



# Battery Energy Storage (BESS)

a possible multitool for energy revolution challenges ?

Congres energietransitie 2023, Thursday 11.05.2023, Vlaardingen – Delta Hotel

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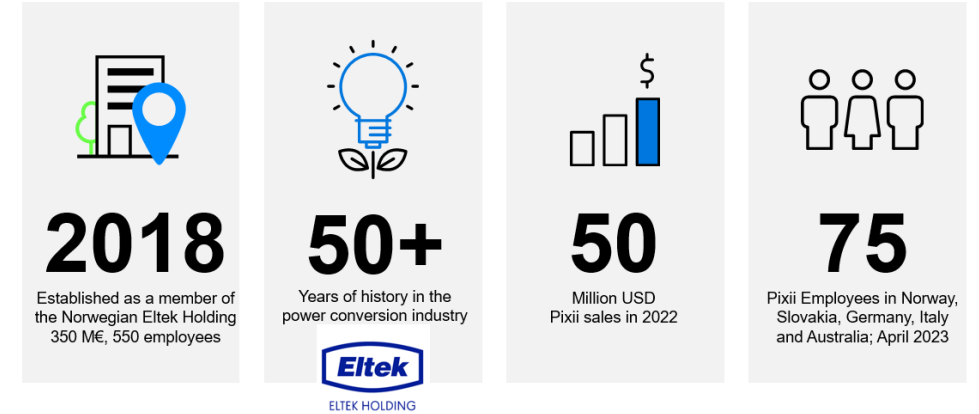




