

1.1 Energy transition and challenges in digitization

The electrical system is one of the most complex systems made by mankind. Partly because electricity cannot be stored on large scale, the electrical infrastructure and the related processes of network management and market trading are considerably more complex than those of other energy carriers. Electricity is one of the key energy carriers of the energy transition. After all, two important sources of sustainable energy (those from wind and sunlight) provide energy in the form of electricity and, moreover, the transition paths of a number of sectors run through electrification (such as transport, industry and heat). Reducing the use of Groningen natural gas is also an additional driving force behind the electrification of the heat supply in industry, buildings and households.

This produces three challenges that cannot be seen and solved in isolation from each other.

- First, the variation and uncertainty in electricity generation from solar and wind is a growing challenge for balancing our electricity system. The supply side of the system is increasingly unable to keep up with the demand side. Demand will also have to follow supply.
- Secondly, the growth in both supply and demand of electrical energy is already overloading the grids in a large part of the Netherlands, and further electrification will reinforce this. Network infrastructure has a lifespan of several decades and we now use the networks in a way that was never foreseen in the design phase.
- Third, decentralization is underway. More and more electricity is generated in the distribution networks (cogeneration, solar, wind). Decentralization is also underway in the balancing process, the process of matching supply and demand in the system on a few seconds basis. Without this balance, frequency problems arise that eventually lead to power failure. The flexibility to maintain the balance at system level and to solve bottlenecks (such as overloading of network parts) in the networks increasingly comes from generating and controllable demand in the distribution networks. This flexibility then comes, for example, through the shift in demand for heat pumps in houses and buildings and from (dis)charging electric cars. This also decentralizes the coordination mechanisms in the electricity system: from the top-down regulation of a handful of power stations to (additionally) bottom-up coordination between local demand, supply and network capacity.

These developments are a driving force behind the second wave of digitization in the electricity system. The roll-out of digital electricity meters and the first-generation automation of transformer substations (IEC61850 standard) were part of the first wave. The second wave is currently unfolding around supply and demand management, congestion management, local access to flexibility, smart use of the growing flow of data and distributed coordination systems[1].

[1] Such as *virtual power plants*, or *virtual power stations*: aggregations of relatively small controllable electricity producing and consuming devices that are operated jointly and as a single unit.

1.2 Artificial Intelligence

Artificial Intelligence (AI) is a key technology in this development[2,3,4,5]. Artificial Intelligence is "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages"[6]. For the purposes of this document, this mainly concerns systems for decision-making, either in decision support systems or in automatic decision systems. AI is a term that has been used since the 1950s and has been used over the years as an umbrella term for a multitude of techniques and technologies. Today, the term seems to be synonymous with data science techniques (learning systems, data-driven modelling, neural networks) while distributed AI, not necessarily based on learning systems, is increasingly being applied, such as multi-agent systems and edge computing.

For the remainder of this document, the authors have chosen not to distinguish between various forms of AI at a high level of detail, but to take the current wave of digitization as a starting point, because for many of the identified risks it is not relevant to know exactly which technology is used to realize an application. There are two types of AI algorithms: one is designed with a specific goal in mind, and there are self-learning systems that learn from, among other things, historical data. With the designed goal, it is better to test in different scenarios than with a machine learning algorithm. When reference is made to AI systems, reference is often made to the machine learning algorithm and not to the designed algorithm.

AI is increasingly being used to keep our electricity system available and reliable, among other things to support the deployment of decentralized units (generation, flexible demand and storage) in balancing (central)[7,8], as for congestion management (local)[9,10]. We are making a transition from a limited number of power stations that together track total demand to a

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[2] Ali, Syed S., and Bong J. Choi. 2020. "State-of-the-Art Artificial Intelligence Techniques for Distributed Smart Grids: A Review" Electronics 9, no. 6: 1030. https://doi.org/10.3390/electronics9061030.

[3] Omitaomu, Olufemi A., and Haoran Niu. 2021. "Artificial Intelligence Techniques in Smart Grid: A Survey" Smart Cities 4, no. 2: 548-568. https://doi.org/10.3390/smartcities4020029.

[4] O. A. Alimi, K. Ouahada and A. M. Abu-Mahfouz, "A Review of Machine Learning Approaches to Power System Security and Stability," in IEEE Access, vol. 8, pp. 113512-113531, 2020, doi: 10.1109/ACCESS.2020.3003568.

[5] Niet I, van Est R and Veraart F (2021) Governing AI in Electricity Systems: Reflections on the EU Artificial Intelligence Bill. Front. Artif. Intell. 4:690237. doi: 10.3389/frai.2021.690237.

[6] Oxford Languages English Dictionary.

[7] Demir, S., Mincev, K., Kok, K., & Paterakis, N. G. (2021). Data augmentation for time series regression: Applying transformations, autoencoders and adversarial networks to electricity price forecasting. Applied Energy, 304, [117695]. https://doi.org/10.1016/j.apenergy.2021.117695. [Ontwikkeling gefinancierd door NL Elektriciteitshandelaar.]

[8] Stappers, B., Paterakis, N. G., Kok, J. K., & Gibescu, M. (2020). A Class-Driven Approach Based on Long Short-Term Memory Networks for Electricity Price Scenario Generation and Reduction. IEEE Transactions on Power Systems, 35(4), 3040-3050. [8957258]. https://doi.org/10.1109/TPWRS.2020.2965922. [Ontwikkeling i.s.w.m. NL Elektriciteitshandelaar.]

[9] Koen Kok, Aliene van der Veen, Sjoerd Doumen, Pieter Loonen, "Transactive Energy in the Dutch Context", Survey Report, Eindhoven University of Technology, February 2022. Url: https://www.topsectorenergie.nl/sites/default/files/uploads/Systeemintegratie/2022-TUe_TNO-Transactive_Energy-Survey_Report.pdf.

[10] "The Mobilize Smart Charge app automatically manages your charging sessions taking into account the capacity available on the electricity grid, the availability of renewable energy, electricity prices and your charging preferences." https://www.jedlix.com/en/mobilize-smart-charge/.

decentralized system of a large number of units that maintain the balance between themselves and keep energy flows within the capacity limits of the network. Due to their distributed nature, online platforms, Internet-of-Things hubs and cloud services will contribute to the growing complexity of the system. Cloud services are services that make hardware, software, data and/or data storage available on demand via the Internet. The Internet-of-Things (IoT) is a distributed system of digitally-connected smart devices capable of communicating data without using human interaction. This may concern data for identification (electronic labels), but also sensor data or control data. An IoT hub is a cloud service that maintains and secures the data connections for one or more IoT applications, processes all data and performs maintenance functions, such as software updates.

1.3 Purpose and scope of the research

The aim of this report is to advise Agentschap Telecom (Radiocommunications Agency Netherlands) on how the Agency, as a supervisor, can anticipate the risks of digital platforms and AI in the Dutch electricity sector and, if necessary, act on this in advance, especially with regard to (future) management of decentralized units of supply and demand for grid stability (balancing and congestion management). This concerns installations and equipment connected to an electricity distribution network, which demand, supply or store electricity and which, regarding their operational patterns, respond to (price or control) signals from another part of the energy system. To achieve this goal, this report will (i) provide an overview of the players and the chain dependence in the Dutch electricity system and also (ii) describe the current use of digital platforms and AI, including (iii) an estimate of the expected developments in the next 5 years. The focus is on the most important and critical applications of AI and Digital Platforms.

The research focused on the following research questions:

1. What role do digital platforms currently play in controlling the electricity supply and how are such platforms constructed?
2. What does the current use of AI applications for controlling the electricity supply within these digital platforms look like? Which applications are crucial for controlling these platforms and how do these applications influence each other?
3. How will the digital platforms develop in the next 5 years? How does in this regard the previously described use of AI change this? Both in the type of AI application and in the location and interaction between the various applications. Describe using scenarios.
4. What important risks are there with regard to the continuity and availability of the electricity supply as a result of the current and future use of AI in 5 years? Systemic risks and cascade effects due to the use of AI must also be included. How can the different risks be weighted relative to each other in a risk model?
5. How (goals and set of instruments) can Agentschap Telecom limit these risks as supervisor and executive organization?

The scope of the research encompasses the entire value network of the electricity supply, with a special focus on the (future) management of decentralized units of supply and demand for grid stability (balance maintenance and congestion management) and the role of AI, online platforms and cloud services. in there. Stakeholders in scope of the study are the stakeholders that use and manage the electricity infrastructure plus relevant data and service providers of which their operation can affect the continuity of the electricity supply. The focus of the research is on the most important and critical applications of AI for security of electricity supply. The focus in the study is therefore not on completeness, but on insight into major potential risks.

1.4 Method and approach

The investigation followed the following steps:

1. **Drawing up a sector description** of the Dutch electricity sector based on available literature and using existing actor models. Describing the digital platforms that are active in the coordination between supply and demand of electricity. This step answers the first research question (role and structure of digital platforms in the electricity supply).
2. **Interviews:** A group of key persons was interviewed to obtain input to answer research questions 2, 3 and 4. See section 3.4 for a list of interviewed persons. These experts represent organizations that are expected to play an important role in the current and future playing field of digital platforms and AI and are active in various roles in the electricity sector to provide a good overview of the interests and state of the technology. The innovative capacity of the organization in question has been taken into account.
3. **Workshop**: As an in-depth approach to answering questions 2, 3 and 4, two workshops were held with an additional group of experts from a broader group of persons/organizations in the Dutch electricity sector, see section 5.1. In the workshop, the insights of the key (interviewed) persons were validated. Furthermore, the identified risks associated with the scenarios drawn up from the interview phase were analyzed during the workshop for impact and probability of occurrence.
4. **Risk analysis**: On the basis of the previous steps, a risk matrix has been drawn up in which the probability of the occurrence and the possible impact of the various risks is qualitatively represented. Systemic risks and cascade effects due to the use of digital platforms and AI are also included in this analysis. Input for this risk analysis was the results of interview phase, workshop and the knowledge of the sector experts.
5. **Sounding board group**: A workshop was held with the sounding board group composed by Agentschap Telecom to identify for the significant risks, targets and set of instruments for its role as supervisor. The risk analysis and the insights from this session served as the basis for answering the fifth and final research question.

