Peter A. M. Hermans

26 The Perfect Storm: Where the Energy Transition Meets the Digital Transformation

Abstract: This chapter emphasizes the pivotal role of digitalization in the energy transition, addressing key challenges in Europe and drawing valuable lessons from the Netherlands' path toward achieving a carbon-neutral society. The objective of the chapter is to contribute to establishing a common understanding of what a digitalized sustainable energy system truly entails and the essential steps, required for its realization.

Readers are encouraged to reflect on and apply these insights in crafting meaningful strategies for their own contributions to a sustainable future. Commencing with an overview of the European energy sector, the chapter delves into challenges faced by Dutch System Operators and explores the European Action Plan for digitalizing the energy system. It also provides overarching insights into transformation and digitalization. The chapter then focuses on four specific areas: Smart Metering, Flexibility, Energy Data Exchange, and Energy Sharing.

Keywords: digitalization, transition strategy, change management, smart metering, flexibility, data exchange, energy sharing

26.1 Introduction

The climate is undergoing rapid change, necessitating the urgent acceleration of the transition to a carbon-free energy system. Simultaneously, the digital transformation is profoundly reshaping our society. These converging forces create the perfect storm where the energy transition meets with the digital transformation.

This chapter emphasizes the vital role of digitalization in achieving a successful and expedited energy transition. It tackles significant European challenges and draws on lessons, insights, and outcomes from the Netherlands' path towards a carbon-neutral society. Readers are invited to contemplate and apply these insights to formulate meaningful strategies for their individual contributions to a sustainable future world.

Beginning with the backdrop of the existing European energy sector, this chapter delves into the current challenges confronted by Dutch system operators. It further explores the "European action plan on digitalizing the energy system" aimed at digitalizing the European energy system, while also examining broader insights into digitalization.

Peter A. M. Hermans, Valcre, Houten, The Netherlands, e-mail: valcre@xs4all.nl

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Subsequently, the chapter addresses four specific focal points: smart metering, flexibility, energy data exchange, and energy sharing.

26.2 The Context of the European Energy Sector

When considering the energy sector in Europe, which sets the context for our digitalization endeavors, a series of trends and developments come into view.

The conflict between Russia and Ukraine, which began in 2014, and the discontinuation of gas exploration in the Groningen gas field, have had a substantial impact on the Dutch and European energy market, accelerating the transition to renewable energy.

With initiatives such as the "REPowerEU" package [1] and the Electricity Market Design (EMD) proposals published in March 2023 [2], the European Commission has accelerated its efforts to stabilize energy prices for EU citizens and industries, while promoting the transition to renewable energy sources.

Consequently, we are witnessing a remarkable surge in renewable electricity generation based on solar and wind energy, along with the electrification of heat, via full electric or hybrid heat pumps, and mobility. Dutch national legislative efforts are also promoting these advancements.

The extensive deployment of photovoltaic (PV) smart inverters, electric vehicles (EV) charging stations, and heat pumps has ushered in a diverse array of intelligent devices, which now play a pivotal role in the energy system. This surge has magnified the pressing necessity for interoperability in exchange of energy data. Today, we are witnessing exploding volumes of data stemming from the grid edge (appliances, smart meters and sub meters), coupled with the emergence of real-time data demands.

26.3 Challenges for System Operators

In the Netherlands, utilities have been fully ownership-unbundled since 2017. This means that distribution system operators (DSOs) and transmission system operators (TSOs) are tasked with transporting and distributing electricity and gas, while the production, trading, and supply of energy to end customers are handled by commercial market participants.

Presently, Dutch DSOs encounter substantial challenges. Previous national subsidy programs, which overlooked system effects, aimed at promoting the adoption of decentralized sustainable energy resources, as well as the electrification of heating and mobility, have led to a notable grid capacity issue (see Figure 26.1) [3]: particularly in rural areas, where land prices are low and network capacity is limited. This applies to both energy feed-in and consumption.

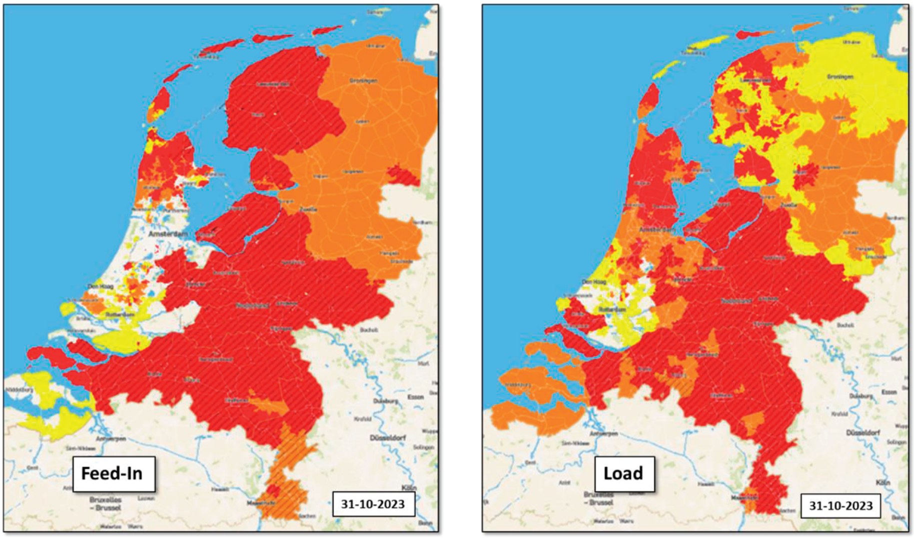


Figure 26.1: Dutch grid capacity challenges.