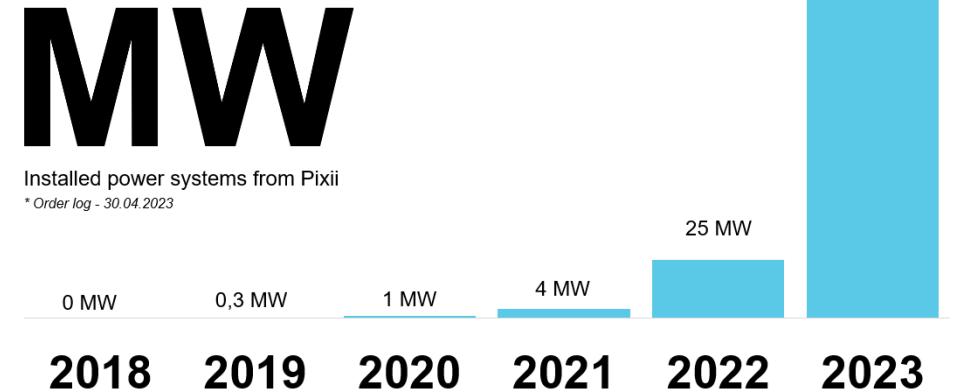
## GLOBAL SETUP



## Facts and figures



## Solid start-up with hyper growth



ABOUT PIXII

# Technology platform – for multiple applications

for capacities 20kW / 20kWh ... 5MW / 30 MWh

PowerShaper2



50kW/50kWh  
40kW/120kWh



PixiiBox 3,33kW



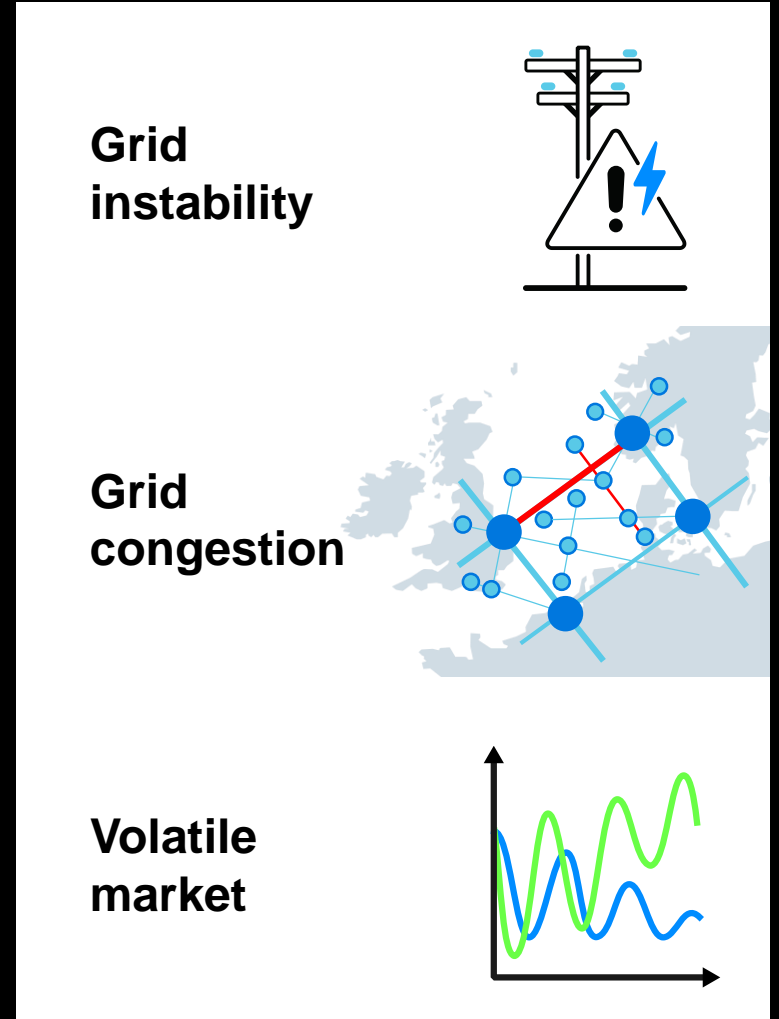
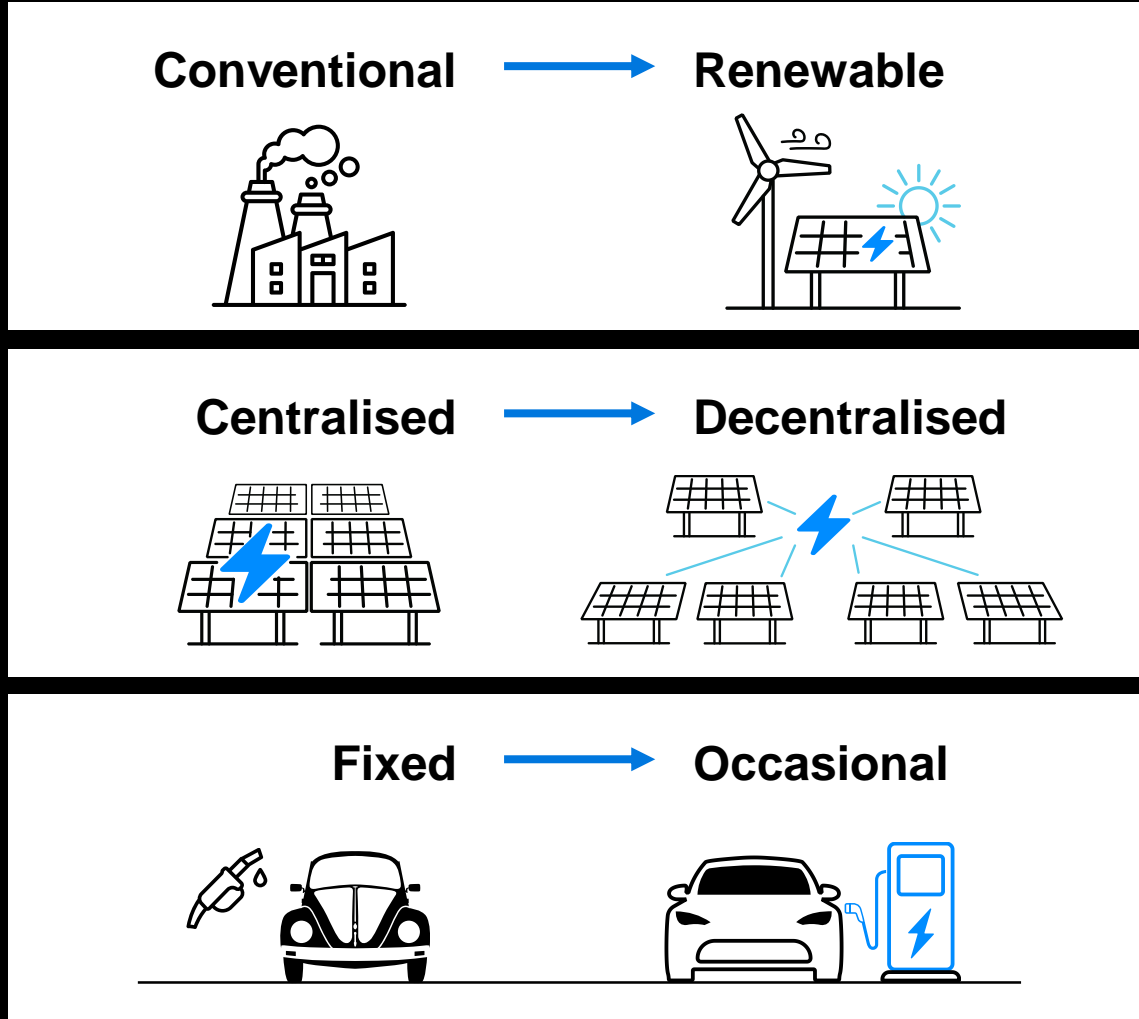
600kW / 600kWh  
480kW/1,44MWh