2 THE EUROPEAN OR DUTCH ELECTRICITY SYSTEM

2.1 Structure of the Dutch electricity system

The *electricity system* is the collection of all systems and actors involved in electricity production, transport, delivery and trade. The electricity system is divided into two subsystems: the physical subsystem and the commodity subsystem. The physical subsystem is centered around the production, transmission, and distribution of electricity and includes the physical assets to do so, as well as the parties operating those assets. The commodity subsystem is the administrative and business counterpart of the physical system. Here, the *electricity product* is traded between producers, traders, energy suppliers and consumers.

Figure 1 shows the Electricity System Model of van Werven and Scheepers[11], a model of the electricity system with the two subsystems and the main actor roles operating in these. Some roles operate in both subsystems, while others are operating in one subsystem only. Some roles can be combined by a single (legal) person.

[11] Werven, M.J.N. van; Scheepers, M.J.J., "DISPOWER. The changing role of energy suppliers and distribution system operators in the deployment of distributed generation in liberalised electricity markets", Report, ECN Policy Studies, ECN-C--05-048, 2005. Figures used with permission.

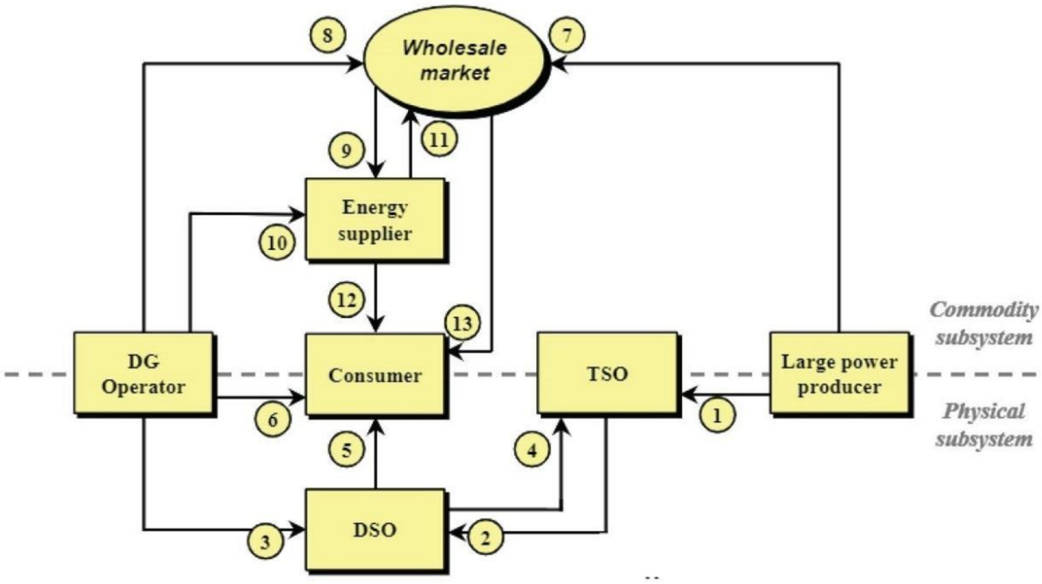

Figure 1: Electricity System Model: Commodity transactions and resulting physical energy flows[11]*.*

The actor roles are:

- **Consumer**: User of electricity, connected to the distribution network and buying its electricity from an energy supplier. All electrical energy use behind a physical connection to the distribution networks is included here: households, buildings, industry, etc.
- **Distributed Generation (DG) Operator**: Operator of a generation asset connected to the distribution network. All owners/operators of generation behind a physical connection to the distribution networks are included here: roof-top solar of households or buildings, combined generation of heat and power (CHP) in horticulture or district heating systems, etc.
- **Energy Supplier**: party selling electricity to consumers and trading on the wholesale market to this end. Optionally, the energy supplier is buying generated electricity from DG operators.
- **Distribution System Operator (DSO)**: Maintainer of the distribution network, responsible for the stable operation of that network. For instance, in the Netherlands Alliander, Enexis Netbeheer and Stedin are DSO.
- **Transmission System Operator (TSO)**: Maintainer of the transmission network, also responsible for the stable operation of that network. In the Netherlands this is TenneT.
- **Large Power Producer**: Producer of bulk electricity directly connected to the transmission network, e.g. an operator of a fossil-fuelled power plant, an off-shore wind turbine farm, or a large hydroelectric power station.

As mentioned above: a single (legal) person can play more than one role at the same time. A consumer who is also owner of a generating asset located at their premises ("behind the meter") plays the DG-operator role as well. An actor who is combining these two roles is referred to as a *prosumer*. Households with roof-top photo-voltaic solar panels and greenhouse farmers operating CHP units fall into this category. Further, in the current liberalized energy market in the EU member states, the roles of Energy Supplier, DG Operator and/or Large Power Producer can be combined.

To familiarize the reader with the model, we describe a few specific cases projected on the model:

- In the **traditional supply model**, Large Power Producers, e.g. those operating large power plants, trade their produced electricity on the Wholesale Market (arrow 7). The produced volume is physically fed into the transmission network of the TSO (arrow 1). This electricity is reaching the consumer though a DSO network (arrows 2 and 5). The consumer buys this electricity from his contracted Energy Supplier that has bought it from the Wholesale Market (arrows 12 and 9, respectively). **Larger consumers** are procuring their electricity directly from the market, as depicted by arrow 13.
- In the case of **self-consumption**, a combined Consumer/DG-Operator is consuming (part of) the produced electricity at the same moment it is produced. This is depicted by arrow 6. Note that this is the only physical energy flow that does not have a counterpart in the commodity subsystem, as this energy is not traded between actors.
- **DG produced energy** that isn't consumed as self-consumption flows into the DSO grid (arrow 3). In case of a prosumer, this energy is sold to the energy supplier through an feed-in arrangement (10). If the distributed generation asset is not located on a consumer's premises, the produced energy is either sold to an energy supplier (also arrow 10) or, if the DG-Operator produces enough volume, directly on the wholesale market (8). In the former case, the energy supplier then either supplies this energy to a consumer (12) or resells it on the market (11). If a certain DSO network segment has more local production than consumption, energy will flow upwards to the TSO's transmission network (4) and then back into another DSO network segment (2) having net consumption.

Trade on the wholesale market happens on multiple timescales. On the *futures market*, electricity is traded years to months ahead of the time of delivery, followed by the *day-ahead market* where electrical energy is traded for the next day in hourly blocks. Finally, the *intra-day market* trade happens in hourly or 15-minutes blocks until five minutes before the actual delivery time. A treatment of the exact detailed operation of these markets is beyond the scope of this document.

An important function of the wholesale market is to maintain the overall balance between demand and supply. Two important mechanisms to this end are the *balancing mechanism* and *balance responsibility*. The balancing mechanism is divided into two parts. Firstly, there is the *imbalance market*, where deviations from traded schedules are traded automatically and, secondly, the *reserve markets* used by the TSO to counteract these deviations using reserve capacity actively offered by market parties. The balancing mechanism is further described below.

Through the system of *balance responsibility*, market parties are incentivized to maintain a balance between demand and supply in their portfolio. All connections to the electricity grid in the EU have an associated *Balance Responsible Party* (*BRP*) in an one-on-one relationship. So, all BRPs together represent all connections with the electricity network. Further, all wholesale market trades need to be associated with a BRP: either the trading party has a BRP license or is represented by another organization which is licensed. Each BRP is responsible for maintaining a balance on a 15-minutes scale between all demand and supply at their associated connections *plus* the volume traded in the markets for these connections. Thus, within these time slots of 15 minutes, referred to as *Program Time Units* (*PTUs*), the sum of all energy traded (bought or sold) on the wholesale markets for those connections need to be equal to the sum of all energy fed in and out of the network.

All volume traded is notified close to the real-time by the BRP to the TSO in a so called E-program. At delivery time, deviations between this prognosis and the realized demand and supply schedule within a BRP's portfolio do occur, for instance due to forecasting errors and technical failures in assets consuming or producing electricity. These deviations are automatically traded as imbalance on the imbalance market. We will come back to this below.

In real-time, the total net imbalance over all BRPs in the Netherlands is determined by the TSO by comparing the sum of all E-program prognoses, which gives the planned cross-border flow from/to The Netherlands, with the measured flow on the interconnectors. Any system-wide deficit is then bought by the TSO on the reserve markets, while a surplus is sold by the TSO on the reserve markets both with the aim to restore the system imbalance as soon as possible. Contrary to the imbalance market where BRPs participate passively, BRPs need to actively place bids and offers to participate in the reserve markets. By doing so, the BRP takes on the role of a *Balancing Service Provider* (*BSP*). Based on the technical parameters of the assets used -such as reaction times and regulation (ramping) speeds- reserves are traded in three different sub markets:

- *Frequency Containment Reserves* (*FCR*), fast regulating assets that automatically react to the 50 Hz grid frequency. These reserves keep (contain) the grid frequency within predefined limits. Grid frequency deviations from 50 Hz indicate instant mismatch between demand and supply in the system. As the measured frequency is the same in the whole of the synchronous grid area of Continental Europe, all assets delivering FCR in this area work together to stabilize the grid frequency in the full area. These reserves are contracted beforehand and activated automatically without data communication as the reaction is triggered by frequency deviations.
- *Frequency Restoration Reserves* (*FRR*), fast reacting reserves for upward and downward regulation. The TSO activates these reserves with the aim to restore the system balance in the Netherlands and, by doing so, steer the grid frequency back to 50Hz as the name implies. BRPs provide offers (upward regulation) and bids (downward regulation) that are activated by the TSO. There are two forms of FRR:
  - ✓ *Automatic FRR* (*aFRR*) which is automatically activated following a real-time price that results from a merit order market mechanism (bidding ladder).
  - ✓ *Manual FRR* (*mFRR*) similar to aFRR but then activated manually. Must be online within 15 minutes after activation.
- *Replacement Reserves* (*RR*), manually activated reserves occasionally used to free-up FRR assets in cases of longer disturbances. It is activated through a phone call and must be online within 15 minutes after the call. Activation happens once a month on average.