The Netherlands previously relied heavily on Groningen gas and lacks a significant heat infrastructure. However, as the energy balance is expected to shift from 80 % gas and 20 % electricity to a more balanced 50 % 50 % ratio, a substantial effort is required to build the necessary infrastructure. This includes a projected expansion of the low voltage (LV) electricity grid by 20 %–30 %, MV/LV substations by 40–55 %, medium voltage (MV) electricity grid by 35 %–45 %, and high voltage (HV) stations by 200 %–300 % [4].

In 2022, the Ministry of Economic Affairs and Climate decided to regulate all new heat infrastructure. This decision will also enable effective system integration between electricity and gas, particularly with the replacement of Groningen gas by “green hydrogen.”

The increasing adoption of decentralized renewables is putting stress on the low-voltage grid, causing power quality issues, due to its original unidirectional design. In addition, distribution network operators (DNOs) are evolving into distribution system operators (DSOs), shifting their focus from assets to (bidirectional) energy flows within the system. They are still in the process of developing capabilities for short-term load forecasts and predictive load flow analysis across all grid levels; the era of unlimited grid capacity (“the copper plate”) is over, and “the last mile” is turning into the “first mile.”

In addressing these challenges, DSOs face a lack of sufficient financial resources, possibly requiring over 200 billion EUR in investments the next 25 years, a shortage of technical staff currently estimated at around 18,000 personnel, and time constraints in meeting the Dutch 2030 climate objectives for 55 % CO_2 reduction. These challenges underscore the necessity for not only additional energy infrastructure but also for a smart digital infrastructure. A digital infrastructure that seamlessly interacts with markets and customers is essential for ensuring the observability and control of energy flows in the future energy system. This, in turn, guarantees reliability and, last but not least, affordability for citizens and enterprises.

26.4 The EU Action Plan of Digitalization of the Energy System

In October 2022, the EU Commission released the European Action Plan for the digitalization of the EU Energy system [5, 6]. This comprehensive plan outlines Europe's vision and strategy for digitalizing the energy system. It forms the basis for forthcoming regulations and initiatives concerning energy data exchange, empowering citizens, investments in smart grids, cybersecurity, and achieving climate neutrality within the information and communication technologies (ICT) sector (see Figure 26.2).

The notion of empowering citizens is already evident in the published EU proposals on the Electricity Market Design (EMD) [2]. Here, the concept of energy sharing by end customers, initially introduced in the 2nd Renewable Energy Directive (RED II directive) in 2019, has been further developed and emphasized.

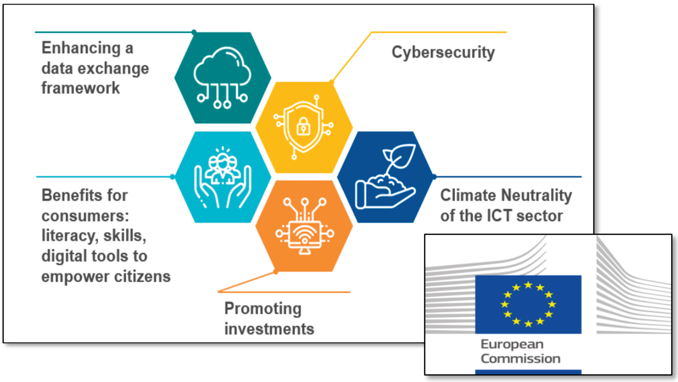


Figure 26.2: The EU action plan of digitalization of the Energy System (source EU Commission).

26.5 Transformation: General Insights

The saying "effectiveness equals quality times acceptance," implies a comprehensive understanding of both content and process. This principle leads to three key insights:

Firstly, the system of the future will not be built on the silos of the past: new human "connections" are needed. Technology, markets, and regulation are strongly intertwined. IT managers, business managers, and legal experts should team intensively, inside an organization and between organizations: systems are built by humans, and if they do not cooperate, neither the systems will. This also highlights the necessity for novel connections among individuals across different sectors as the building, transportation, and energy sectors, as well as among established and emerging stakeholders within the energy sector itself. To support the establishment of new connections, a 48 hrs transform hackathon was organized in the Netherlands in November 2022, leading to a much better common understanding on how the future energy system (referred as "the world of B") should look like [7].

Secondly, it is essential to acknowledge a significant sociological trend [8, 9] in our society, wherein collective citizen initiatives are emerging to organize access to energy, healthcare, and housing. There is a growing Dutch public sentiment that the market should serve society's needs, not the other way around. This sentiment is paralleled by an increasing mistrust in governmental institutions, with some perceiving them as not wholly aligned with public interests. As a consequence, significant shifts in the political landscape in the Netherlands currently are taking place. When designing new digital solutions, it becomes imperative to anticipate on these societal changes, empowering customers further, such as, for example, in the energy sector, granting direct access to markets or enabling energy sharing or collective self-consumption operating models. The sheer number of citizens initiatives underscores a clear desire for more participatory and community-oriented solutions in the related sectors.

Thirdly, while much of the European discourse revolves around content, such as new legislation or network codes, there should be a much stronger emphasis on well-defined transition and change management strategies. Various pathways can lead us towards our, still developing, goals. By initiating transition and change management strategies based on a shared, well-defined, understood, and agreed-upon vision, rather than simply implementing ambiguous regulations differently across European member states, we can significantly enhance our effectiveness and speed in achieving a carbon-neutral European society. This requires strong leadership.