Pixii Home Q4.2023



10+10kW/20kWh

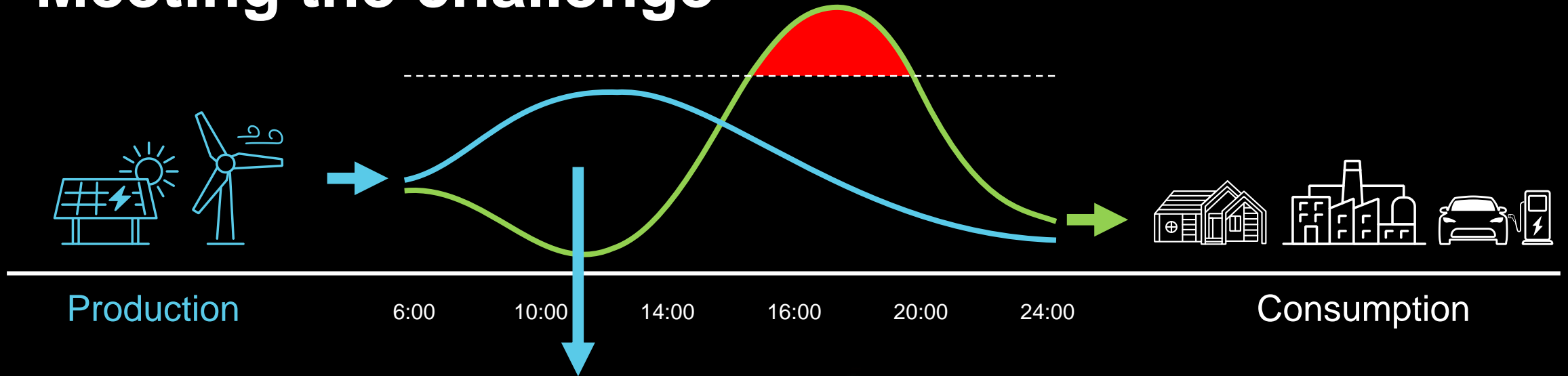
# Decarbonization is causing grid challenges