Before the terminology was harmonized within Europe, FCR was known as primary reserve, FRR as secondary reserve and RR as tertiary reserve. Note that the TSO is the sole trading counterpart of the BSPs delivering reserve power, buying energy in case of upward regulation and selling with downward regulation. Note further that upward (downward) regulation can be achieved by lowering (increasing) demand.

Prices on the imbalance market -the 15 minute prices used to settle with the BRPs that deviated from their schedule- are derived from the real-time prices used in the same time frame in the reserve markets in such a way that this is a zero-sum game for the TSO. Hence, all costs made maintaining the balance using reserves, are settled through the imbalance market with those BRPs that caused imbalance.

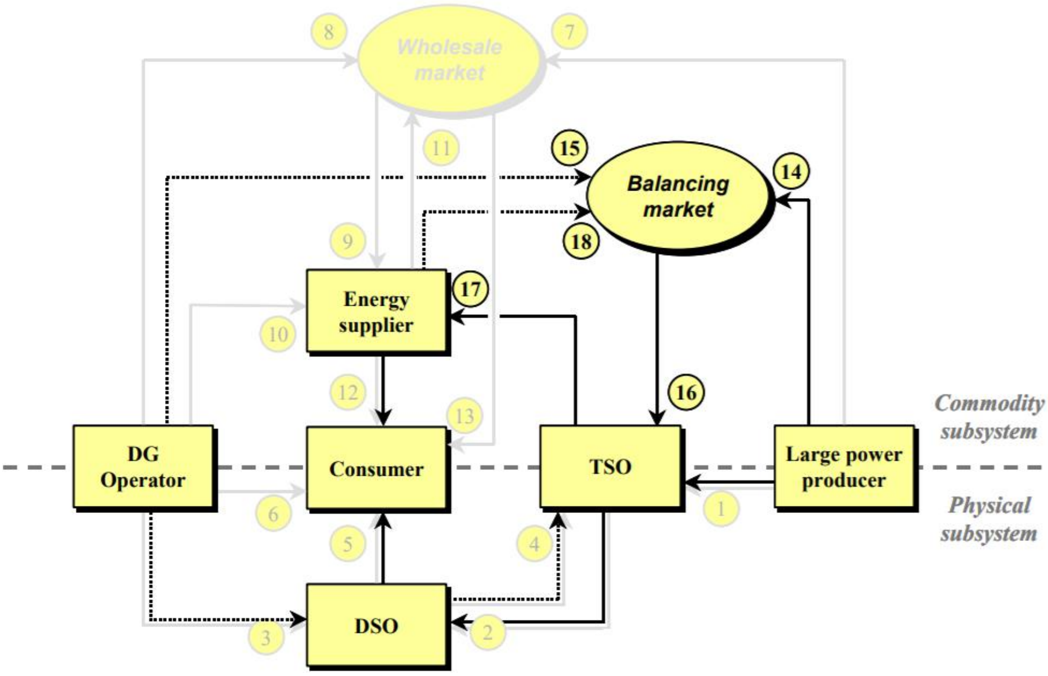

Figure 2: Electricity System Model: Market transactions including the Balancing market[11].

Figure 2 shows the balancing market in the Electricity System Model. Transactions are shown for imbalances occurring in the consumption of electricity. The solid arrows depict the traditional situation in which regulation power is delivered by the large power producers, while the dotted Arrows show the transactions when distributed generation assets are delivering regulation services as well.

3 DIGITAL PLATFORMS AND AI IN THE ELECTRICITY SUPPLY

What role do digital platforms currently play in controlling the electricity supply and how are such platforms constructed?

The role of digital platforms in controlling the electricity supply will increase sharply in the next five to ten years. When it comes to managing the supply and demand of electricity, digital platforms are now mainly active in the markets for reserve capacity. It is likely that a dominant platform will emerge in the next decade.

3.1 Digital platforms bring physical energy supply and demand together

A digital platform[12] is a software-based online infrastructure where interactions between users or actors, other platforms or systems take place. Digital platforms can act as a collector of data, which can then be used to train systems. Furthermore, digital platforms can also provide the basis for systems that realize physical control for bringing together the supply and demand of electricity, or as a physical part of the infrastructure. In this context, we make a distinction between (1) a digital platform to bring together supply and demand online in real time without a direct link with infrastructure and physical assets and on the other hand (2) a digital platform that has a support function for demand/supply coordination within the infrastructure. An example of the latter is an algorithm that automatically controls grid components (such as transformers and switching elements) to an operationalized configuration at some point in the electricity network. Both platform types can control the electricity supply themselves.

Digital platforms in the Netherlands have often arisen from (semi-)public parties

The image that digital platforms are mainly emerging from Silicon Valley must be corrected for the electricity supply. A party like Tesla, whose Autobidder service enables the switching of battery packs in electric cars, meets the traditional image of a digital platform originating from Silicon Valley. However, digital platforms are proactively designed by, among others, the Netherlands' own TSO TenneT, precisely to better deal with the decentralized electricity system. Examples include crowd balancing platform[13], intra-day trade[14] and congestion management[15].

[12] Amrit Tiwana, "Platform Ecosystems: Aligning Architecture, Governance, and Strategy".
[13] https://equigy.com
[14] https://etpa.nl
[15] https://www.gopacs.eu

3.2 Domains in which digital platforms are active within the electricity system

Studying the active digital platforms in the electricity supply shows a concentration around six activities. These activities are not inexhaustible, but they do occur frequently and thus provide a good overview of the current state of affairs.

Activities of digital platforms active in the electricity supply in the Netherlands	
1	Aggregating flexibility capacity of smaller units that can be used as control capacity
	Coordinately controlling devices that are individually too small to operate in the reserve power markets. For, among other things, electric cars and heat pumps, and it is expected also home batteries in the future. The timing of the activation signal for this and the settlement of costs/revenues takes place at the digital platform. In the future, electric cars will go a step further than timing the charging of the car at times when the power is advantageous: temporary feeding back into the grid from the car battery (vehicle to grid) will also be supported.
2	Aggregation and Deployment of industrially controllable supply or demand as reserve power
	Deploying industrial reserve power on FCR and FRR reserve markets, for example with cooling installations, pump power, solar parks, combined heat and power installations, assimilation lighting for horticulturists and, increasingly, grid-scale batteries. As above, power can be aggregated to obtain enough capacity to be admitted to the reserve power markets.
3	Exchange of energy between connected parties (households, companies)
	Mutual settlement of energy between households in an energy cooperative, for example in the event of too much solar power produced and the presence of a neighborhood battery, or between companies on an industrial estate (*energy hubs*). *Energy communities* will be given more options in future legislation, as stated in the EU Clean Energy Package, and network companies are currently developing options to support energy hubs of companies through tariffs.

4	Energy home management systems
	Energy and cost savings through intelligent switching of equipment in the house, such as lighting, heat pumps and heating. User interaction is in some cases limited to setting the parameters that set the boundary conditions within which the system regulates. When the netting scheme (in Dutch: "salderingsregeling") is phased out, these systems will also focus on real-time use of their own generated electricity. Then the use of home batteries also becomes interesting. In countries without a netting scheme (such as in Germany), this type of optimization "behind the meter" is already being used on a large scale and home batteries are also common.
5	Substation automation
	Metering and control of transformer stations in low-voltage and medium-voltage networks. These systems placed in the transformer station provide a more detailed insight into the electricity network. Data can be used for (real-time) optimization of the relevant grid part, but also for the rapid localization and remedying of faults and for preventive maintenance.
6	Congestion management in electricity distribution networks
	Providing financial incentives for the deployment of purchase and redispatch[16] to avoid congestion in electricity distribution networks. At the moment this is still happening to a limited extent and only in medium voltage networks. However, flexibility of devices and electric vehicles connected to the low-voltage network can be used for this. This form of congestion management may also be used in low-voltage networks in the future. Which can (in the future) use the same flexible units used for activity 1 and 2.

Table 1: overview of various activities currently undertaken by digital platforms in the Netherlands within the electricity supply.

3.3 Overview of digital platforms to bring together supply and demand in real time

In the electricity system, a number of digital platforms are active in the Netherlands. It is not always clear where and when AI will be used for these applications, but it is clear for which functional applications within the electricity system AI can be deployed by a digital platform.

[16] *redispatching* means a measure, including limitation, that is activated by one or more transmission system operators or distribution system operators through a change in the generation and/or load pattern in order to change the physical flows in the electricity system and to relieve physical congestion or guarantee system security in a other way.

In order not to be and remain dependent on reporting from companies about the use of AI -of which the toolbox is developing rapidly and AI systems are being retrained- it seems most feasible and sustainable to approach the AI system as a black box and consider its application and the sources from which it is analysed. One method of monitoring this, is running simulations, more about this will be elaborated upon later. The revenue models of these digital platforms benefit from good predictability and operate in a complex environment of many variables, which will lead to a further increase in the use of AI to switch automatically at times when the earnings are greatest.

To illustrate this, an inventory has been made of digital platforms active in the Netherlands. This list is not exhaustive, and the party in question does not have to express itself as a digital platform.