26.6 Digitalization: General Insights

When reflecting on the digital transformation in general, three general insights are relevant:

Firstly, it is important to recognize that the transformation to a digitalized business ecosystem will require integration of the IT department in the business: IT is not a cost-center anymore. This also requires the adoption of an "outside-in" mindset of the IT department, where IT developers really understand the value of their software in the complete business value chain, which may cross companies borders.

Secondly, data exchange in a digitalized business ecosystem is not anymore a protocol and data format issue only. It represents a transaction defined in business, legal, technical, and operational terms, and should be dealt with as such.

Thirdly, to accommodate business agility in this emerging digitalized business ecosystem, modeling of the business, including its interactions in the business ecosystem, which are supported by a loosely coupled IT architecture, will be required; different parts of the business may develop in different directions, at different speeds, and may regroup with other stakeholders, as the new energy ecosystem develops (see box).

Business modeling. For achieving more business agility, the DSOs in the Netherlands modeled [9] their business as six domains: serving customers, meter data collection, grid capacity analysis & planning, infrastructure operations (build and maintain), system operations (day ahead forecasting, balancing and congestion management), and market facilitation (providing metering data, enabling supplier switching and allocation, reconciliation & settlement of energy). This is elaborated in the Nbility capability model [10] (comparable to the e-TOM model used in the Telecoms sector), which today serves as basis for intensified cooperation between all Dutch DSO's.

26.7 The Digital Architectural Framework of the New Energy System

Reflecting on the historical energy system from a digitalization perspective leads the following insights:

- Centralized generation and data processing: In the past, energy generation was centralized, and data processing followed a similar centralized approach. Energy flows were predominantly unidirectional, and there was a significant focus on assets in the energy infrastructure.
- Limited energy carrier integration: Integration of energy carriers (electricity, gas, heat) was minimal or absent in the historical energy system.
- Fragmented digital landscape: Regulatory factors led to a fragmented digital landscape, suboptimal optimization across the value chain, and a lack of a commonly agreed upon digital architectural framework.
- LV grid digitalization gap: Whereas observability and controllability of HV and MV grids improved by digitalization, LV grid digitalization, except for smart meters, remained low due to its unique size and nature.

The future energy system, when addressed from a digitalization perspective, requires a layered digital architectural framework as depicted in Figure 26.3, encompassing the following key characteristics:

- *integrated energy approach*: In order to arrive at an optimal efficient energy system, an integrated approach over various energy carriers (electricity, hydrogen gas, heat) is required. Utilizing the concept of minimum interoperability mechanisms (MIMS) [11] can facilitate the transition toward an integrated system. Embedding MIMS within the digital architectural framework offers valuable guidance for developing a roadmap and allows for the prioritization of initial implementation steps. Standardizing interoperability mechanisms, enforced by European energy regulation, will accelerate this integration.
- *decentralized data processing*: Data processing is decentralized, offering advantages such as reduced latency and enhanced real-time decision-making capabilities, utilizing edge and cloud computing in an open federated architecture. This design facilitates smooth data exchange among diverse stakeholders in the energy landscape, while avoiding dependencies on existing hyperscale platforms.
- *open standard APIs*: The adoption of open standard application programming interfaces (APIs) is essential for the comprehensive transformation of the energy value chain. Integrating these APIs into future energy regulations in fact defines and enforces "the digital unbundling": this is essential to achieve interoperability, to create a level playing field, and to establish an addressable market for ICT service providers, who are active in the digital energy ecosystem.
- *edge data processing for resiliency & privacy*: Prioritizing edge data processing enhances grid resiliency, improves General Data Protection Regulation (GDPR) compliance (as data could stay at customers premise), and aligns with the transition to a decentralized energy system.

Current European and national energy regulation emphasizes roles and responsibilities but still lacks specificity in regulating data exchange and open APIs on cloud and edge platforms. This results in fragmented solutions and high interoperability costs. As stated, standardizing digital twins and APIs, enforced by regulation, is essential. This represents a shift in the future digitalized energy system that will significantly alter the current energy management and interaction landscape.

Continuing developments will drive the journey towards a digitalized energy system. A balanced distribution of benefits of digitalization among consumers, market participants, and system operators is essential. The exponential growth of PV, EVs, and heat pumps in a fragmented and non-standardized market, and connected to the grid in a wide variety of configurations, will be an important driver for arriving at these standardized APIs, as it will enable balanced benefits for all stakeholders.

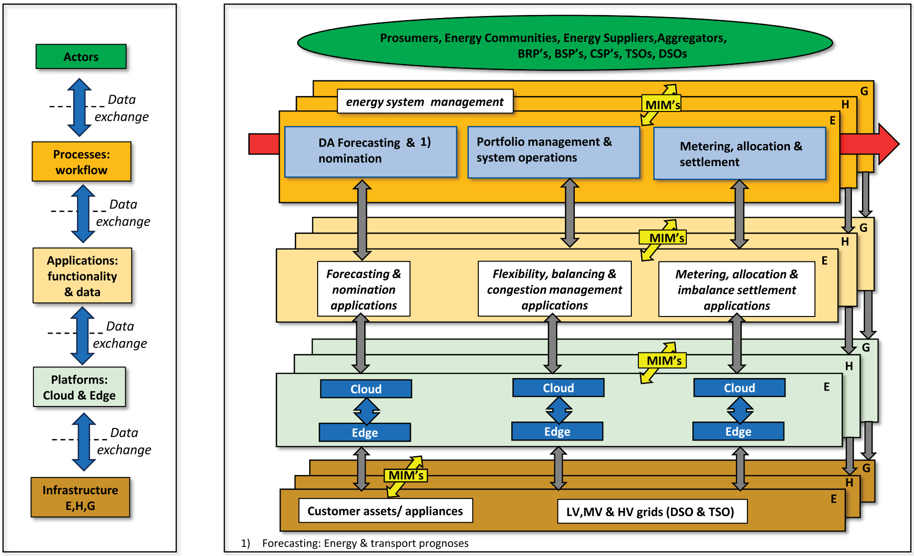


Figure 26.3: Digital Architectural Framework of the Energy System.