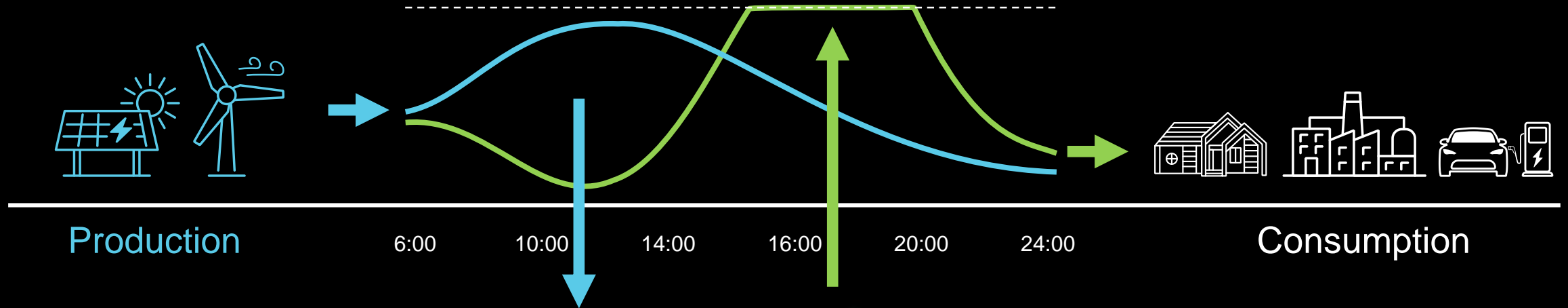
MARKET

# Meeting the challenge



MARKET

# Meeting the challenge



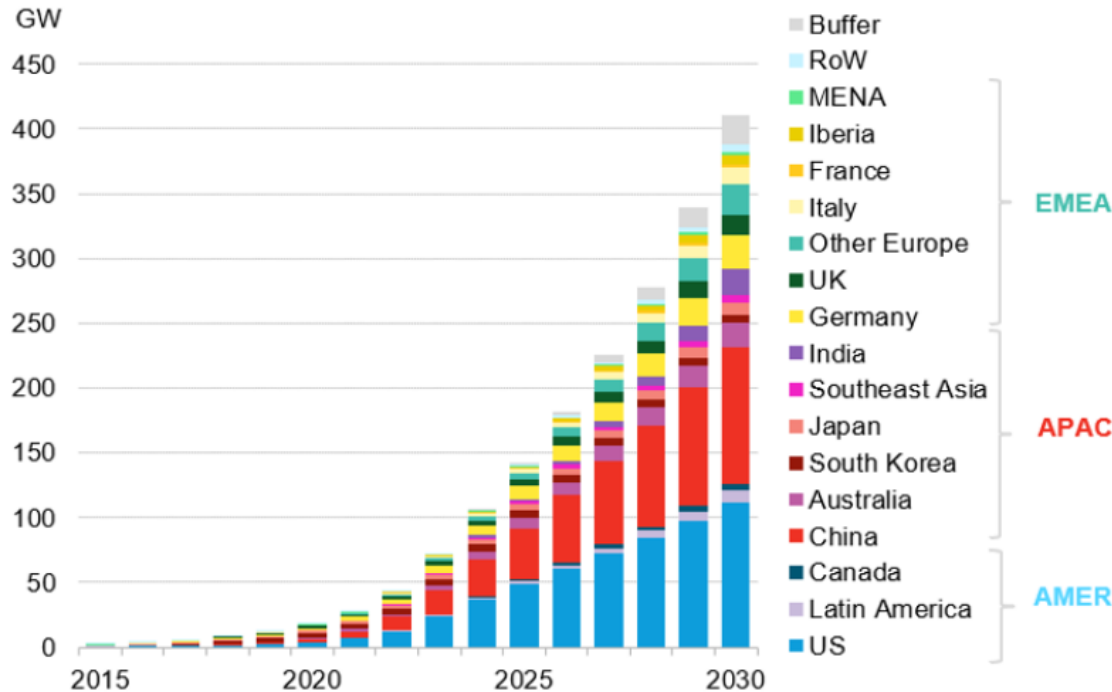


# Global ESS market development

→ The global energy storage market was valued at USD 10.37 billion in 2020, and it is expected to reach USD 37.06 billion by 2027, registering a CAGR of 19.9% during the forecast period of 2022-2027

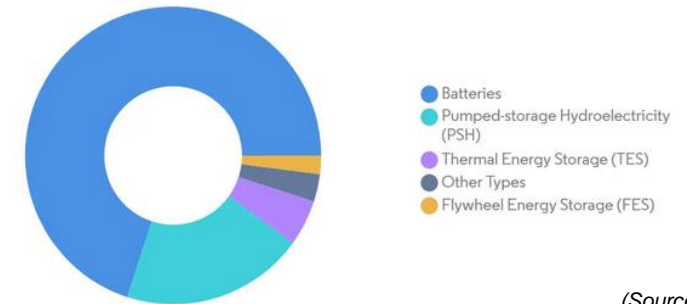
## Global cumulative storage installations, 2015 – 2030

Note: „MENA“ refers to the Middle East and North Africa; RoW refers to the rest of the world; „Buffer“ represents markets and use cases that BNEF is unable to forecast due to lack of visibility