Platform	Description	Activity Nr (Table 1)
Tesla Autobidder	Real-time trading and monitoring platform for energy assets, such as Tesla's Powerpacks, Powerwalls and Megapacks, optimized by machine learning to better utilize and monetize the assets. At the beginning of 2021, Autobidder had 1.2 GWh of energy storage under management. Activities in Europe are currently only taking place in southern Germany. Machine learning is applied within Autobidder for predicting prices, load and generated energy, optimization of dispatch and smart bidding.	1, with individual cars and Powerwalls 2, with Megapacks and fleets of cars Possibly also 6
Equigy (ex TenneT)	A Crowd Balancing Platform based on blockchain technology that allows TSOs to access flexible electricity reserves by leveraging operational flexibility of devices such as heat pumps and batteries in electric vehicles. Equigy is active in Switzerland, the Netherlands, Germany, Italy and Austria. The platform supports electric cars, heat pumps, water boilers, household and mains batteries.	1, 6.
Jedlix (ex Eneco)	Jedlix automatically charges electric cars as much as possible with green and cheap energy at the best times for the energy market. They are active on the aFRR market. They use AI, Machine Learning, and data science combined with behavioral science[17].	1, possible 6
Sympower	Flexibility provider for electrical assets. Active for industry, mobility (EV fleets), solar parks and households. For both the primary (FCR) and	1, 2, possible 6

[17] Jedlix CEO Serge Subiron in an interview. https://www.jedlix.com/en/blog/jedlix-at-the-iaa/.

	secondary (aFRR) and tertiary (mFRR) reserve markets.	
ETPA	The Energy Trading Platform Amsterdam (ETPA) is an intra-day trading platform. TenneT is the (co-) initiator of this platform. ETPA is easily accessible for smaller players (in terms of offered capacity), which means that it opens up flexibility in that part of the market.	Enabling for short-term trading with flex assets. Also enabler for 6.
GOPACS	Congestion management TSO & DSO through flexibility of supply and demand. Launched by ETPA and a partnership of the Dutch national and regional grid operators. GOPACS is a congestion management platform linked to an intra-day market (such as ETPA). Buyers and suppliers have the option of linking location data to bids on the intra-day platform (via an EAN code). Grid operators can then use these localized bids for redispatch to avoid forecast congestion.	6
Toon **(Eneco)**	Home thermostat integrated with home automation, so devices can switch on and off when residents are away. Possibly soon with extensions in controlling home batteries.	3
CrowdNett **(Eneco)**	Virtual power plant of home batteries, incl. energy trade.	1
Locamation SASensor OpenPlatform	SASensor is a platform for the automation of substations in the medium voltage and low voltage network. OpenPlatform offers a third possibility to develop applications on top of this platform. Data from the network is made available via this platform for third-party applications.	5
Vattenfall (formerly Senfal)	Platform for bidding across different markets. Automated demand response and robotic energy trading. Software for flexibility options in the industrial sector, wind and solar parks, cooling installations and battery installations. Algorithms have been developed in collaboration with the Center for Mathematics and Computer Science CWI Foundation.	5, in Energiekoplopers field trial in Heerhugowaard also 1.
EDMij	Energy and data specialist. Predict energy consumption and production and trade energy directly on the market or among themselves (P2P). Energy supplier for agricultural companies	2

	whose flexibility (for example of CHP and assimilation lighting) is used to improve the market position.	
Powerpeers **P2P energy supplier**	Powerpeers brings together supply and demand of energy. For example, households with solar panels can supply energy to other households. For the time being, this is an administrative set-up that does not directly control the electricity system itself. Costs and revenues are settled afterwards.	-
SCADA wind turbines	SCADA (Supervisory Control and Data Acquisition) systems that control wind turbines: turbines can be shut down at times when power prices are negative. Control and data collection of offshore wind turbines is increasingly being carried out by a limited number of OEMs.	-

Table 2: overview of digital platforms active in the Netherlands

3.4 Insights from the Interviews

There have been interviews with 7 experts on this topic. Below we provide an overview of the most relevant topics discussed for this study. The functions of the interviewed experts are:

- Innovation advisor within a Distribution System Operator (DSO)
- Project Manager EV Charging Infrastructure employed by a Regional Grid Operator
- Strategist National Transmission System Operator (TSO) TenneT
- A former CTO of an international ICT service provider
- Director of public infrastructure automation company
- Head of IT at a Market Facilitator (Trading Platform)
- Cyber-security Expert at a Knowledge Institute

Innovation advisor within a DSO on Aggregation and DSO Congestion:

An Innovation Advisor within a network company points to aggregation platforms (activities 1 and 2 in Table 1) that drive units located in the distribution networks for system-level control purposes. "*This form of aggregation where you don't look at where something is taking place is inconvenient from a DSO perspective. It can cause congestion and this can lead to blackouts in years to come. The DSO must play a guiding role in this. […] You can force congestion to be included in the consideration.*"

This expert also mentions the distinction between open and closed platforms: "*you can stack GOPACS with the intra-day market(s), with a closed system this is not possible, it is then all tied together*". The system operators (TSO, DSO) should develop open markets and mechanisms with which they can put questions in the market, instead of making developments where they themselves "*sit in the aggregator's chair*".

DSO Innovation advisor on platform services lock-in

The Innovation Advisor warns against lock-in due to infrastructure and platform services becoming intertwined. "*At charging stations, you often see that the charging infrastructure and the platforms/services are provided by the same parties. […] Infrastructure operators prefer a closed platform, so that they can build up a monopoly on the infrastructure and thus also build up a monopoly on the platform services. This creates a monopoly battle for the infrastructure.*" An example is the charging infrastructure for electric cars in Amsterdam, where Vattenfall has rolled out (a large part of) the public charging stations. Insight into the operation of the charging infrastructure makes it possible to make a better estimate of future costs and necessary investments, so that other parties in a subsequent tender, work with an information backlog and are less likely to win the tender.

The spreading of infrastructure and control platforms/services is also seen by the expert as beneficial for the development of the platform services in the longer term, because the same services can then be offered more easily in different countries.

The expert warns against the emergence of a market for off-grid or semi-off-grid systems. For the suppliers, "*each blackout becomes an incentive to get more customer*s". This creates parties that have an interest in blackouts.

Project manager EV Charging Infrastructure about EV Smart Charging and Standardization

Project manager EV Charging Infrastructure employed by a DSO and seconded to the ELaadNL foundation. ELaadNL plays a role in the development and roll-out of charging infrastructure for electric vehicles (EVs) in the Netherlands and in establishing the necessary data protocols, for example in the coordination between car and charging station and for billing charging sessions at public charging stations.

This expert explains that it was soon concluded in the development of the charging infrastructure that the power demand for charging EVs is so large that much more is needed than just registering charging for billing. Thensmart charging provides an option, for which the charging process must be controllable and more insight is needed into which grid capacity is available and when.

"*It is expected that smart charging will become the standard, while at the same time, there will be a customer's choice on a more detailed level. The customer reports with a card at the charging pole how he or she wants to charge within the applicable preconditions. This way you as a user can purchase the service you want.*" This still poses challenges for implementation, because charging systems at different locations currently have their own fixed interpretation with regard to the charging profiles used. "*That is not ideal, in the end you only want to have one standard.*"

About the danger of a lock-in: "*IElaadNL is safeguarding that all management of EV charging will happen using the open protocols developed for this purpose. Proprietary Software is unwanted.*"

Project Manager EV Charging Infrastructure: Aggregation, DSO Congestion and Safety Net

When asked about the tension between the use of smart charging for reserve power and the imbalance market and the available capacity in the distribution network: "*You can already see a new market division emerging in which you, as a customer, decide what type of charging service to purchase. A mobility service provider can bet fully on the imbalance market and package it in a charging service in such a way that customers want to purchase it.*" If a DSO would want to use a similar approach, they would have to have constant insight in the location of consumers, and check whether there is no congestion problems at that time. The expert sees the emergence of two mechanisms for the DSO: a congestion management mechanism, in which flexibility of smart charging can (also) be used to prevent congestion, and a safety net function that detects and prevents problems.

ELaadNL is now developing an autonomous monitoring system, called Grid Shield, that continuously monitors the local grid situation and can control charging stations to prevent the power supply from experiencing problems in certain situations. This system is intended to prevent the coaction of charging actions from (unintentionally) causing overload in the grid. But it must also intercept hacks: "*if the system detects improbable charging actions, it shuts down preemptively.*" The grid shield must be so robust that it will not intervene more than necessary. "*The more functionalities it contains, the greater the chance of failure will become*," says the expert.

Project manager EV charging infrastructure: interaction grid management and telecom

Electricity network operators manage their own telecom network to ensure reliability. "*There is a mutual tension there: telecom does not want to go without electricity, grid management does not want to go without telecom for control.*"

Strategist national grid operator

Expert in the field of frequency regulation and data governance at TenneT.

"*Ultimately, TenneT revolves around 2 people in Arnhem who maintain the frequency. These people are getting more and more information sent to them. Automation and optimization are crucial here. Tests show that these [operators] base their decisions on what they see and that if they don't see something they can forget it. AI can play a major role in filtering the right information.*"

The expert sees an increasing use of platform systems that use AI at providers in the FCR, aFRR and mFRR markets. TenneT has an interest in having enough supply in these markets: "*It is […] extremely important that we facilitate the markets properly.*" Balancing through these markets is "*increasingly dependent on decentralized sources.*" The expert indicates that until now mainly very large, often international, players have been active in this market, "*but we want to see more aggregators on the market.*" In support of this, an event is described on May 1 in a recent year. The first of May is a public holiday in many parts of Europe, but not in the Netherlands. More reserve capacity was needed in the Netherlands, but because many large program responsible parties are located abroad, this was almost never offered. "*We were also unable to reach them by phone with requests to provide more reserve power.*"

Former CTO international ICT service provider

A former CTO of an international ICT service provider indicates that too little attention is paid to the negative aspects of digitization. "*Developments follow each other in rapid succession, trends reinforce each other and choices are not always transparent.*" He emphasizes the danger that a proprietary platform will take on a too dominant position. "*Consider adopting open stacks. In the energy world, more open standards need to be defined and used.*"

This expert also sees that the support for digitization within the energy companies was very low until recently. "*The revenue model for network companies is regulated by law and investments mainly took place in physical infrastructure.*"

"*It is conceivable that a digital markets department will also be set up for the energy sector at supervisors. In this context, the traditional scope of the regulator can shift from regulation and control to management and the stimulation of best practices.*"