26.8 Smart Meters: Learnings and Insights

In the Netherlands, approximately 8.4 million smart meters have been rolled out between 2013 and 2020 in different generations, achieving an 89 % connection coverage. Daily metering values are collected on a daily basis, with a key performance indicator (KPI) of 99.3 % of correctly collected values. At first sight, this may seem correct, but it actually implies approximately 59,000 non-correct or missing daily metering values. As customers opt-in to receive 15-minute interval values (96 daily), the total volume of monthly collected data grew from 275 million in 2022 to 470 million, marking a 70 % increase. Given the emerging need for more real-time data, it is concluded that collecting metering data, not only for billing purposes, has evolved into a mission-critical activity today. Key learnings and insights on smart metering in the Netherlands include the following:

– Rolling out smart meters differs significantly from operating them. More attention should be given to the large-scale operational processes of data collection, including lifecycle management issues related to telecommunication standards (e. g., phasing out GPRS[1]). Given the interdependence of telecoms and energy, exploring new forms of public-private cooperation between the two sectors is relevant.

1 GPRS means General Packet Radio Service.

- When collecting smart meter data, we must ensure privacy and General Data Protection Regulation (GDPR) compliance, as the data reflects personal behavior. It's essential to earn and maintain the trust of our customers.
- A smart meter is more than a traditional meter with onboard software. It serves as a digital component within the digital business ecosystem, supporting multiple use cases (see box) of various stakeholders; a digital component which interacts with appliances behind the meter, and, as a gatekeeper, also should contain functionality to mitigate cyber security risks to the energy system as a whole.
- For the future, a modular and innovative smart meter setup is necessary. Currently, Dutch distribution system operators (DSOs) are defining and piloting the NEXT generation smart meter. They are preparing for decentralized data processing by introducing a modular design that features basic metering devices (sensors) connected to an Internet of Things (IoT) edge gateway through open APIs. This approach enables decentralized data processing (see Figure 26.4), allowing market actors and system operators to develop edge applications. These applications will also include tools for customers to have enhanced control over their own data.

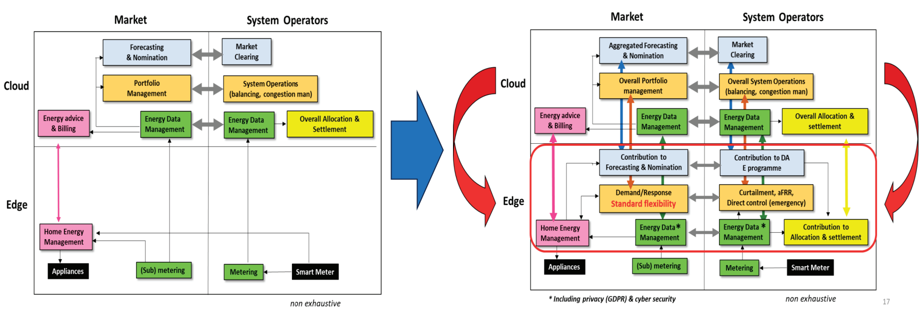


Figure 26.4: Application candidates for edge computing.

The Dutch DSOs developed a demonstrator project to showcase the new modular smart meter design, along with a configuration that integrates the gateway into existing smart meters. By integrating the system operator (SO) app with existing SCADA[2]-based DMS[3] systems, real-time observability and control of the low voltage grid can be achieved. This integration will also enable support for balancing and curtailment when market-based flexibility is unavailable. Figure 26.5 shows the architecture as well as the envisaged roadmap.

2 SCADA means "Supervisory Control and Data Acquisition".

3 DMS means "Distribution Management System".

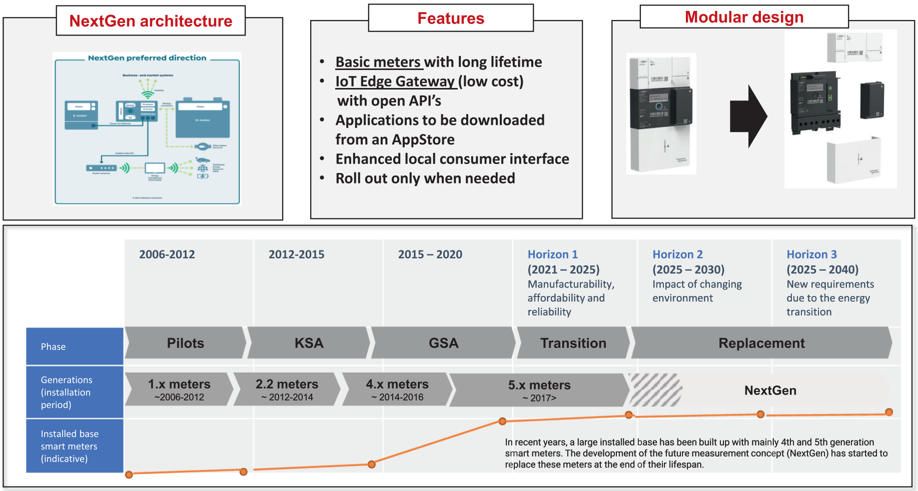


Figure 26.5: Next Generation smart meters.