(Source: BloombergNEF, 2022)

## Revenue share (%), by type, global, 2021



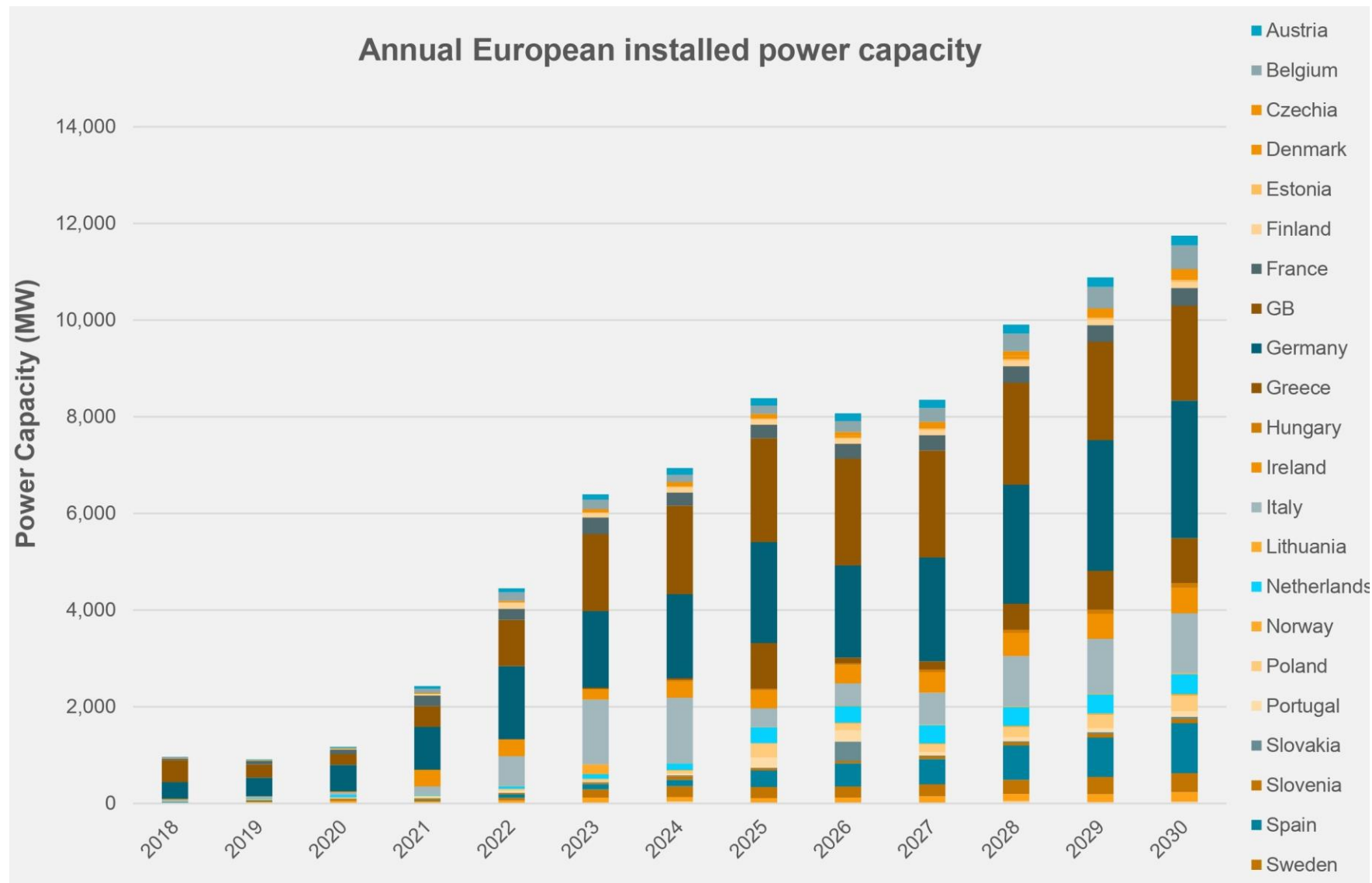
(Source: Mordor Intelligence)

