2.1 Report on asset categories.

Showcasing the potential of market and weather dependent control freedom

Inhoud

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1 Introduction

In this chapter four types of assets are discussed with a high replication potential among a broad range of industrial/commercial companies. The selection of these assets is based on customer data available trough Oktow and discussions from Oktow with selected clients during site visits. This selection is no limitative list, but a starting point focussing on type assets with high replication potential.

Different communication channels have been used to communicate the potential of flex to the target audience. Specific presentations have been made and presented to Oktow customers as discussion basis. This has led to many additional insights in potential customer behaviour and implementation challenges and opportunities. Several insights have been communicated to wider audiences trough Linkedin, Flux 50, Solar Solutions International. Also, participation in working groups of other projects such as Vernetflex (TETRA) has led to information exchange with other actors.

2 Type assets

2.1 Heat pumps

A standard 'flexible asset' are heat pumps for HVAC applications. Many companies are integrating them into their HVAC system for comfort heating and product storage. They are often applied in a hybrid system, consisting of gas and electricity. Market observations and client analysis however show that efficient implementation of heat pumps is not always straightforward. Okow often observes underperforming heat pumps due to implementation errors or overly conservative limits calculations and dimensioning.

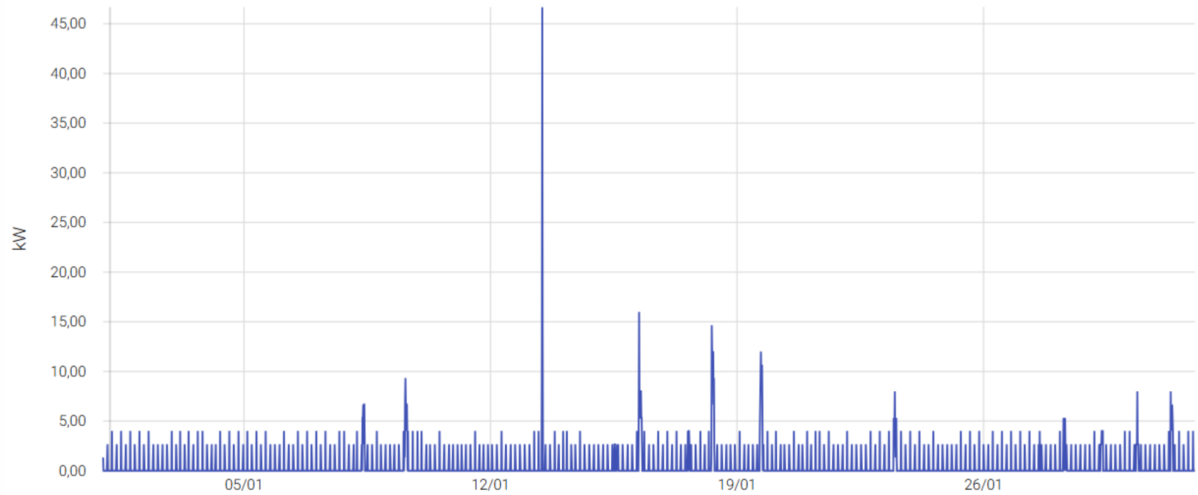


Figure 1: heat pump power demand - januari 2025

2.1.1 Hybrid installations

The power graph shows the electrical demand of a heat pump in January, designed for space heating. However, as the target temperature in the heating system is designed for gas heating at 65°C, the heat pump starts but can never contribute to actual heat delivery. This system would be an ideal candidate for price arbitration between electricity an gas (see below), but this would require reprogramming of the Building Management System (BMS). This however would add an additional level of design complexity, incorporating gas and electricity pricing, and dynamic operation of system setpoints based on actual building needs.

2.1.2 Over capacity design

Systems are designed for worst case scenarios, often leading to extra capacity in the majority of environmental conditions. As shown in the measurements below, a 110 kW heat pump can draw 110 kW during the brief startup phase. Once in actual continuous operation, power is limited to less than half the capacity. The first 'smart' control would be to limit the power draw during working hours of the production department, limiting the peak power demand. As will be discussed further, this requires a lot of work to implement as each type of heat pump has different communication capabilities. As long as this requires a lot of system specific knowledge, this is a simple but expensive option to implement. Customer involvement is crucial to free budgets to fix a working system. This is often not well understood and received by customers. Therefore a clear value proposition is required. This is also relatively new to the suppliers as it requires a lot of knowledge to ensure that implementation in the field is possible within the budgeted timeframe.