Using smart meter data for grid management purposes became possible after approval in May 2022 by the Dutch Data Protection Authority [12] of a code of conduct on GDPR compliance [12]. This code of conduct also required Dutch system operators to establish a national independent monitoring body with an appropriate mandate to ensure GDPR compliance. This monitoring body was accredited by the Dutch Data Protection Authority in June 2023, based on European criteria defined in 2022 by the European Data Protection Board (EDPB) [13].

LV grid management use cases. The Dutch distribution system operators (DSOs) have identified several use cases (see Figure 26.6) for utilizing smart meter data in smart grid management, leading to better monitoring and control of the low-voltage (LV) grid. Due to the significant increase in photovoltaic (PV) installations at customer premises, the LV voltage monitoring use case has been prioritized. Currently, DSO Stedin monitors all its 2.5 million connections for anticipated voltage violations. This use case allows for timely and appropriate actions to prevent PV smart inverters from switching off, as this would result in significant customer complaints about lost revenue from feed-in.

26.9 Flexibility: Learnings and Insights

In the realm of energy management, flexibility is an important tool among others. Alongside flexibility, also options such as grid tariffs, connection agreements, curtailment, and grid expansion play vital roles. The Netherlands' grid congestion has prompted discussions about congestion management, flexible connection agreements, notably non-firm transport contracts, and collective transport contracts (e. g., for an industrial area where

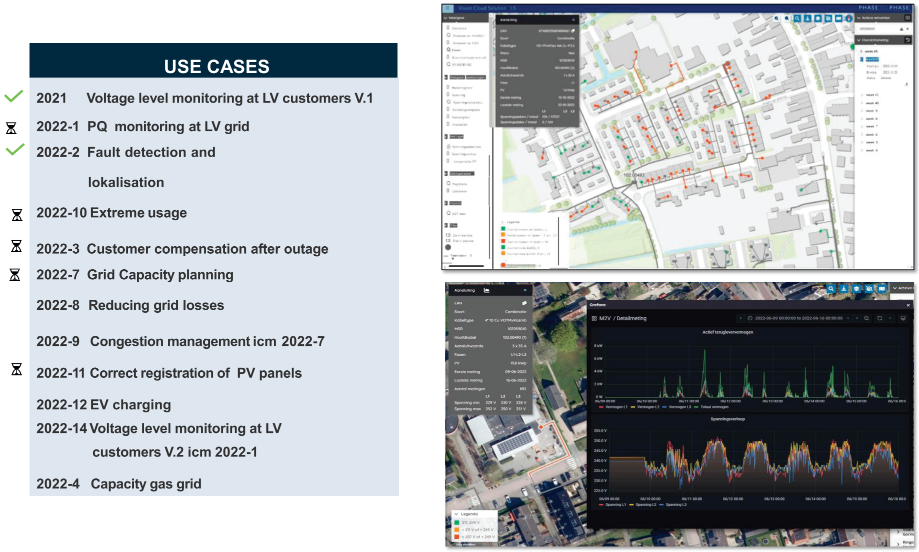


Figure 26.6: Voltage Monitoring at LV grid level.

companies share available grid capacity). These innovative approaches enhance adaptability and efficiency, addressing the challenges posed by congested energy infrastructure. Four key takeaways are relevant to reference here:

- A different mindset is needed for operating the system in which demand side flexibility and Demand Response should be possible. We are transitioning from “supply follows demand” to “demand follows supply,” requiring behavior change at the consuming side. Concrete actions on end users behavior change to date however are lagging behind; the adaptation of dynamic price contracts (hourly based pricing) is increasing, but may at the same time have an adverse effect on peaks in grid load.
- We have multiple grids, but, within one balancing zone, only one system. At system level system operators (TSO & DSOs) should closely cooperate to ensure that any redispatch or balancing action, initiated by either one of them, would not harm any other system operator. This basic principle was agreed between TSOs and DSOs in 2016 and published in the TSO-DSO Active System Management report [14]. In the Netherlands TSOs and DSOs invested in more intense human relations and cooperation since 2017, from which the TSO-DSO platform coordinating flexibility needs (GOPACS) was the first visible result.
- As previously mentioned, there’s a need for day ahead load forecast and predictive load flow analysis capabilities at the distribution level, specifically on 15-minute intervals, across all grid levels. This capability is essential to anticipate congestion occurrences and enables the market to solicit redispatch bids. Currently, DSOs lack this critical capability. The EU’s digitalization action plan has also highlighted this