Director of public infrastructure automation company

About the digitization of the distribution grids: "*Where TenneT is already extensively digitized and automated in the substations, the regional grid operators are not that far yet. Probably because there was never really a need for it. Enexis probably has the most insight into control stations now. Our company has looked at increasing smart operation and sees the following general steps in it:*

1. *Data collection and monitoring by people with domain knowledge. Possible analysis by a data scientist.*
2. *Identify interesting patterns in the data and automate their detection.*
3. *Decision support: after a while the advice is so good that people almost only agree with it.*
4. *Autonomous system.*

We are still at the very beginning of the distribution network, but level 3 has been reached in the high-voltage network. Such a whole process can take a long time. For example, after 15 years there was autonomous traffic management in the Maastunnel." About the monitoring & control of distribution networks, the expert continues: "*The control room of the future is empty: you cannot look at thousands of km of low voltage. There will be a lot of algorithms that automatically process signals and switch to them. Equipment that is placed in the infrastructure and that analyzes signals on site, is also a platform. It now analyzes cable degradation, voltage quality and forecast profiles.*"

"*The non-functional requirements such as availability, resilience and response time are becoming crucial. The energy sector may now be too stuck in closing the business case.*"

"When an incident occurs in the infrastructure, the sensors may not signal that incident because the sensors themselves no longer provide a reliable signal." The Fukushima disaster is cited as an example: "*of the 59 measuring stations, only 1 appears to have been usable; other monitoring stations were shut down by water and the earthquake."*

Regarding the mutual dependency between the networks for electricity and telecommunications, this expert remarks: "*simultaneous outage of electricity and telecom is problematic, as telecom critical for detection and solving problems in the electricity infrastructure. As a connection between the mid-voltage and low-voltage levels in the electricity network may serve around 4000 telecom connections (e.g. consumer internet) the impact is highly leveraged.*"

Head of IT at a Market Facilitator (Trading Platform)

An IT Manager at a Market Facilitator (Trading Platform): "*We ensure that market parties can come together and buy and sell their electricity. We are currently seeing a clear shift towards trading on the intraday market, short term trading. An important task for us", he continues, "is how we offer tradable products to the market that ensure that the network operators have as little work as possible.*"

They do not have a good view of the share of trading that is fully automated, he says. About 20% of all market orders are placed via the user interface, i.e. by a person. The other 80% goes through an API, an Application Programming Interface, but how many of those are submitted without being looked at, is unknown.

"*We are seeing more and more smaller assets, such as CHP installations and pumping power that is offered in aggregate,*" he continues. They do not yet see EVs at charging stations being used for flexibility, because "*no process has yet been developed on the side of the charging station.*" Furthermore, the expert indicates that most aggregators are active in the markets for reserve power, in particular the aFRR. "*That's where the low-hanging fruit is and that market is less complicated for market parties from an administrative point of view.*"

This expert sees the possibility of flash crashes, or extreme volatility, occurring in the future due to synchronization in the state in which the devices, such as heat pumps, electric cars and batteries, are. "*In the current system there is still enough rotating power [from traditional power stations] to absorb this. One connection or one aggregator will not affect the system, but if you get excessive synchronization it can cause problems. Then you can get flash crashes due to fully-automated algorithms trading high volumes of energy while reacting to price incentives in a similar manner.*" The expert suggests to investigate how homogeneous the assets are on the net using analyzes.

Cyber-security Expert

EA cyber-security expert at a knowledge institute mentions a number of general risks of AI[18] that are also relevant for the energy supply:

[18] Energie en democratie: hoe democratische invloed op Regionale Energie Strategieën en andere complexe besluitvormingsprocessen kan worden versterkt

- Adverserial AI[19]: "*Slowly feeding the AI with bad data. Spam filters are now also gradually being fed messages, so that a malicious email can get through.*"
- "*If you let an AI perform a task that is complicated for people, there is a risk that only very few people will be able to do the task themselves and control the AI. Examples include landing an airplane or manually separating large numbers of cells in a lab for tumor diagnosis.*"

About the danger of hacks: The cyber-security expert expects a strong growth of smaller (edge) devices in the lower parts of the grid. "*Although these devices may be easier to hack on their own, the risk is limited there, because the impact is much smaller there than on higher grid surfaces. It only becomes a system threat if you hack a lot of them. However, if the technology homogenizes on the lower grid surfaces, it is possible to hack large amounts at once. Then it becomes a much greater risk.*"

The speed at which solar energy is currently developing may lead to vulnerability. "*Inverters are often internet connected these days. Such a device communicates with a server, in China for instance, for updates of its firmware. However, in the current situation, I think China has little benefit from shutting down the electricity grid in the Netherlands, but it is a risk.*"

3.5 Application of AI by digital platforms

What does the current use of AI applications for controlling the electricity supply within these digital platforms look like? Which applications are crucial for controlling these platforms and how do these applications influence each other?

Based on the well-known platforms, the insights from the interviews and the available knowledge of the authors, we arrive at the following picture:

- Directing digital platforms within the electricity supply can currently be found mainly in the flexibility of supply and demand in the electricity system.
  - ✓ More and more sources of flexibility are located in the distribution networks. This concerns industrial capacity (such as cooling capacity, CHP installations, larger battery capacity) and increasingly to capacity in the built environment.
  - ✓ An important driving force is the increasing uncertainty in the electricity supply due to a growing share of generation from solar and wind.
  - ✓ The volume of electricity traded in the intra-day markets (EPEX and ETPA) has been growing in recent years. This flexible supply and demand is partly linked to the distribution grids, which respond to increased price volatility.
  - ✓ Furthermore, this flexibility is currently being used as regulating capacity (FCR, aFRR, mFRR).
  - ✓ The GOPACS platform is also used on a limited scale, but to an increasing extent, for congestion management at both the transmission and distribution level.

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[19] "Adversarial machine learning is a machine learning method that aims to trick machine learning models by providing deceptive input. Hence, it includes both the generation and detection of adversarial examples, which are inputs specially created to deceive classifiers. Such attacks, called adversarial machine learning, have been extensively explored in some areas, such as image classification and spam detection" [https://viso.ai/deep-learning/adversarial-machine-learning/].

  - ✓ Trading in the Intra-day markets, the reserve power markets and GOPACS, lead to control of supply and demand units.
  - ✓ Where large numbers of smaller assets are aggregated (e.g. electric vehicles or domestic heat pumps and boilers), aggregators develop AI models, for example to predict the aggregated behavior of the decentralized units.
- The use of decentralized units as control capacity or on the intra-day markets can lead to congestion in the distribution networks.
  - ✓ This usually takes place out of sight of the regional grid operators, because large parts of the distribution network are not equipped with remotely readable sensors.
  - ✓ The regional grid operators have a limited legal framework within which they can solve congestion in their grids by directing connected units.
  - ✓ In specific cases, providers of, for example, control power can manage congestion via their digital platforms for extra earnings.

4 FIVE SCENARIOS FOR THE NEXT 5 YEARS

How will digital platforms develop in the next 5 years? How will the use of AI change in this regard?

The possible developments are described on the basis of five possible future scenarios. Each scenario starts with a situation sketch, the identified risks, and the opinion of the interviewed experts about the probability and impact of the scenario in question.

4.1 Structural synchronization of decentralized assets

In 2027, a flourishing market has emerged for control capacity from decentralized units with relatively high fees and frequent deployment. This will create various digital platforms that unlock power from consumer units, such as electric cars, solar panels and home batteries. Margins are low in this competitive market, because the revenues have to be shared with a large number of owners of decentralized units, so that the platforms choose to use as much already available ICT as possible, such as data and algorithms that have been made available elsewhere. This one-sided data provision and use of the same/similar algorithms can lead to synchronization of different assets, where they exhibit the same behavior and a one-sided load on the networks occurs.

Another cause of synchronization of decentralized units is buffer behaviour. Flexibility of decentralized units is often achieved by buffering energy in some form. This can be thermal storage (for example in the case of heat pumps or CHPs for space heating and/or cooling) or direct electricity storage (for batteries in vehicles or buildings). With this form of flexibility, amount of flexibility becomes smaller the longer the flexibility is used. For example, batteries in smart charging electric vehicles that respond to price incentives will all become full over an extended period of low prices. This synchronizes the filling level over a large number of vehicles and thus limits the available flexibility of the whole for quite a few hours in the future. Similarly, after a period in which the heating task is postponed following a (price) signal from the electricity system, heat pumps for space heating will prioritize heating when the lowest comfort temperature has been reached. The amount of available flexibility is then depleted for a period of time. A large group of heat pumps that have all responded to the same (price) signal over a longer period of time will all have arrived in a state in which they have to run to guarantee comfort. This behavior has been observed in system studies[20] and also in field trials in the Netherlands, such as in PowerMatching City.

Risk(s):

- When decentralized units start exhibiting synchronized behavior on a large scale, this can lead to stability problems in the grid. Congestion may arise or too little flexibility may be available for balancing.

[20] Chengyuan Han, et al., “Collective effects and synchronization of demand in real-time demand response”, Journal of Physics: Complexity, IOP Publishing, Vol. 3, Nr. 2, April 2022. Doi: 10.1088/2632-072x/ac6477

This scenario is recognized by the experts interviewed as something that could occur incidentally within 5 to 10 years, although the impact on the stability of the electricity system is estimated to be limited.

As a mitigating measure, one can think of a stress test for algorithms and the development of models that estimate the amount of flexibility available from the decentralized sources at system or regional level. Or by making large-scale storage and buffer capacity available, such as heat-cold buffers and home batteries.

4.2 Aggregate trade and capacity issues

It is 2027 and large-scale (often aggregated) trading is taking place with flexibility from the distribution network in markets for reserve power. Trading parties and their algorithms themselves have no insight into bottlenecks in the distribution network: assumption of a '*copper plate*'[21]. There are no/few sensors that report congestion in real time. The DSO uses AI models to predict congestion. Actual congestion (place and time) can only be determined retrospectively on the basis of the data from the usage meters. The distribution system operator has no (legal) instruments to prevent congestion.