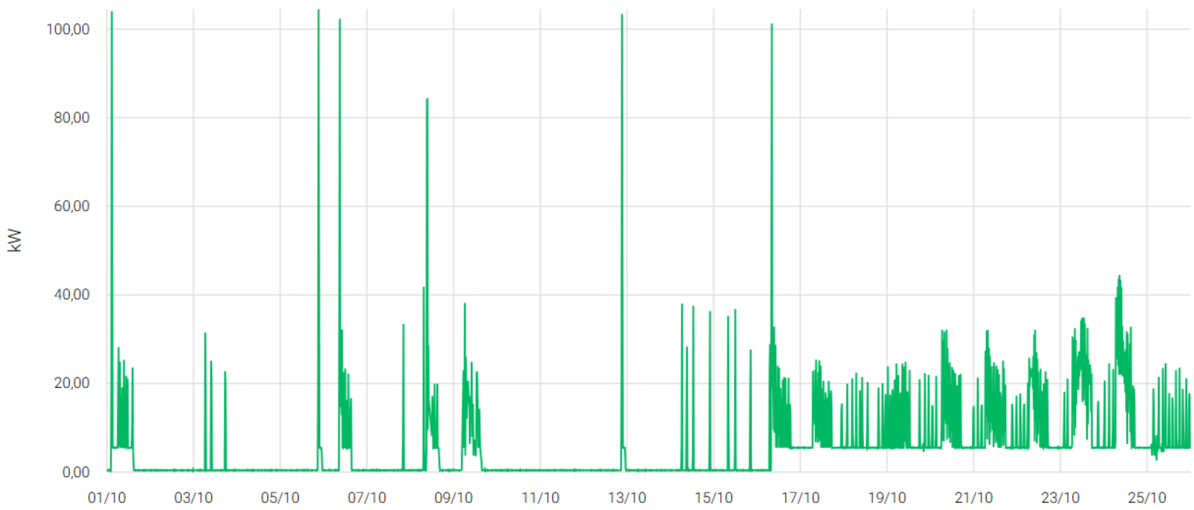
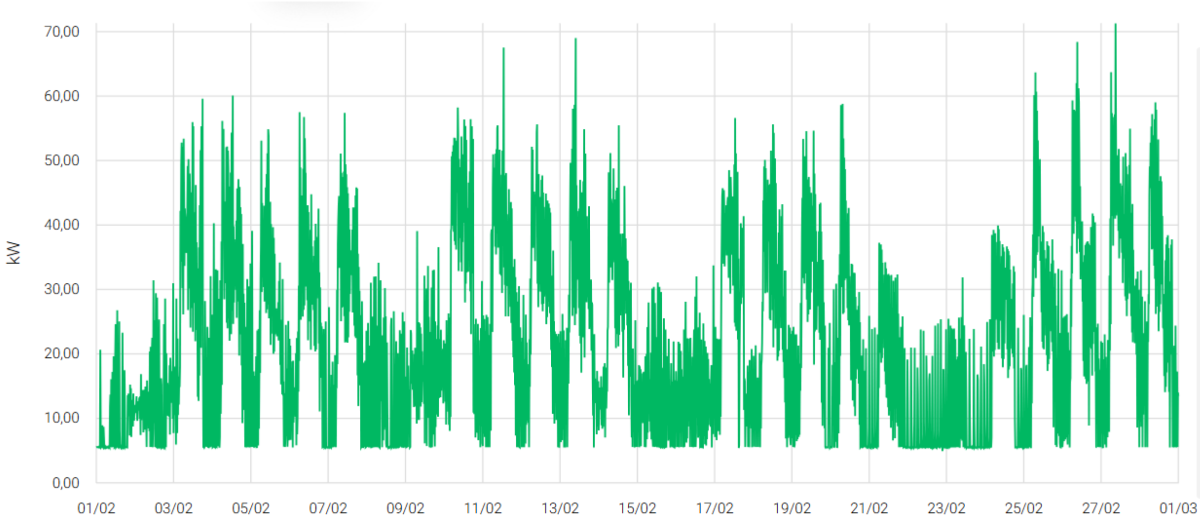


Figure 2: heat pump electrical energy demand, October 2025

The extra capacity could be used as a flexible resource, utilising the buildings thermal inertia. Especially in modern well insulated buildings, thermal inertia is significant compared to flex requirements in the electricity market timeframes. An extra step could be the addition of a thermal buffer to further decouple thermal and electrical power.



Even during peak heating demand, the heat pump often remained well below rated power levels, opening the potential for demand response based on energy markets.

Limiting these applications are the lack of insights by clients in the dynamic behaviour of building systems. Also engineering companies report clients consider ‘an operational system’ as trivial and won’t budget for advanced controls during construction and commissioning phase. This often requires an extended retrofit of already build installations in order to enable systems to exploit flexibility. This retrofit ranges from additional (network) cabling, additional sensors and measuring points and building physics analysis. Especially on existing buildings, it can be hard to obtain building models as many are only available on paper in archives by the clients. BIM models are often not shared with the end client (if already applicable), and become hard to obtain years after delivery of the building. This increases the challenge of modelling building demand and flexibility.

2.2 Building cooling

Building (comfort) cooling should be considered a separate application as the seasonality is opposite of heat pumps for building heating. Cooling could be both comfort cooling in office buildings, but also product cooling and storage. Both categories have broad and spreading applications throughout industry. The important factor here is the weather dependency of space cooling. This increases the potential synergy with PV production on the same site, but also increases the market potential of low price signals. Potato storage is a traditional first application of market and PV production based cooling in West-Flanders. The large thermal inertia of product storage creates potential large control freedom.