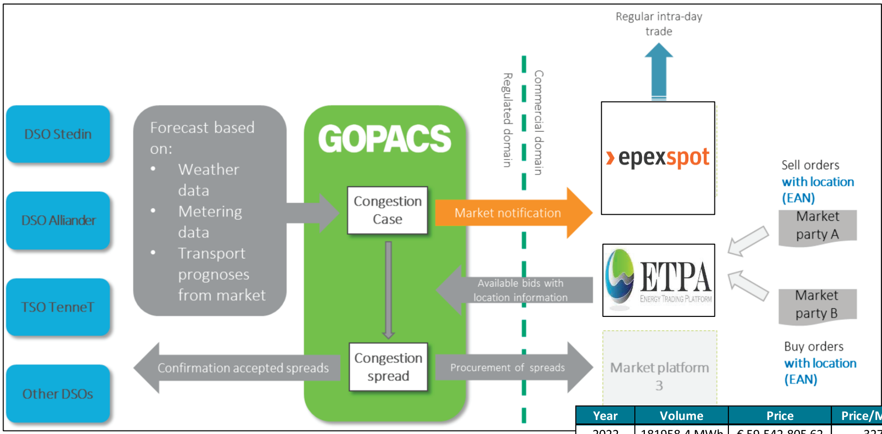
need, and a 2023 white paper from the European association EDSO has confirmed it as a crucial action point for DSO's [15].
- A precise and unambiguous definition of congestion is necessary. Currently there's ongoing discussion with the regulator regarding whether congestion should be defined based on the anticipation of physical overload within specific time intervals (e. g., day ahead or measured intraday periods) or, alternatively, congestion should be defined as occurring when the combined total of operational and pending transport contracts exceeds the available grid capacity. Due to this discussion, DSOs have halted connecting new customers in congested areas.

In 2018, the Dutch TSO Tennet and DSOs collaborated to create the national coordination platform, called GOPACS [16], which procures market-based flexibility to alleviate congestion. The GOPACS platform, operational since September 2019, is jointly owned and operated by all Dutch DSOs and TSO Tennet. The GOPACS platform plays a crucial role in coordinating congestion management in the Dutch energy market. It operates as follows:
- *Coordination Bid Requests*: GOPACS requests participants from the existing intraday market to submit bids for redispatch, whether voluntary or mandatory, through the ETPA and EPEX Spot trading platforms. Connecting with more trading platforms is expected.
- *Locational Information*: Market participants willing to contribute to congestion management add locational information to their bids, allowing the existing intraday trading platforms to forward these bids to GOPACS.
- *Validation*: GOPACS validates that the received bids do not cause system imbalances or create congestion elsewhere before selecting and activating them.
- *Spread Creation*: GOPACS creates a spread between unmatched buy and sell bids from the intraday market. This spread helps mitigate anticipated congestion, resulting in transactions on the trading platforms at a price that equals the difference between the buy and sell bids.

At the time of writing, flexibility is offered from 809 connections in the Netherlands, resulting in traded redispatch volumes of 36,552 MWh in 2019, which increased to 181,958 MWh in 2022 (see Figure 26.7). This demonstrates the platform's effectiveness in managing congestion through seamless integration with the intraday markets.

26.10 Energy Data Exchange: Learnings and Insights

Regarding energy data exchange, or Energy Data Spaces as referred to in Europe, there are four insights and learnings to consider:



Year	Volume	Price	Price/MWh
2022	181958.4 MWh	€ 59.542.805,62	327
2021	144035.6 MWh	€ 45.221.897,61	314
2020	53965.5 MWh	€ 6.165.575,43	114
2019	36552.1 MWh	€ 4.464.483,75	122

Figure 26.7: TSO/DSO GOPACS platform.

– *Governance First*: Prioritize and engage stakeholders in establishing governance when implementing a data exchange layer or data space before delving into the detailed use cases for data exchange. Start with agreeing on principles, have dialogues with stakeholders, build trust and agree on the governance set up.
– *Data's Value*: Data holds significant value akin to currency. Ensure equitable access to data that fosters a level playing field in society and the marketplace.
– *Cross-sectoral Relevance*: Anticipate a broader applicability of energy data beyond the energy sector. Energy data can also hold relevance for sectors such as social housing, construction, transportation, finance, and the public sector.
– *Dedicated Data Exchange Layer*: It's important to establish a distinct Data Exchange layer that connects data requesters to data sources (see Figure 26.8). This layer can incorporate reusable services, including IAA (Identification, Authentication, and Authorization), and, if applicable, invoicing services through e-commerce couplings with the financial sector.

These insights emphasize the importance of data access, inter-sectoral cooperation, technical infrastructure, and governance when shaping effective data exchange mechanisms.

In 2018 it became apparent that the energy transition would require data exchange between more parties within the energy sector, and with other sectors, such as transport, buildings, and the financial sector. A national initiative was launched and resulted in the legal entity Beheerder Afspraken Stelsel BAS (the data exchange framework administrator) and the association Market Facilitation Formum (MFF) which followed up/replaced an existing energy sector specific organization on energy data exchange [17].

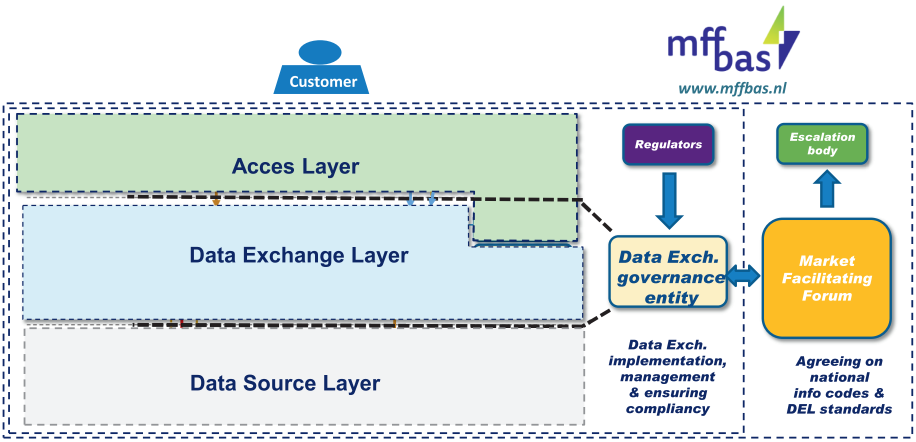


Figure 26.8: Dutch Energy Data Exchange implementation (2022).