Risk(s):

- Mechanisms for short-term trading (intra-day markets) and balancing at the (inter)national level cause congestion in parts of the distribution grids without the distribution grid operator having the means to prevent this.

This scenario is seen by the interviewed experts as something that is already happening. Current regulations for curtailment, limiting the output of (decentralized) generators, lag behind what is technically possible: Grid Shield[22] application for limiting the power demand for charging electric cars, the development of a real-time interface with decentralized generating installations by Netbeheer Nederland[23] and a curtailment test for solar parks by Enexis and Liander[24].

Mitigating measures can be included in legislation and regulations, as is already the case in Germany. Curtailment can be used as an intervention. However, there is currently no legal basis for this in the Netherlands. Nevertheless, technical solutions, such as Gridshield from ELaadNL, are being developed in anticipation of an adjustment of the legal basis to make this service possible. It could be considered to only allow delivery or purchase if there is capacity for this, whereby dividing into different bidding regions is an option.

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[21] The current energy system is based on an electricity grid that facilitates users and the market, whereby users can assume three market freedoms: freedom of connection capacity, freedom of transaction and freedom of dispatch. This is called the "copper plate" principle.

[22] https://www.elaad.nl/smoothems-met-gridshield/

[23] https://solarmagazine.nl/nieuws-zonne-energie/i27108/realtime-interface-op-komst-noodrem-leidt-tot-veel-extra-aansluitcapaciteit-wind-en-zonne-energie

[24] https://solarmagazine.nl/nieuws-zonne-energie/i21795/pilot-curtailment-enexis-en-liander-mogelijk-30procent-meer-ruimte-door-dimmen-zonneparken
https://www.topsectorenergie.nl/sites/default/files/uploads/Systeemintegratie/TSE_SI_holarchie_202011.pdf

4.3 One dominant platform for managing decentralized assets

One party won the battle for charging and battery infrastructure in 2027. This party manages most of the Dutch charging stations and manages many battery systems. These assets are driven by an internationally closed platform for aggregation of flexible assets. Other parties such as DSOs, TSOs and market parties cannot ignore the platform due to their great need for flexibility.

Risk(s):

- Monopolist can drive up the price of flexibility, resulting in higher social costs for DSO and TSO.
- Lock-in by the local (charging) infrastructure operator leads to insight into asymmetry (an advantage in trade information) and therefore higher social costs/lack of innovation.
- Restriction of the monopolist can reduce flexibility provision, causing instability.
- The international monopolist has no incentive to consider locally caused capacity constraints in switching operations.

The risks surrounding the emergence of a dominant platform must be factored in. In other domains, among others, Google and Facebook have become dominant. A monopolist may be legally forced to split up in Europe, but in the US, for instance, where most major tech companies are located, this is difficult or impossible. Location of the platforms is essential. A dominant position can also arise around the control of physical infrastructure, such as with inverters for solar panels, a large part now comes from China and firmware maintenance is often done in China. The question arises as to what to do when the monopolist is beyond the reach of European regulators.

In terms of measures, the following are considered:

- Monitoring the formation of monopoly positions.
- With contracts it is possible to pursue divergence to avoid this
- Encourage/oblige disclosure of data, such as transaction data.
- Make good agreements, but above all limit dependence.
- Work on European policy regarding digital platforms and AI.

4.4 Lots of speculation on trading platforms

Increasing volatility has lured many traders to the electricity markets in 2027. Traders who send a disproportionate amount of decentralized capacity in a congestion region can earn extra by 'solving' self-induced congestion. This can be deliberate, but the used AI algorithms can also pick up this speculation as a lucrative strategy. Signaling this (by the trader or the regulator) is difficult because the majority of transactions are performed by *non-explainable* AI, of which it is not clear how the AI model arrives at its outcomes. Many of these parties are located abroad.

Risks:

- Transactions are made network agnostic. Can lead to congestion and instability in the network.

- Adjustment is difficult with program responsible parties are located abroad.
- Speculation increases the social costs for commercial gain.
- Algorithm trading on intraday markets leads to switching power stations on/off and can cause imbalance. Flash algorithms indirectly disrupt physical infrastructure.

Speculation on trading venues is considered highly probable and crucial to monitor. The question arises as to whether more regulation should be considered with regard to the current market forces in which speculation from geopolitics and profitably is beneficial. The design of the trading market provokes gaming speculation without considering the consequences; the consequences of this can be overcome by pricing congestion and network, such as in California, where the costs of transport are also charged. The emergence of brokers who speculate on short-term markets such as the intraday market is seen as worrying.

Mitigating measures

- Provide insight into the consequences for the network and work on pricing network costs.
- Design regulation so that it is not profitable.
- Making algorithms manageable by providing the right incentives in market design.

4.5 Autonomous distribution network

Only scenario now for 2032 instead of 2027, understandable since it is a lot further from the current situation, the control room of the distribution system operators will be fully automated and controlled by algorithms. Employees only monitor. Real-time curtailment of energy demand or supply (curtailment) is applied from digital switching relays that make autonomous choices based on information compiled by AI. Metering has not yet been rolled out sufficiently everywhere in the distribution network.

Risks:

- The knowledge to operate the network manually is lost.
- Great dependence on data from new ICT.
- Cyber attacks can disrupt control, while detection is slowed down by autonomy.
- Risk of data manipulation.
- AI also switches in the absence of local measurement data.
- In situations that occur very rarely, so-called “black swan” situations, a data-driven AI solution is not reliable.
- Ownership and accountability of the autonomous electricity grid is fading.

The promise of an autonomous distribution network is seen as plausible. To this end, the Topsector Energie has been commissioned to develop such a '*holarchic*' energy system[25] that could be operational around 2030. Employee involvement remains important in a monitoring role, comparable to pilots who fly on autopilot, but who must also be able to flying manually themselves. There is concern that it will become unclear who will own the autonomous distribution network. Is there still a market, if there is one? Which actors arise in this?

[25] Topsector Energie - Major HOLON research project launched. 20-01-2022 https://www.topsectorenergie.nl/nieuws/groot-onderzoekstraject-holon-van-start

Possible mitigating measures:

- Gradually equip control rooms DSO and TSO with explainable AI as a source of information. Explainable AI provides models from which it is possible to trace how outcomes were achieved.
- Control on information chain introduced by illogical AI circuits.
- Designing for cyber resilience. Monitoring. Use local AI where it can locally.
- Simulations for insight into extreme situations.
- Create clarity about who is accountable and responsible for choices and consequential damages by the algorithm.

5 RISK ANALYSIS DIGITAL PLATFORMS IN THE ELECTRICITY SUPPLY

What important risks are there with regard to the continuity and availability of the electricity supply as a result of the current and future use of AI in 5 years?

Simultaneously phasing out the traditional flexibility provision, such as controllable gas-fired power stations, and the rapid build-up of renewable energy sources, there is a greater dependence on flexibility and its control among other things by digital platforms and AI.

5.1 Approach

The findings from the interviews and the five scenarios were presented and discussed in an expert workshop. The risks of the scenarios were reflected in this meeting. While professionals from the industry were chosen for the interviews, the workshop group consisted of scientists and innovation professionals. Workshop participants were:

- Scientist Digitization in the Energy Transition at the Rathenau Institute
- Scientist Digitization of the Electricity Supply, University of Twente
- Scientist Governance of AI, Eindhoven University of Technology
- Program Director at Topsector Energie

5.2 Digitization and platforms are already putting pressure on the energy supply

The discussion about digital platforms and AI is not far off: AI is already widely used in the electricity system. However, these AI systems currently mainly provide information on the basis of which an operator makes decisions. When the intended step-by-step transition to autonomous or holistic energy systems takes place, operator intervention will phase out and the importance of a reliable and verifiable decision-making system will increase. That verifiability is currently completely lacking.

The energy domains in which AI is applied, mainly flexibility provision and energy trading, are already, or will become, substantial in the foreseeable future. The growth in switchable capacity, such as with the batteries of electric vehicles (EVs), is of great importance here. Forecasts from the International Energy Agency IEA suggest that by 2030, the feed-in potential of EVs at peak capacity in Europe will exceed 160 GW[26]. This is made possible by the substantial and fast-growing fleet of electric cars: by 2021 there will be more than 4 million EVs on the road across Europe[27]. By 2030, there will be some 7 million electric cars on the road in Germany alone - representing about 70 GW of flexibility. The current European heat pump

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[26] https://www.iea.org/data-and-statistics/charts/vehicle-to-grid-potential-and-variable-renewable-capacityrelative-to-total-capacity-generation-requirements-in-the-sustainable-development-scenario-2030.

[27] https://www.eafo.eu/vehicles-and-fleet/m1

stock of 14.9 million units (2020) represents 521 GWh of storage capacity[28]; in the Netherlands this is 14.2 GW. All this rapidly growing available capacity that is outside the traditional electricity system highlights the importance of this exploration study.

5.3 From risks to mitigating measures

Risks have been identified from the previously presented scenarios, which are further specified in the table below in terms of impact, probability of occurrence and possible mitigating measures. These risks were presented to experts from, among others, regional and national grid operators during a workshop, and adapted and enriched in the process. Risks that were not recognized or deemed important have been removed from the overview. The remaining risks provide an initial exploration of this domain and can be further explored.

The currently available knowledge and understanding of these risks is inadequate, so an attempt has been made in the overview below to estimate the probability that the risk will occur (column 2) and the impact when this occurs (column 3). Here, "L" stands for low risk, "M" for medium risk and "H" for high risk. The basis for this assessment comes directly from the workshop with experts. The time horizon considered here is the period up to 2030, in which the interim climate goals must be achieved and many changes in the electricity system are expected. The estimated probability that a risk will occur is therefore no more than an estimate by these experts that the risk will occur, possibly as part of the scenarios discussed earlier. The expected impact when this risk occurs (column 3) is also an estimate of this expert group. Many of these risks are qualitative, without direct consequences for the physical electricity supply, whereby a more thorough risk analysis may consist of a study into the various aspects of the consequences for the availability, reliability and affordability of the electricity supply.