## Energy storage market – Growth rate by region, 2022 - 2027



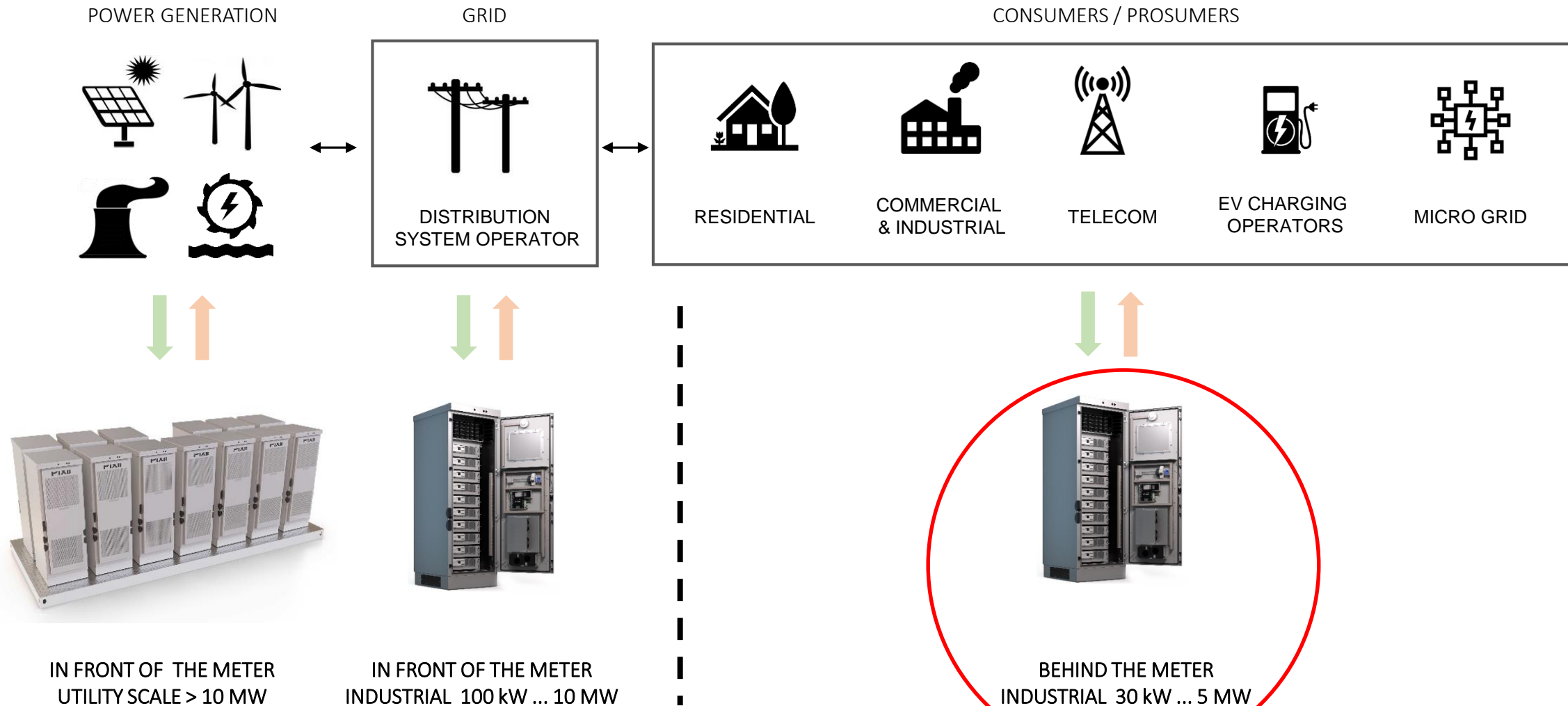
(Source: Mordor Intelligence)

# European BESS market development





# SMART ENERGY STORAGE AT THE «GRID EDGE»



# Functions/applications

## 1. Energy Cost Reduction

<p>DC or AC coupled solar</p>	<p>Arbitrage</p>	<p>PV</p>	<p></p>
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<p>Active power compensation</p>	<p>Reactive power compensation</p>
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<p>Community battery</p>	<p>Active and reactive power compensation</p>
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<p>Gen-set integration</p>	<p>EV Charging</p>
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## 2. Grid Flexibility Services