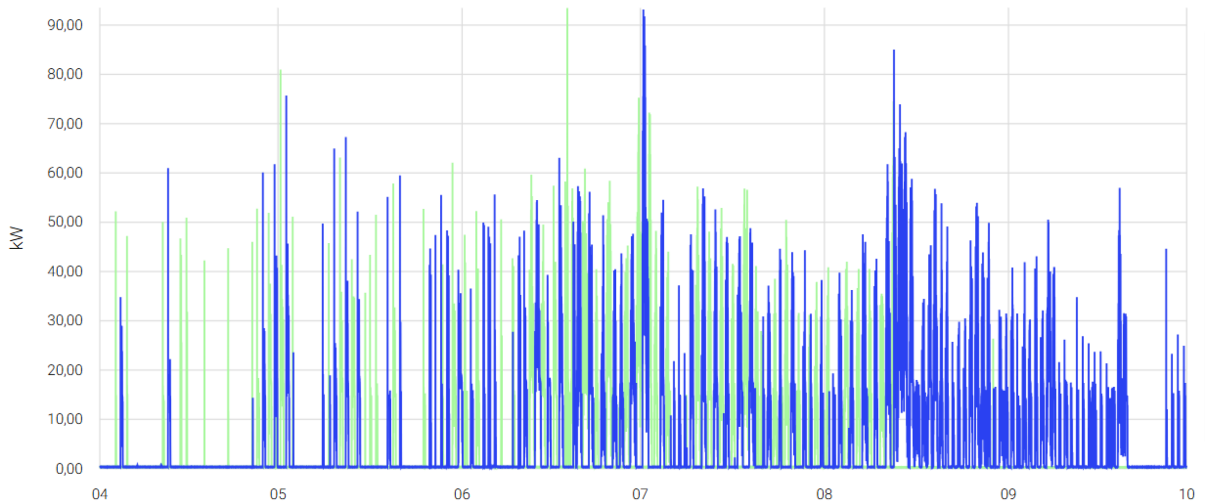


Figure 3: cooling machines power case 04 - 2025

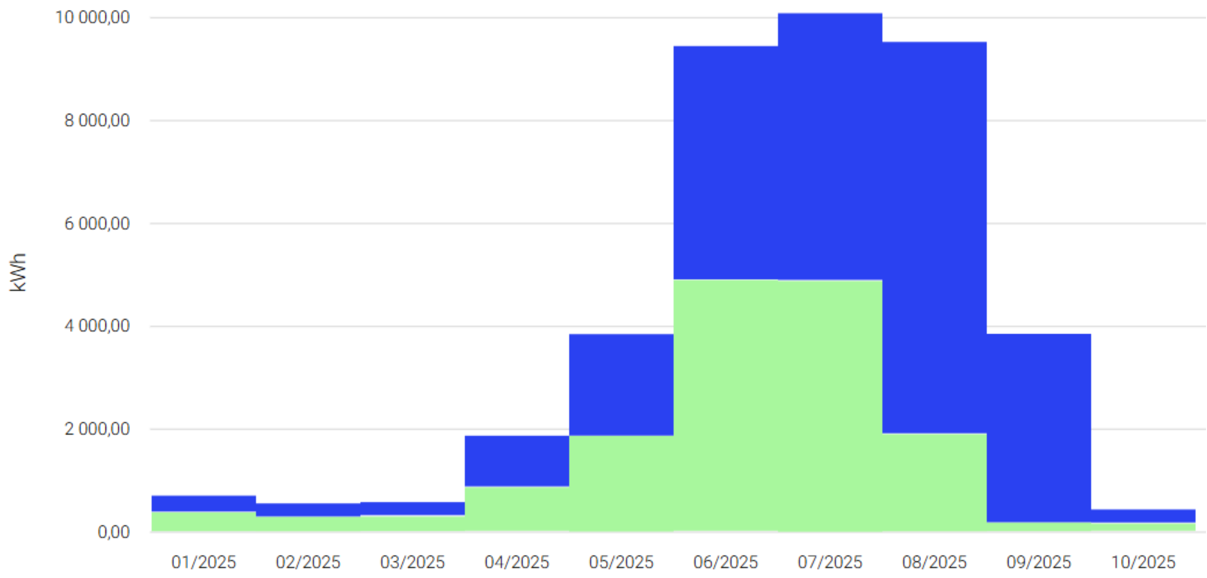


Figure 4: cooling machines energy demand, case 04, 2025

These graphs show the power and energy demand from two typical building cooling installations. As expected these show a seasonal dependence and are hence prime candidates for PV control. As observed with Case 04, these installations are often not yet equipped for advanced control.

In spring 2025, case 04 has been selected as a prime candidate for optimisation and advancement to work package 3. However, first steps to be taken are digital connectivity of these cooling machines and extra monitoring on the cold distribution system. Both cooling machines were only controlled on/off by a open relay contact. Installing cabling to enable fine grained and direct setpoint control required physical connection of these installations with the network. Also, in relation to WP1 and WP4, it has been determined that a more detailed data set of the cooling distribution would be beneficial to system operations. Currently, an offer is made to this client to install this additional measurements, allowing real time monitoring of cooling demand in both power and temperatures. This will enable more advanced control of the cooling system during sunny hours, allowing the system to predict actual cooling demands and precool or delay cooling within operational limits set by the operators.

2.3 Car charging

Similar to building heating and cooling, car charging is also a widespread application with a significant potential for demand response across industries. As observed during the last three years with a multitude of Oktow clients, adoption rate of electric vehicles could be fast. Charging equipment (Electric Vehicle Supply Equipment, EVSE)

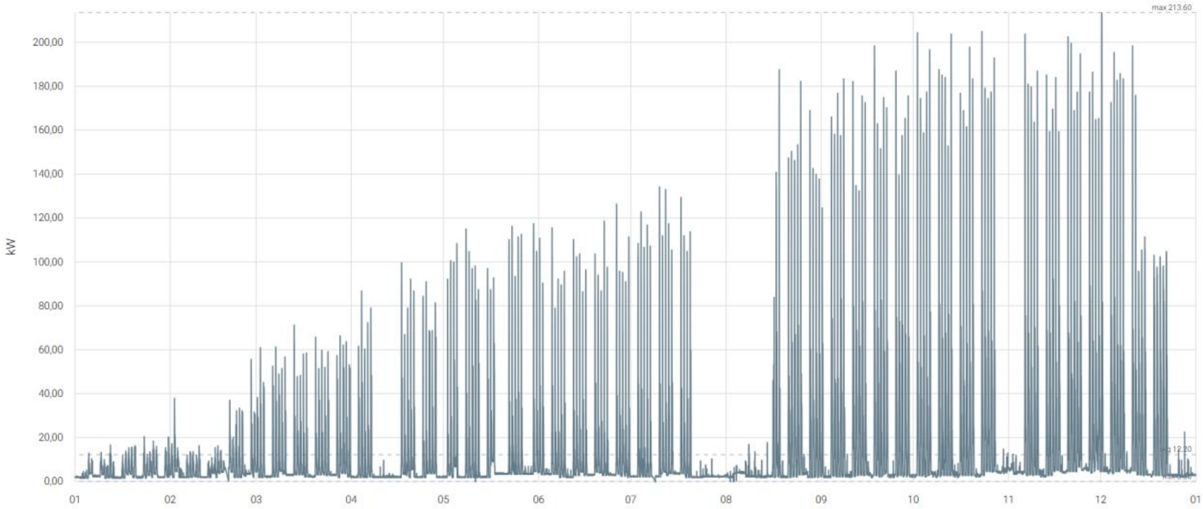


Figure 5: energy charged by company cars, medium sized building engineering company - 2023

Impact on total site energy consumption and peak power has been observed as often significant, even in larger industrial sites.