[28] http://www.stats.ehpa.org/hp_sales/country_cards/

Overview risks	Chance of occurrence	Impact	Mitigating measures
General risks			
1. Contradictory incentives for sub-markets (generation/feedback, flexibility, congestion) lead to instability of the electricity network.	M	H	Adjustments to the market model or regulations for platforms, possibly by Europe.
2. Failure of AI system as a result of which flexibility provision is no longer available.	L	L	Diversity in platforms used for the AI system itself.
3. Existing public values of the energy system at stake: sustainability, reliability, affordability, privacy and cybersecurity.	M	H	Awareness, discussion, inference in regulation and incentives. Stakeholders from the energy sector.
4. Tensions in emerging public values: energy democracy, energy communities, controllable technology, individual autonomy, justice and equality.	M	H	Awareness, discussion, inference in regulation and incentives. Stakeholders from (semi) government.
Scenario 1. The scenario in which structural synchronization of decentralized assets occurs			
5. Synchronization of assets. When assets (e.g. EVs) all start exhibiting the same behavior at the same time, this can lead to stability problems in the grid. Congestion may arise or too little flexibility may be available for balancing.	L	H	Stress test for algorithms.
Scenario 2. Aggregated trade and capacity problems.			
6. Mechanisms for short-term trading (intra-day markets) and balancing at the (inter)national level cause congestion in parts of the distribution grids without the	H	H	Mitigating measures can be included in legislation and regulations, as is already the case for instance in Germany. Curtailment can be used to

distribution grid operator having the means to prevent this.			intervene. There is currently no legal basis for this.
Scenario 3. One dominant platform for managing decentralized assets			
7. Monopolist can drive up the price of flexibility, resulting in higher social costs for DSO and TSO.	M	L	Monitoring the formation of monopoly positions.
8. Lock-in of local (charging) infrastructure operator leads to insight asymmetry and therefore higher social costs/lack of innovation.	M	H	Encourage/mandatory disclosure of data, such as transaction data.
9. Restriction of the monopolist can reduce flexibility provision, causing instability.	M	L	Make good agreements, but above all limit dependence.
10. The international monopolist has no incentive to consider locally caused capacity limitations in switching.	M	M	Work on European policy regarding digital platforms and AI.
Scenario 4. Lots of speculation on trading platforms			
11. Trades are made network agnostic. Can lead to congestion and blackouts.	M	M	Provide insight into the consequences for the network and work on pricing network costs.
12. "Gaming" increases social costs for commercial gain.	M	H	Design regulation so that it is not profitable.
13. Algorithm trading on intraday markets leads to switching power stations on/off and can cause imbalance. Flash algorithms indirectly disrupt physical infrastructure.	M	H	Making algorithms manageable by providing the right incentives in market design.
Scenario 5. Autonomous distribution network			
14. The knowledge to operate the network manually is lost.	M	H	Gradually equip control rooms DSO and TSO with explainable AI as a source of information. Explainable AI

			provides models from which it is possible to trace how outcomes were achieved.
15. Great dependence on data from new ICT. Risk of data manipulation.	M	L	Control on information chain introduced by illogical AI circuits..
16. Cyber attacks can disrupt control, while autonomy slows the detection.	H	L	Designing for cyber resilience. monitoring. Run local AI where it can locally.
17. AI also switches in the absence of local measurement data.	L	H	Simulations for insight into extreme situations.
18. In "black swan" situations, a data-driven AI solution is not reliable.	H	L	Simulations for insight into extreme situations.
19. Ownership and accountability of the autonomous electricity grid is fading	M	H	Who is accountable and responsible for choices and consequential damage of the algorithm?

Table 3: long list of risks that can occur with operational digital platforms and artificial intelligence in the electricity supply.

5.4 Reflection on risks from the five scenarios

This first analysis shows that currently the main risks of digital platforms and artificial intelligence for the availability, affordability and reliability of the electricity network lie in speculation on intraday trading platforms without considering the transport and distribution network (risk #11). The trading platform has no insight into whether trades are made by a human trader or a system. Earnings from early buying and selling of positions are expected to increase as more renewable, unpredictable electricity becomes available; that leads to more speculation. By taking up a trading position, for example, a gas-fired power station is actually switched on. If this position cannot be placed at the end of the trading period and the trading party does not actually decrease the volume physically, a systemic problem arises. Volumes of, for example, European wind farms are 12 GW and 400 GW (the current and the intended European offshore wind capacity in 2050) and cannot be immediately expanded. The FCR in Europe is 3 GW, so with a lower power there is already a challenge here. When this happens, protective systems in the high-voltage grid switch off. This does not cause permanent damage to the network, but does lead to a *blackstart* situation in which the switched-off part of the network is phased back into operation. In the worst case, this can take several days.

What is striking is that experts are unanimous about the current situation in which risks of conflicting incentives that cause congestion (risk #1), public values of the energy supply are at stake (risk #3) and manageability of emerging public values such as controllable technology (risk #4) is already seen as the current status quo. In order to apply mitigating measures, it is important to identify the cause of this tension on public values. For example, is privacy legislation falling short, have a number of parties become too dominant, is there too little variation or too little capacity in the regulation capacity, is there no question of price elasticity in the market?

The emergence of monopoly and oligopoly positions of digital platforms seems likely. What is important here is the type of organization that fulfills this position: if the monopolist is a public party with a view to social costs, such as TenneT, then the situation is different compared to the situation where this is fulfilled by a commercial party. The consequences of the creation of a monopoly or oligopoly position by a commercial party vary from lock-ins such as the outsourcing of charging infrastructure due to information advantage (risk #8), to the creation of congestion due to simultaneous switching of charging or discharging capacity (risk #5). Where such lock-ins arise, social costs can rise and local/national entrepreneurship is discouraged. In order to prevent the information advantage that underlies this type of monopolies, one could consider measures to make data and possibly data analysis from the network such as charging transactions and maintenance-related data public. Simultaneous switching is a likely scenario, which already occurs basically due to commuting times and price incentives. To this end, the charging sector for EV is designing a "*grid shield*" that limits the power supply when the network reaches its limits.

The path taken towards an autonomous distribution network mainly encounters risks related to governance. The knowledge to operate the network manually is lost (risk #14) because information is delivered in bite-sized chunks, interpreted by the AI system and switched. A limited number of employees currently manage the control rooms for regional and national grid operators, in which the state of the grid is monitored and is responded to incidents. This work is increasing in complexity and problems are occurring more frequently, making further automation the most likely route into the future. If this network knowledge would disappear and this responsibility lies with a digital platform that is owned or operated by a commercial party, risks to the availability and affordability of the electricity network will increase. It is important to maintain a clear market model, whereby, even when an algorithm switches independently, the actor within the market model is held responsible for the consequences (risk #19).

6 ROLE OF THE SUPERVISOR

Instrumentation of Agentschap Telecom in the light of digital platforms, AI and the electricity supply.

How can Agentschap Telecom as a supervisor and executive organization limit these risks?

Supervision is especially important for digital platforms that switch in the electricity supply in real time or close to real time. Coordination with other regulators in the energy sector is essential. Organize broad learning capacity around the effects of digitization in the sector. Consider building new competencies such as simulations.

6.1 Power of Agentschap Telecom

The energy sector welcomes the presence of a number of supervisors: the Dutch Autoriteit Consument en Markt (ACM, Authority for Consumers and Markets), the Dutch Autoriteit Persoonsgegevens (AP, Data Protection Authority), Staatstoezicht op de Mijnen (SodM, State Supervision of Mines (SodM)) and Agentschap Telecom (AT). Based on the law Beveiliging Netwerk- en Informatiesystemen (WBNI, Network and Information Systems Security Act)[29], AT supervises the security of network and information systems for the continuity of the essential service. ACM[30] ensures that the investments of network operators are carried out as efficiently as possible. AP is active everywhere and only cares about the protection of personal data, not the proper functioning of the energy system. SodM is committed to human safety and the protection of the environment when extracting energy and using the subsurface. AT is expected to become increasingly active in the energy sector[31]. It is important to continue to make clear agreements between supervisors about responsibilities and possible measures, especially for rapidly developing digital domains.

6.2 Supervision of Digital Platforms

With regard to the role of digital platforms and AI in the electricity supply, the following activities are to be submitted for consideration to Agentschap Telecom.

1. Supervision of AI within the electricity grid based on the European AI Act[32].
2. Supervision is important for digital platforms that switch in the electricity supply in real time or close to real time. Also when the operator switches based on the outcome of an algorithm. This takes place in the management of physical assets, but also on trading platforms.

[29] Wet Beveiliging Netwerk- en Informatiesystemen (Wbni) voor Digitale dienstverleners
[30] Wat doet de ACM op de energiemarkt?
[31] https://www.agentschaptelecom.nl/documenten/rapporten/2021/07/12/verkenning-rollen-agentschaptelecom-energietransitie
[32] Briefing aan het Europees parlement inzake de Europese AI Act

3. Supervision should be considered for measurement companies that make data available to which digital platforms and AI switch.
4. Supervision of IoT equipment within electricity networks.
5. Given the system need for digitally-driven flexibility options, it is worth considering providing an experimental space for innovation within the digital platforms and to enable short-term market entry for these types of solutions, provided that risks have been thoroughly mapped out using scenarios and cascade effects.
6. Scenarios and cascade effects can be calculated using simulations, among other things. Competences for this are available at, for instance the University of Twente[33] and TU Delft's digital twin of the electricity network[34]. Agentschap Telecom can build up these competences itself, outsource it or require simulation-based risk analyzes from the digital platforms themselves.