Both became operational in April 2022. BAS is a separate and independent legal entity with the Dutch TSOs and DSOs as its shareholders. BAS is expected to handle all energy data exchanges, between data requesters and data sources, either based on a legal obligation or customers consent (exchange of anonymized and aggregated data is outside the scope of MFF and BAS).

In the MFF meetings all relevant energy and cross-sectoral stakeholders, who require access to energy-related data, meet and agree on standard data formats and data exchange processes that should be used. Once agreed, BAS implements these solutions, and monitor and report on their correct usage. The role & responsibilities of BAS and MFF are anchored in the upcoming new Dutch energy act.

Use cases for data exchanges are being actively developed and include use cases related to congestion management, smart charging EVs, and supporting social housing associations to renovate the homes of their tenants for improving their energy efficiency, being a national target for 2028.

To date MFF in the Netherlands has 78 members representing, next to the energy stakeholders, installation companies, social housing corporations, Energy Communities, EV sector, price comparisons companies, the Dutch rail infra company, R&D institutions, and organizations representing industrial customers.

26.11 Energy Sharing: Learnings and Insights (ongoing)

Energy sharing or collective self-consumption is a concept where individuals collectively use self-generated electricity. Though it was initially defined in the 2nd European

Renewable Energy Directive 2019/944 (RED II), its prominence grew in early 2023 with the publication of Electricity Market Design (EMD) proposals [2]. This concept aligns with the EU's focus on empowering customers and places them at the core of the energy transition.

Energy sharing or collective self-consumption [18] holds a promise for a future energy system that is more inclusive, sustainable, and adaptable to changing energy dynamics. It represents a transformative shift in market design, moving operating models from "energy supply" to "facilitating energy transactions between producers and consumers," across all timeframes.

Current discussions in Europe focus on a common taxonomy, the perimeter of energy communities, local markets, local prices, and their relation to the existing wholesale market.

Various models of energy sharing are emerging, including a hybrid energy sharing/supply model (see Figure 26.9). In this model, energy sharing between an energy producer and consumer is achieved by facilitating the agreed energy transaction, taking into account factors such as price and day profile. This transaction is complemented by engagement with the energy wholesale market for selling and buying energy surplus and deficit, respectively. The entity operating within this model holds a supplier license and bears full responsibility as a balance responsible party (BRP). In the Netherlands, there are currently three energy communities, with citizens and other energy communities as shareholders, which operate this model.

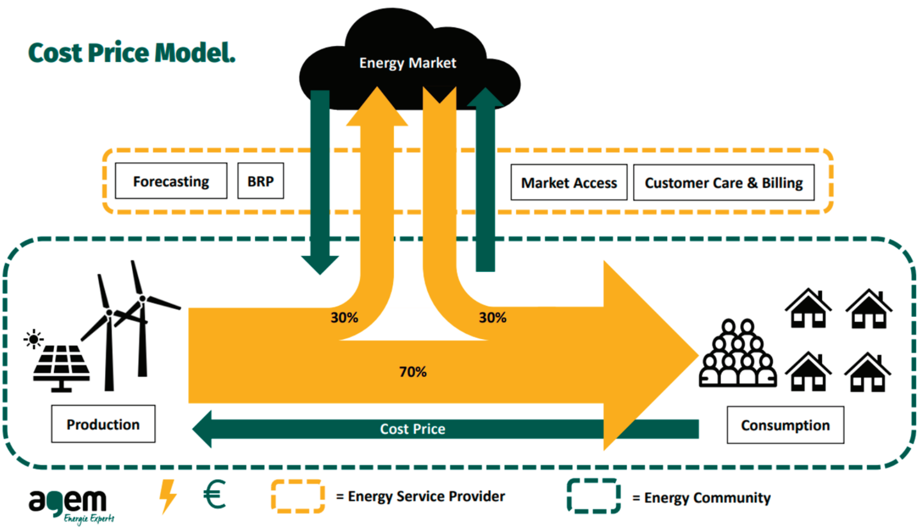


Figure 26.9: Hybrid Energy Sharing/Supply model.

Another model, suitable, for example, for citizens residing in a multi-tenant building, involves energy sharing through a collective installation. In this setup, citizens share energy generated collectively, while maintaining their individual contracts with their chosen energy suppliers, each holding BRP responsibility. This model accommodates multiple actors operating simultaneously over a single connection. To ensure accurate allocation of metering data to each participant, system operators must process the metering data in a way that correctly allocates energy usage to each respective actor. This can be done without having to install an additional smart meter.

Energy communities, (currently around 700 in the Netherlands and 9000 in Europe), are actively implementing energy sharing. In the Netherlands, the branch association of energy communities (EnergieSamen) launched at the beginning of 2023 the national program Local4Local [19], in which different models are piloted. An amendment article related to energy sharing is anticipated in the upcoming revision of the Dutch Energy Act.