A large industrial site with peak power of 2.5 MW has equiped 4 parkings with charging equipment. Total charging peak power is observed to reach more than 600 kW, consisting of 20% of total peak power, despite being controlled by a simple load management system.

2.3.1 Basic power limitation

The major 'flex' application observed by Oktow with its customers is currently power limitations of EVSE. Many industrial automation suppliers have products in the market to control peak power of (groups of) EVSE. The direct financial benefits are infrastructure sizing and contract power.

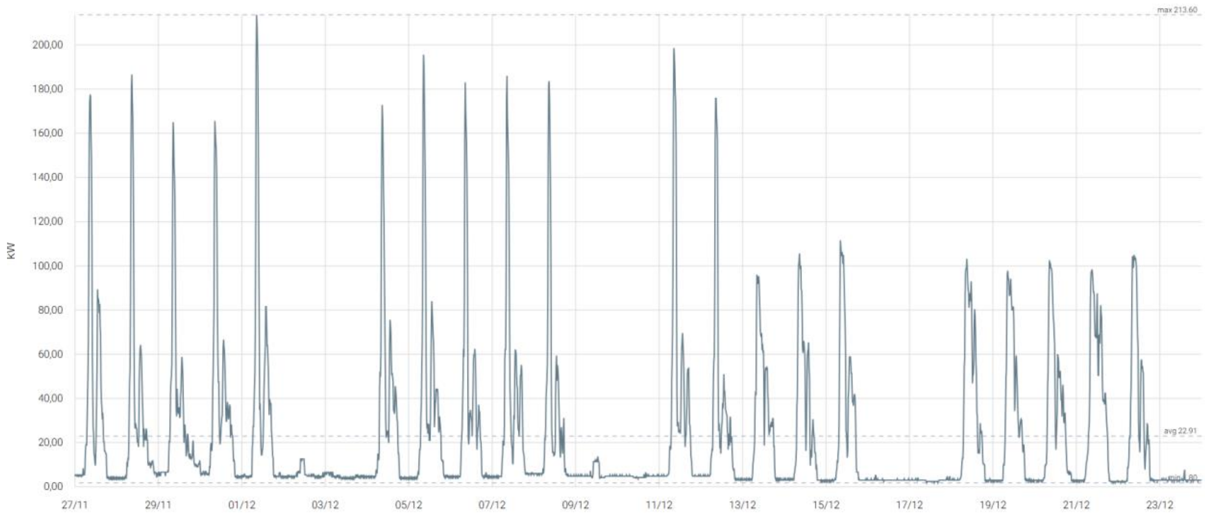


Figure 6: Peak power reduction on EVSE

The most simple control system is often provided by the EVSE manufacturer. This mainly consists of a power meter on the main connection and digital control of the EVSE in order to limit the peak power of the total site by controlling EVSE power. These systems tend to be rather simple in functionality, but are suited for small applications as integration is relatively simple.