6.3 Safeguarding non-technological aspects

The Rathenau Institute recently published a report[35] in which it considers the emergence of digital platforms in the electricity supply and calls on regulators to pay attention to this. The Rathenau Instituut indicates that in addition to the AI governance measures set by the European Commission, measures are also needed that limit automation, whereby people lose autonomy, (cyber) safety is guaranteed and both guidelines for the market and additional capacity for regulators to counter price manipulation and the emergence of oligarchies and monopolies. Discussions with stakeholders from the sector give rise to the impression that this cannot be taken for granted and that the rise of digital platforms and AI is already a factor. It is recommended that these additional governance measures will be embedded in supervision. In this context, it is important to organize learning capacity within the sector, so that rapid developments can be anticipated. This learning capacity can be shaped, among other things, by regularly bringing together policymakers, strategists and entrepreneurs around tricky issues and explorations, as is now organized within the energy sector in the Club van Wageningen.[36].

[33] Hoogsteen, G. (2017). A Cyber-Physical Systems Perspective on Decentralized Energy Management. (1 ed.). University of Twente. https://doi.org/10.3990/1.9789036544320
[34] Delft Integraal, "Levensecht evenbeeld van stroomnet", 12-2021. https://www.tudelft.nl/delft-integraal/articles/dec-2021-nieuwe-energie/levensecht-evenbeeld-van-stroomnet
[35] Niet I, van Est R and Veraart F (2021) Governing AI in Electricity Systems: Reflections on the EU Artificial Intelligence Bill.
[36] https://clubvanwageningen.nl

7 CONCLUSIONS AND RECOMMENDATIONS

The concern about emerging digital platforms and control by algorithms is shared by experts in the Dutch electricity sector. Specific attention is needed here to safeguard the public values of the electricity supply; namely availability, affordability and reliability.

The assessment in this report based on literature research and interviews with experts provides a further explanation of possible bottlenecks. Possible scenarios indicate how digital platforms and the use of AI can develop and what risks this entails. This report describes the main risks related to the availability, affordability and reliability of the electricity grid. And therefore not other bottlenecks that manifest themselves in the digital domain, such as guaranteeing inclusivity and personal data, nor cyber resilience and cyber security.

7.1 Conclusions

What role do digital platforms currently play in controlling the electricity supply and how are such platforms constructed?
The role of digital platforms in controlling the electricity supply will increase sharply in the next five to ten years. A number of digital platforms are currently active, such as Tesla Autobidder. The growth of these digital platforms goes hand in hand with the growth of switchable energy supplies, such as electric cars and solar panels, and the associated increasing value of predicting future demand, supply and, among other things, congestion.

Digital platforms are now mainly active in the market for power regulation, with the regulation of charging electric cars being the most common. It is likely that a dominant platform will emerge in the next decade. Such a scenario is elaborated in scenario 3.

Many of the currently active digital platforms have been developed and introduced into the market by (semi-)public organizations. Examples include trading platform ETPA[37] and balancing platform Equigy[38] which have been introduced by TSO TenneT. Congestion platform Gopacs in turn was introduced by the aforementioned trading platform ETPA. Digital platform Jedlix for timing the charging of electric cars has been introduced by energy supplier Eneco. The picture that digital platforms from Silicon Valley are making rapid advances in the electricity sector in Europe and the Netherlands therefore needs nuance.

What does the current use of AI applications for controlling the electricity supply within these digital platforms look like? Which applications are crucial for controlling these platforms and how do these applications influence each other?
Controlling digital platforms within the electricity supply can mainly be found in the flexibility of the electricity grid, especially in regulating capacity (aFRR) and congestion management. In the absence of regulations, the use of decentralized units for aFRR can actually lead to congestion in the distribution networks. This usually takes place out of sight of the regional network operators, because large parts of the distribution network are not metered. But, more importantly, the regional grid operators have a limited legal framework within which they can

[37] https://etpa.nl
[38] https://equigy.com/the-platform/

solve congestion in their grids by directing connected units. In specific cases, aFRR providers can even manage congestion through their digital platforms for extra revenue.

How will digital platforms develop in the next 5 years? How does the previously described use of AI change in this regard? Both in the type of AI application and in the location and interaction between the different applications. Describe using scenarios.
The development of digital platforms is set out in five different scenarios in Chapter 4. These scenarios range from unwanted network effects caused by one-sided algorithms to the emergence of monopoly positions, from automated speculation on trading platforms to an autonomous distribution network. AI is already being applied in these domains and will be more widely distributed. The Energy working group of the Dutch AI coalition confirms this picture in its desired development agenda for algorithms in the electricity system[39].

What important risks are there with regard to the continuity and availability of the electricity supply as a result of the current and future use of AI in 5 years?
The main risks identified are (1) speculation on intraday trading platforms without considering the transport and distribution network. (2) The emergence of monopoly and oligopoly positions of digital platforms may lead to lock-ins that range from, the outsourcing of charging infrastructure due to information advantage, to the creation of congestion due to simultaneous switching of charging or discharging capacity. (3) Experts interviewed are unanimous on risks of conflicting incentives causing congestion, public values of energy supply being compromised and feasibility of emerging public values such as controllable technology.

7.2 Recommendations

How (goals and set of instruments) can Agentschap Telecom as a supervisor and executive organization limit these risks?
Supervision is especially important for digital platforms that switch in the electricity supply in real time or close to real time. Coordination with other regulators in the energy sector is essential. The Dutch Autoriteit Consument en Markt (ACM, Authority for Consumers and Markets), Agentschap Telecom and the Dutch Autoriteit Persoonsgegevens (AP, Data Protection Authority) are active in the energy sector. Coordination prevents overlap and gaps in supervision. Organize broad learning capacity around the effects of digitization in the energy sector. Consider building new competencies such as running simulations to test the reliability of algorithms.

1. Build competencies in simulating scenarios. Using digital twins and calculation models, it is possible to explore the impact in various extreme scenarios in fine-grained parts of the electricity system, such as the low-voltage network. Agentschap Telecom can perform this type of simulation in-house, but this is a complex and specialized activity. Outsourcing to parties such as the University of Twente or having active market parties calculate extreme scenarios themselves and report regularly (annually) may be an option to consider.

[39] Report Dutch AI coalition: AI als versneller van de energietransitie.
https://nlaic.com/wp-content/uploads/2021/09/Position_paper_AI_als_versneller_van_de_energietransitie.pdf

2. Undesirable effects by digital platforms often only become clear when it is too late. Organize learning capacity among policymakers, strategists and companies so that undesirable effects are identified in time, policy can be drawn up and implemented, and business can proceed. Such a learning community is already active in the energy domain under the name "*Club van Wageningen*"[40]. Initiatives around Digital Sovereignty are also relevant in this regard.
3. Given the system need for digitally-driven flexibility options, it is recommended to offer an experimental space for innovation within the digital platforms and short-term market entry for these types of solutions, possible under the condition that risks have been thoroughly mapped out using scenarios and cascade effects.
4. It was unclear in this exploration study, whether simulations, among other things, take consequential damage into account. The consequences of a voltage dip or outage can be significant, as witnessed by recent events in the hospital St. Jansdal Harderwijk[41], the eviction of the VU medical center[42] and the power failure that halted air traffic at Schiphol in 2018 due to an incorrectly configured emergency generator, problems in data networks and software[43]. This deserves further exploration and investment to improve resilience to these types of disruptions.
5. Prevent ambiguities about domains in which a specific supervisor is active. Agentschap Telecom is the third regulator to become active in the energy domain. Coordination with other regulators is desirable in order to guarantee speed and an unambiguous policy towards this rapidly developing market.
6. The creation of monopoly positions due to data and insight from years of management can be prevented by making agreements in case of outsourcing by making both data and analysis available to competitors. Digital platforms active in the energy domain are often contracted by local authorities, such as for the construction and operation of charging infrastructure for electric cars.
7. This report has been prepared on the basis of identifying the main risks of the availability of the power supply. As a result of this choice, less attention has been paid to factors such as inclusiveness and public values, while these are coming under pressure due to decentralization and digitization. When digitization of the power grid is shaped by algorithms, it is important to test these for public values[44].
8. Possibly the most important factor not mentioned in the conclusions: in 2022 algorithms will have more effect on (sustainable) energy use than algorithms help to achieve sustainable energy use. The energy consumption required for training algorithms such as image recognition has grown by a factor of 300,000 from 2012 to 2018. Training and running algorithms is already an unbearable burden on the electricity infrastructure, measures in data centers. Awareness among AI developers is essential for a sustainable and sustainable future.

[40] https://clubvanwageningen.nl
[41] NOS, Extern onderzoek naar stroomstoring bij ziekenhuis van Harderwijk, 4 januari 2022.
[42] Ontruiming VU medisch centrum na wateroverlast, 2015.
https://nos.nl/liveblog/2056568-ontruiming-vumc-na-wateroverlast
[43] NRC, Hoe een stroomdipje van niets heel Schiphol plat heeft gelegd, 01-05-2018
[44] Rathenau Instituut, Seeking Public Values of Digital Energy Platforms, 2021.
https://www.narcis.nl/publication/RecordID/oai:pure.tue.nl:publications%2F768d9b56-eb0b-4449-8eb9-50e2ad255170

8 Appendixes

8.1 Overview of the different types of balancing energy

Type balancerings-reserve	Gebruikelijke Europese naam	Uitleg
Primary Reserve Power	Frequency Containment Reserve (FCR)	Activates automatically within seconds in the event of a grid frequency deviation, and must be able to deliver full contracted power within 30 seconds. The mains frequency is kept constant in Europe at 50 Hz.
Control capacity	Automatic Frequency Restoration Reserve (aFRR)	Is centrally controlled by the grid operator Tennet and must be able to be fully activated within 15 minutes, with a minimum ramp rate of 7%/min. After activation, the grid operator sends a new setpoint every 4 seconds that must be followed within a strict accuracy band. In this way, the grid operator can adjust the balance accurately.
Reserve power (mFRRsa) & Emergency power (mFRRda)	Manual Frequency Restoration Reserve (mFRR)	Emergency and reserve power are used to make the Regulation power available again in the event of large and prolonged imbalances and must be able to be fully activated within 15 minutes. Reserve power works according to free bids, while Emergency power is pre-contracted. In the event of major imbalances, these reserves can support the grid frequency for minutes to hours.