Insights gained from energy sharing activities reveal that the application of the principle "use local what you produce local" can offer three significant benefits:

– *For citizens*: It results in more affordable energy (at cost price +), as it protects against high market prices (e. g., triggered by the Ukraine-Russian conflict); it fosters social commitment, and strengthens community bonds.
– *For system operators*: It eases stress on distribution system operators (DSOs), as it has the potential to reduce grid congestion (when demand and supply are locally balanced), to lower capital expenditures (CAPEX), consequently also leading to a reduced increase in grid tariffs, and to reduce workforce challenges, linked to grid expansion projects.
– *For the government*: Energy sharing accelerates an affordable transition as citizens become co-investors in the energy system. This fosters increased integration of renewable energy generation through solar and wind, while reducing reliance on fossil fuels. Importantly, energy sharing helps ensure that the pursuit of national 2030 targets is not or less impeded by grid congestion.

Energy sharing necessitates the development of novel digital platforms to support diverse operational models. These platforms must offer functions encompassing membership management, customer support, billing, forecasting, energy nomination, wholesale market trading, and portfolio management (including managing flexibility in production, consumption, and storage). Additionally, these platforms should enable interaction with system operators for tasks such as metering, allocation, and imbalance settlement.

The current unresolved issue pertains to whether the entity offering these platform-based "transaction facilitating services" should be formally recognized as a distinct market role within the energy sector or not. Certain parts of the required IT platform services could also be viewed as an extension of the existing market facilitation portfolio provided by system operators. Also, the provider of these services could potentially be positioned solely as an IT services provider, offering support to various actors within the energy system. This approach could open opportunities for the ICT sector to enter the energy sector.

Given the goal of maximizing value for all citizens as members within an energy community, the prospect of enhancing the current market facilitation services provided by system operators seems enticing: regulated system operators are not focused on maximizing profits, which introduces an intriguing dimension to this option.

Energy sharing will have a significant impact on the current market facilitation services provided by DSOs and TSOs. As energy communities become recognized as new market participants and novel operational models centered around energy sharing emerge, DSOs and TSOs will need to expand their market facilitation offerings to accommodate energy sharing. Simultaneously, they must ensure the continued reliability of the existing system. This entails clear and unambiguous allocation of energy flows to balance responsible parties. Additionally, system operators must adapt to processing metering data, certified and originating from various sources at the grid edge, beyond the smart meter.

Contemplating this, leads to new insights on metering data:

- Currently, metering data from a metering point is directly transmitted to processes at the value chain's end (potentially stored temporarily in the advanced metering infrastructure (AMI) Head End): Allocated metering data corresponds 1-to-1 to metering data from a single metering point (MP).
- When multiple actors are simultaneously active on a single connection, it becomes vital to distinguish between measured data, also originating from multiple (sub)meters, from allocation data, representing the energy assigned to a market participant (see Figure 26.10). DSOs are responsible for accurately processing metering data collected from one or more metering points across one or more connections, unambiguously into allocation data linked to energy market actors.

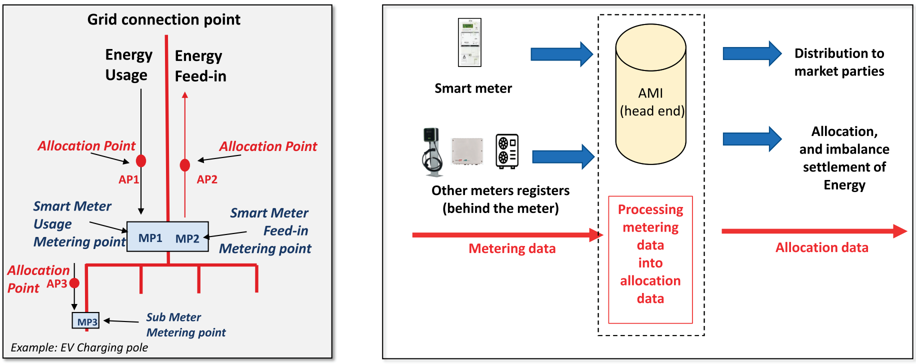


Figure 26.10: Metering & Allocation Data.

The EU regulation 2019/943s update on Electricity Market Design (EMD) [2] introduces the incorporation of certified submeter data, such as from PV inverters, EV charging stations, or heat pumps. Upon adoption, this development will accelerate the need to establish a clear distinction between metering data and allocation data. Once achieved, it has the potential to unlock a wide range of new market possibilities, laying the foundation for data-driven market models.

26.12 Conclusion

This chapter discussed the convergence of the energy transition and the digital transformation, creating a "perfect storm." It encourages readers to reflect on this intersection and apply it to their own endeavors.

A prevailing conclusion is that we are merely at the outset of this storm. In this chapter, numerous insights and lessons contribute to the imperative need to invest in establishing a common understanding of what a digitalized sustainable energy system truly entails. Markets, technology, and regulations share a commonality – they are all products of humans. By investing in a broader and deeper shared knowledge base and fostering extensive knowledge sharing, we can accelerate the creation of the digital energy system of the future.

Considering the latest United Nations (UN) and Intergovernmental Panel on Climate Change (IPCC) reports, it's evident that swift action is required to fulfil our responsibility of transitioning to a sustainable society, not just for ourselves but for the well-being of future generations. Therefore, as an overarching conclusion, our primary focus should be on people: enabling seamless cooperation and managing successful change.

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Short Vitae

Peter Hermans. As a thought leader and opinion expert in the European energy sector, my focus is on Technology, Markets, and Regulation. I have a strong background in digitalization (IT) and Telecoms, with a track record of initiating and driving strategic business programs at the C-level in the Dutch Energy Sector to success. I am also a member of several European Advisory Boards.
Please note that the views expressed in this chapter represent my personal opinion; any reactions or discussions are welcome.