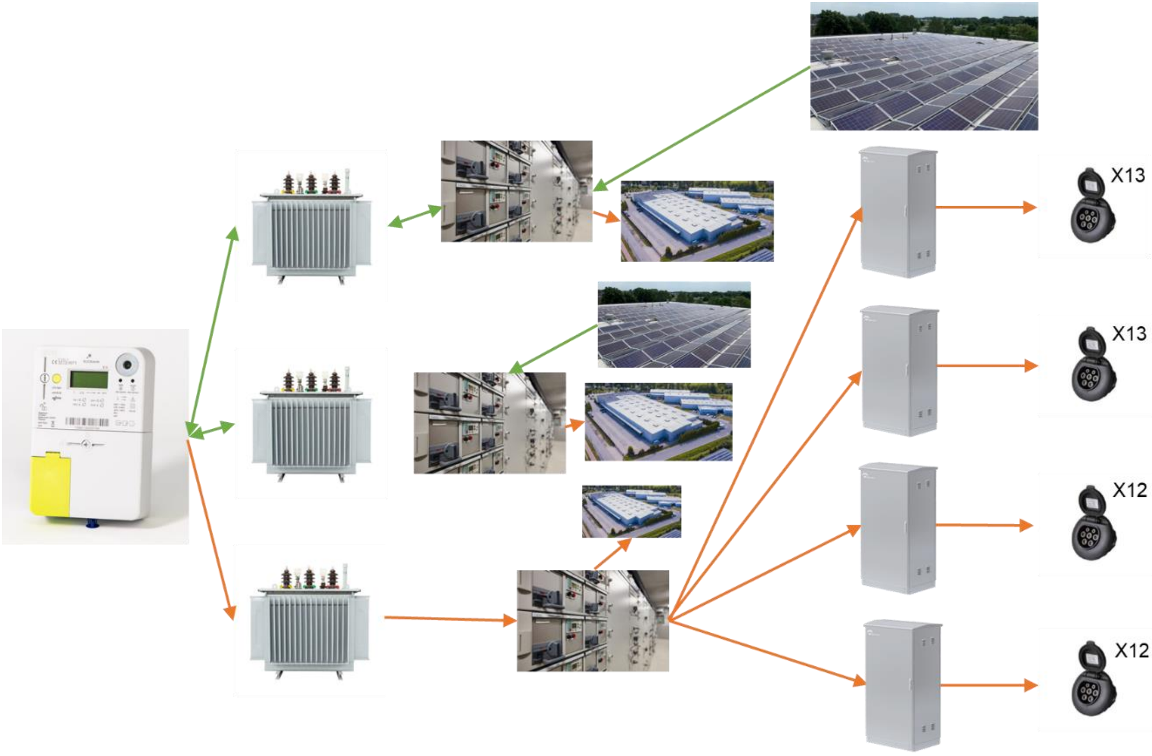


Figure 7: complex EVSE integration

Oktow monitors and (partially) implemented a couple of different more complex systems. When the main site connection and EVSE equipment are more spread throughout the site, with several layers of potential choke points such as distribution cabinets, multiple transformers, PV production on different coupling points, … A simple control solution as often provided by EVSE manufacturers doesn't suffice. Multiple large manufacturers of automation equipment and even SME's offer such products: Schneider, ABB, Siemens, … Observation with existing clients and first hand testing and implementation of several commercial applications by Oktow shows these products are working within a limited scope. Many operational limitations exist, mainly on compatibility and stability issues. Most suppliers have a limited list of integrated products, making the right choice complex for end consumers.

Also, in complex systems a small error could result in high costs if systems fail at the wrong time in the wrong mode. Especially IT related stability issues have been observed, where systems fail due to network failure. Observed field experience showed network intrusion detection systems flooding the IP endpoints on EVSE, bricking the communications until a hard reset. Also, in a complex system, non-fail safe communication to a single meter of non-controllable load resulted in a to high calculation of total available power, resulting in a peak power surge of more than 100 kW above the contracted power. This resulted in a fine of more than € 8000. As multiple parties, owner IT department, EVSE supplier, EMS supplier and system integrator are involved, responsibility determinations are not easy and still ongoing, 8 months after the error.

2.3.2 Energy optimisation

However, more advanced energy optimisations are much less common compared to power management. Energy optimisation would require much more advanced predictions and optimisations of power requirements, energy requirements, PV availability on site, market costs… Several systems are commercially available, however pricing is often complex. As will be further discussed in the section on market control freedom, knowledge with end users on EVSE flex cost allocation is still quite low and spread over multiple responsibilities within one company.

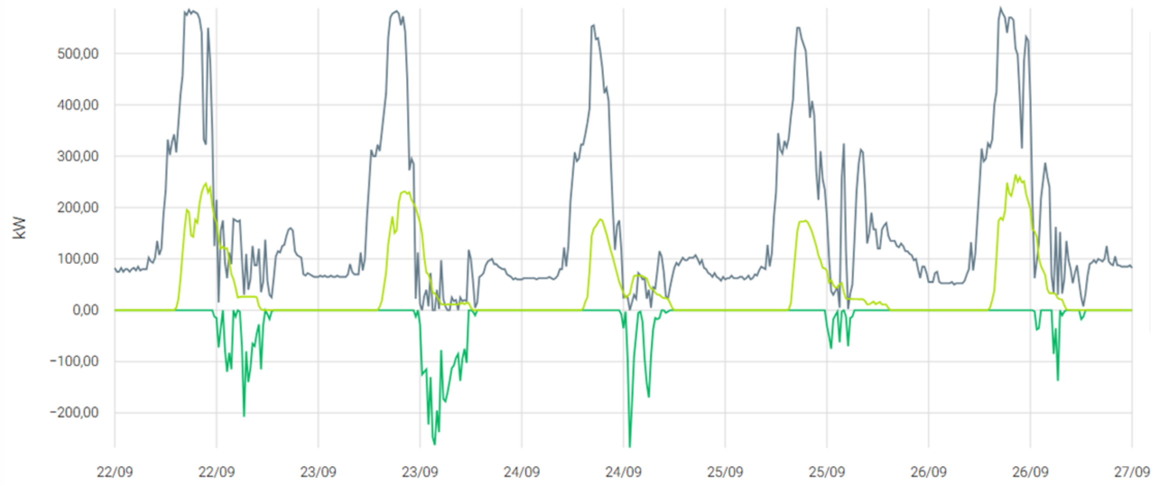


Figure 8: PV and EVSE power (grey: total site power, light green: EVSE power, dark green: PV injection power)

On most observed client sites, EVSE power comes mainly from the grid, as peak charging power is often observed between 8h30 and 10h30, across industries and clients of Oktow. PV injection is mainly concentrated around 14h, resulting in an energy mismatch. A huge potential is observed, but market readiness is low. As this is a relatively new technology, especially on this scale, awareness among end users is low and limiting implementation requests.

2.3.3 Responsibility split

EVSE are often ordered by HR departments. Based on company policy, CAPEX availability is often limited as this is a non-core process for the company. This often results in less EVSE compared to the total number of vehicles to be charged.

Physical installation is often coordinated by the facilities or engineering departments, based on directions of HR. Also equipment (perceived) failures are often handled by these departments. Focus is therefore often on ease of implementation and low CAPEX, neglecting OPEX as this is handled by a different department. Therefore, load management based on peak power could often be warranted by equipment sizing reduction and sometimes limited captar costs.

However, customer interviews displayed that engineering departments often neglect OPEX as this is not their current focus and 'insufficient data' is available to determine the effective requirements. Hence, a simple captar increase is ordered with the legal/financial department as 'charging cars requires a lot of energy'. This has been observed with multiple clients within the first years of EVSE deployment. However, after several billing cycles, it can be observed that departments start to align KPI's and become more interested in OPEX optimisation.

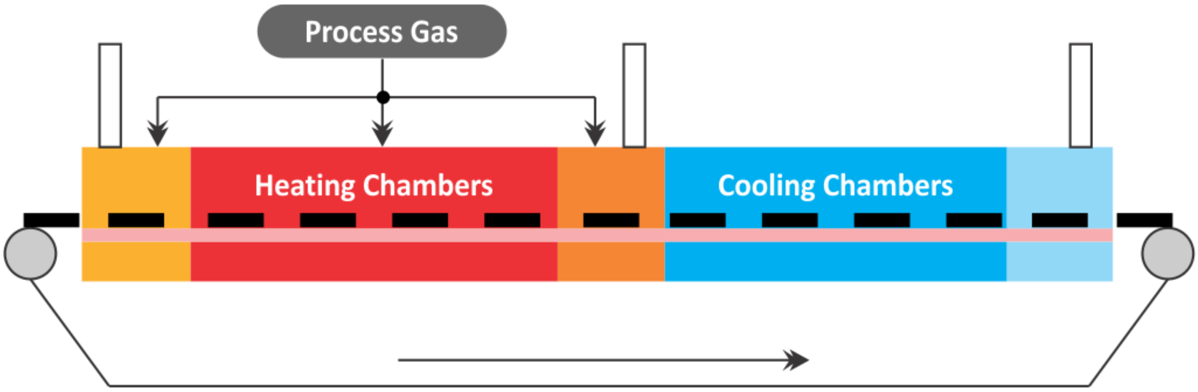
2.3.4 User experience

Most electric cars have an app showing charging status. Active monitoring of the charging process could result in user range anxiety as the car is charging slow during the morning hours, as peak demand or energy costs are high and the charging power is limited. This results in user complaints as the car is not or just slow charging. Especially if charging is temporarily stopped , users get warnings on their phone their car is not charging. This could lead to escalating situations where the EVSE responsible increases the limits or completely disables the load management system to avoid user confusion and complaints.

2.4 Fuel switch – gas to electricity

Multiple assets have been identified which are hybrid fuel: they both contain gas and electric heating elements. These type of assets are either already present, but mainly used as backup, or the electric option could be added if necessary. In this asset category, we mainly talk about direct electric heating, not trough heat pump technology. This category mainly focuses on applications where the required temperature is higher than available trough commercially available heat pump technology. However, this ceiling is increasing and heat pump technology for low pressure steam applications is becoming commercially available/viable.

Direct electric heating is still required for a lot of backing processes in both industry and food. Direct electric heating could be implemented trough different heating elements: Infrared (radiation) heaters or immersion heaters are the most common types of electric heating elements. IR heaters are used for indirect heating applications, e.g. in baking products. These applications are being observed in both metal processing plants (paint muffling kilns) and food processing (bakery) plants. Direct electrical heaters (immersion heaters) are more and more installed in low pressure steam applications.



However, in practice, industrial electricity contracts are hard to obtain as an external partner. Also, both companies have indicated that major investments in energy infrastructure are difficult at this moment as they work currently significantly under capacity. Instaflex hopes on a recovery in 2026 to advance these cases.

3 Market dependent control freedom

3.1 Electricity market dynamics

As has been studied in WP7, the electricity markets in Belgium are under constant reform. Up until September 2025, day ahead prices were established on an hourly basis, but this changed to 15 minute pricing. Also the impact of the Picasso (spring 2025) system of imbalance settlement had a significant impact on market dynamics, lowering the average imbalance prices, but increasing the peaks. In this report, the main focus is on wholesale market pricing and dynamics, as this has the most direct potential to market for individual companies.

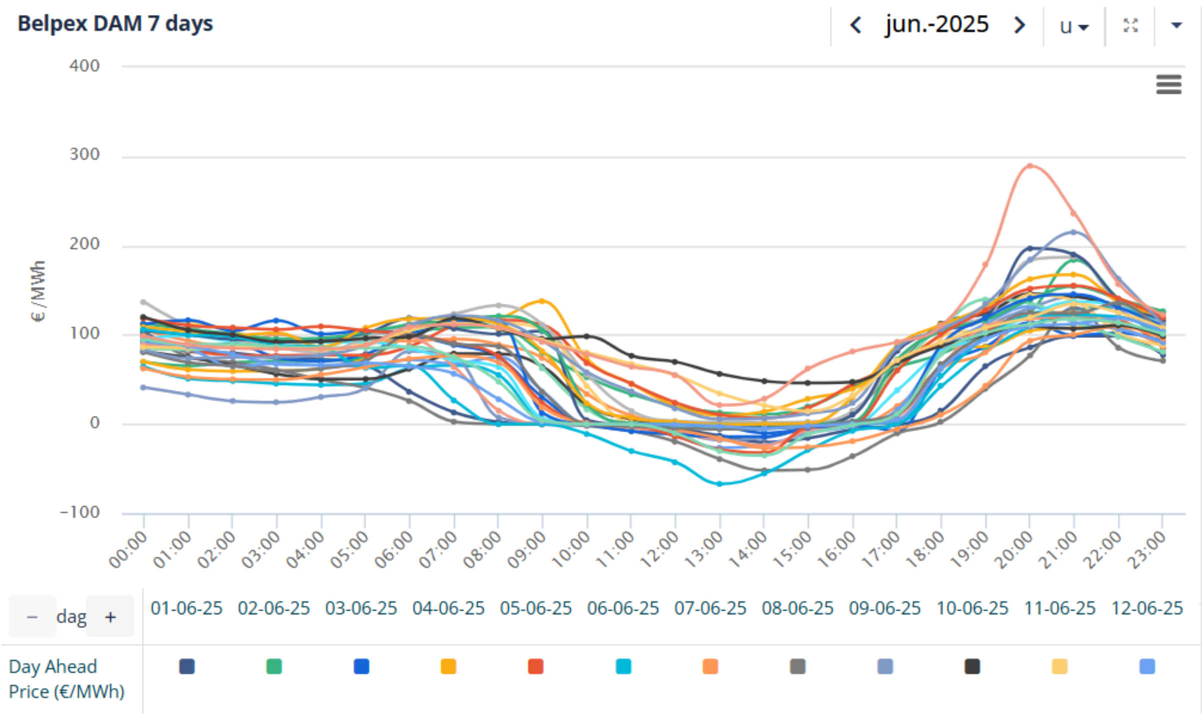


Figure 9: Belpex Dam prices June 2025

A remarkable difference has been observed between June and July 2025: as in May and June, lots of negative prices have been noted, from July onwards, negative wholesale prices have been almost cut completely.

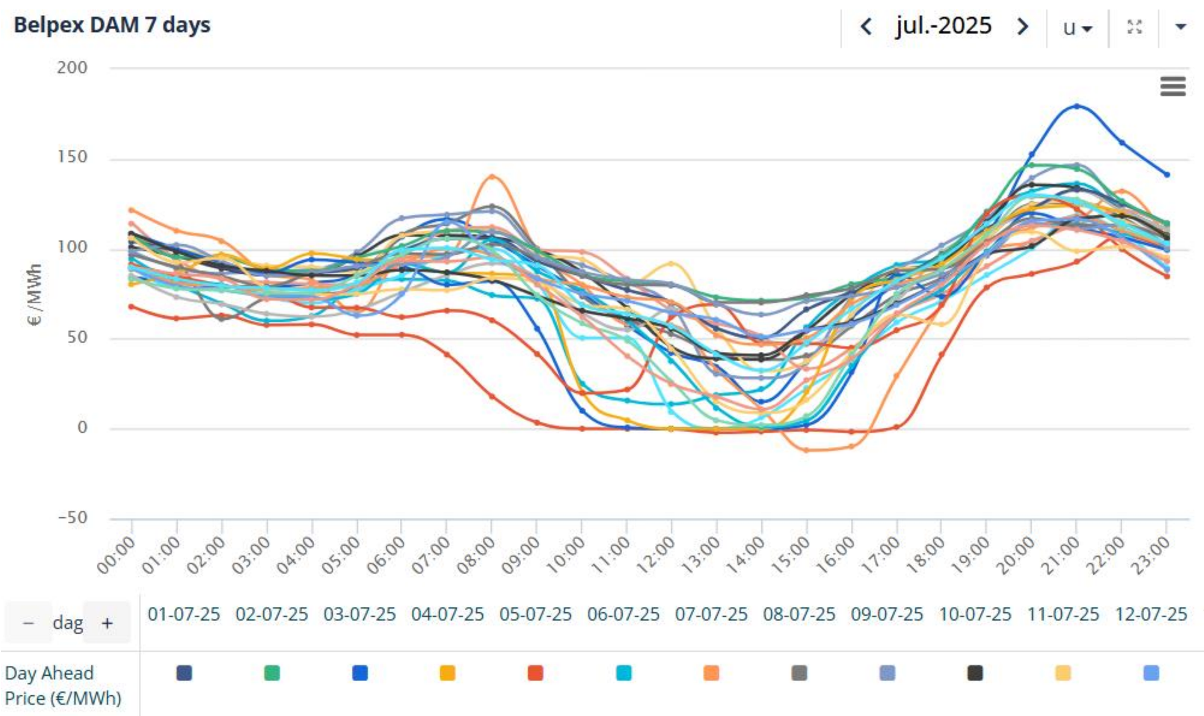


Figure 10: Belpex Dam prices July 2025

Although a record number of negative prices have been registered in 2025, most of these occurred before summer, indicating a significant market dynamics shift. This shift could have a significant impact on flexibility potential of many applications, as grid costs are not being compensated by negative commodity prices anymore.

3.2 Capacity tariff optimisation

Within the Flemish region, a significant impact on the energy bill can be allocated to the capacity tariff. Companies should 'reserve' a certain capacity on their grid connection. This reserved capacity is billed monthly, but fixed for a year. Increases could be made continuously, but reductions can only be made after one year since the last change. This capacity tariff has significantly increased since its inception in 2023.

Kosten per DNB - 1-26kV net	Antwerpen	Halle-Vilvoorde	Kempen	Limburg	Midden-Vl	West	Zenne-Dijle	Imewo
Toegangsvermogen 2025	37,52	41,55	35,97	35,96	39,62	43,61	44,27	42,15
maandpiek 2025	55,11	62,49	50,72	53,14	55,71	59,12	62,12	58,66
Toegangsvermogen 2024	25,70		24,5635080	21,02	23,7990312	33,73		26,32
maandpiek 2024	34,42		30,6857088	27,15	31,6570644	41,35		34,23
Stijging TV 24-25	46%		46%	71%	66%	29%		60%
Stijging MP 24-25	60%		65%	96%	76%	43%		71%

Customer interviews show this is not well known by many companies and hence the commercial reaction seems to be delayed. However, more and more customers are becoming aware of the potential of peak reductions. However, it is perceived that the broad landscape in commercial energy management systems with high promises but limited compatibility lists are creating 'cold feet' with many potential clients and even system integrators. The scattered field in applications with each its own scope and target audience is observed as an implementation bottleneck. Also, the broad range of low level communication channels and protocols requires often a custom implementation, increasing the learning curve.

3.3 Data availability and insights

3.3.1 Energy contract availability and insights

Oktow has a broad range of customers in the commercial and industrial sectors. Energy cost data availability could generally be split between privately owned small businesses and medium and larger companies. In small businesses, the owner has total overview of both energy usage and contracts. Although energy cost is not top of mind for most small businesses, a positive impact can be realised as all data could be obtained trough one person.

In medium and large enterprises however, utility maintenance and operations is split from the financial department. Many facility managers have no direct access to energy contracts. As has been observed by Oktow during consultancy meetings, objectives and knowledge within the companies are often also not aligning. Facilities, often also in charge of utilities, needs to 'keep things working', with as little extra burden as possible.

Energy contracting is often processed by either the financial or legal departments. Especially in large companies, non-disclosure agreements between the company and the energy supplier prohibit sharing contract information with external partners. This creates a big hurdle to obtain relevant information on price structures for energy contracting.

Finance and legal departments in a most companies have little to no energy market knowledge. 'The bill is the bill', and contracts are being negotiated without fully realising internal price drivers such as time of use or peak demand. Most financial departments are not deeply involved in where and when energy is consumed in the company and therefore the cost allocation of energy usage. Detailing and spreading this information to decision makers and aligning objectives between departments is therefore a major task in 'freeing' energy flexibility.

Financial, legal and technical departments should be made aware of price structure drivers determined by internal consumption behaviour and external market incentives. Technical departments should also become more aware of cost implications of energy consumption patterns. Most only have a rough idea of the monthly average cost, but not the impact of behaviour on the cost formation.

3.3.2 Third party assets

A third hurdle could be found in third party financing of (mainly PV) installations. This often results in the injection meter being registered under a different company, requiring additional steps in obtaining this data. PV injection is being observed as being more and more susceptible to market dynamics, indicated by the decreasing 'capture rate', the average price obtained for injected PV compared to the average energy market pricing.

Most companies are reluctant to switch to dynamic prices for consumption. This would open up potential, but incentives are scattered over different departments and would require a major switch in energy consumption behaviour. This would require technical, legal and financial departments to more intensive coordination and cooperation. In most companies, energy is not the priority as energy cost is not the biggest cost and flexibility is often perceived as 'complicating things more'.

3.3.3 Gas pricing

Gas pricing on the contrary, is for most companies based on monthly pricing. These prices are often based on the TTF market:

CONTRACT	LAST	TIME(GMT)	% CHANGE	VOLUME
NOV25	31.280	10/27/2025 1:44 PM	-2.299	40485

CONTRACT LAST TIME(GMT) % CHANGE VOLUME

3.4 Integration cost

3.4.1 Metering and control infrastructure

Integration cost of smart control starts with data availability to establish dynamic operational freedom. Although Oktow currently monitors thousands of metering points, it is often realized that more specific data is required to accurately model demand behaviour.

Next, integrating advanced control requires digital access to core appliances. As has been shown with many potential cases, this would require additional network infrastructure in existing installations, as these are often cut during construction phase in order to save costs. These low level backbone infrastructure is per unit inexpensive, but installation in existing infrastructure during operations often becomes very time consuming.

3.4.2 Digital structure

Oktow has experienced several difficulties with multiple clients on utilising existing network infrastructure to implement basic monitoring and advanced control. Especially when a third party IT manager is involved, getting and maintaining connections to all devices requires a lot of coordination and effort. Obtaining and fixing IP addresses can be very time consuming. As many controllable assets are located within the 'office' infrastructure, the IT network is maintained by IT, not OT. Whereas OT networks are considered as 'must run' critical infrastructure with a ring-like topology and with redundancy in mind, IT often has many critical paths, easily temporarily blocking communications between controller and end devices.

3.4.3 Edge devices

Many companies and communications focus on high level AI and cloud applications. However, this cloud infrastructure needs to communicate with different end devices with different communication capabilities and protocols in the field. In the frame of NIS 2.0, proper IT management requires to reduce the attack surface by limiting the devices connecting directly to the internet. An edge device functions as a secure gateway between the cloud environment and the local devices.

Several systems have been tested, e.g. Edge Controller vs PFC300 vs KontronPi. Also the SmartGridOne from Eniris has been tested. This showed limited capabilities to connect and control legacy systems such as older PV inverters. Testing of implementations of known end devices in a PLC have also failed to setup communication on legacy systems.

3.4.4 Connectivity local – cloud

Oktow and Prophesea have tested several communication systems trough API calls, UDP channels and different controller types. Also different programming environments have been tested to reduce implementation time on specific cases. Both companies are building further on experiences built during the Transfo test project, prior to the Instaflex project.

3.4.5 Fail safe systems

Many parties are involved in demand response applications: owner, system integrator, cloud provider, end device installer… All have to ensure proper handling of edge cases and fault response. What should happen to e.g. an EVSE if connection with the load balancing system is lost? Should the cars stop charging, should they charge at 6A, … What happens if PV is curtailed but cloud connection is lost? Who is responsible for error handling and what is the required response time? If a load management system fails to curtail demand when the sun is covered by clouds due to a reboot of a network switch by the IT department, who is responsible?

4 Conclusions

The 'standard' assets as heat pumps (and cooling) and vehicle charging are still prime candidates with a wide potential of replication. Industrial applications could benefit from direct electric heating during low price points. However, customers are still more likely to prioritize CAPEX over OPEX, as in a rapidly changing market risks are high to implement risky high levels of market based control.

Next to the economic risk, the complexity of low level implementation and risk management is difficult and not standardized, requiring loads of knowledge to successfully implement a reliable optimisation system. The new rules around the BACS systems will require companies to invest in more low level connectivity and metering, creating a viable base infrastructure for more advanced control systems.

Even low hanging fruit such as charging vehicles when the sun shines show slow adoption of flexible energy management as different stakeholders have different KPI’s and priorities. However, due to the significant increase in capacity tariffs in 2025 showing on the bill, discussions are starting to appear. Also the media coverage of negative prices in regard to PV injection costs have created awareness to the dynamic nature of the electricity system. Clients are however still seeing PV curtailment and demand response as separate problems.