<p>Flexibility markets</p>	<p>FFR</p>
<p>Voltage support</p>	<p>FCR-D</p>

<p>Phase balancing</p>	<p>Flexibility made simple</p>
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## 3. EV-Charging Infrastructure



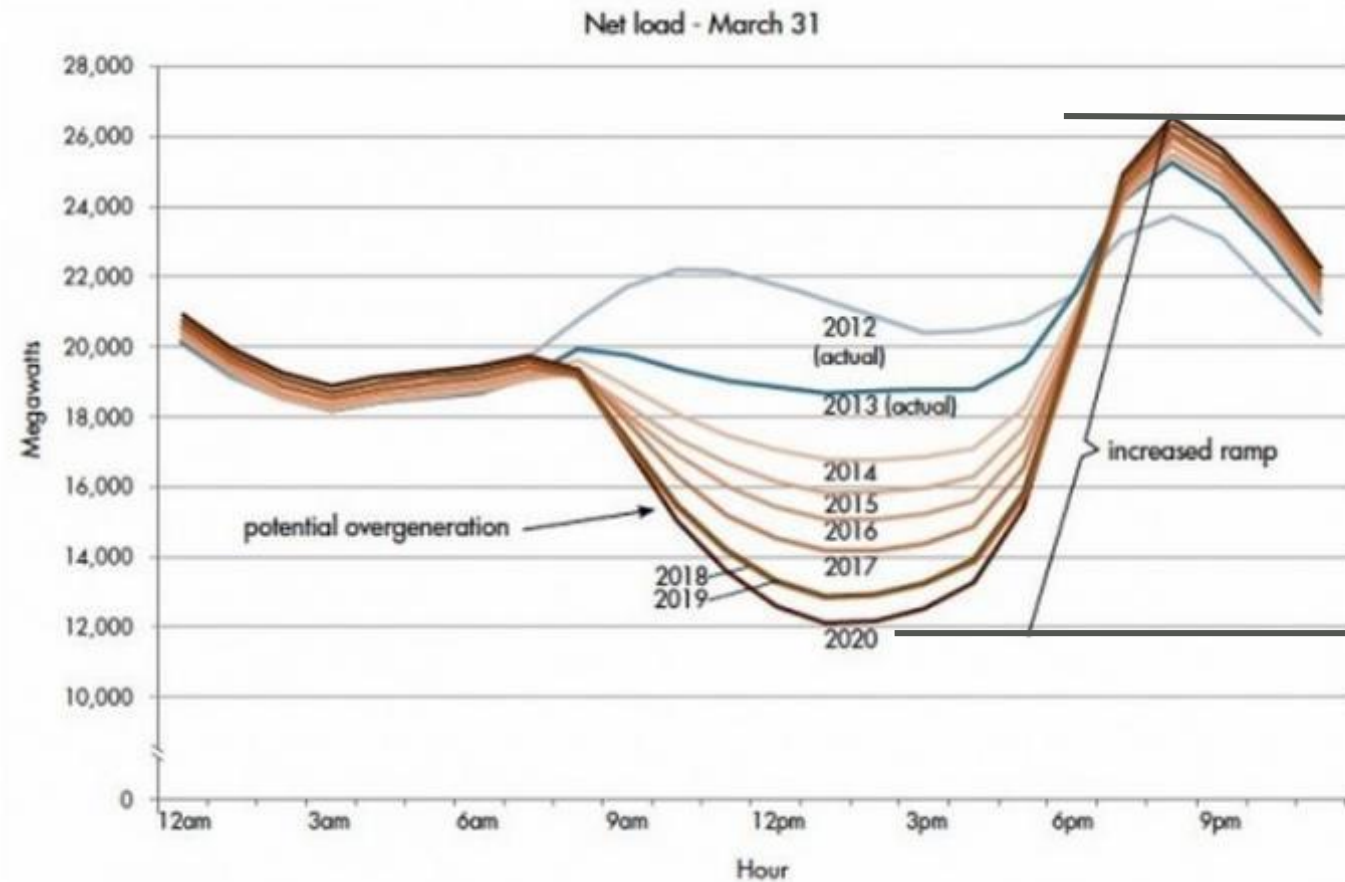


# Commercial and industrial

Energy optimization and cost reduction revenue streams to meet green targets

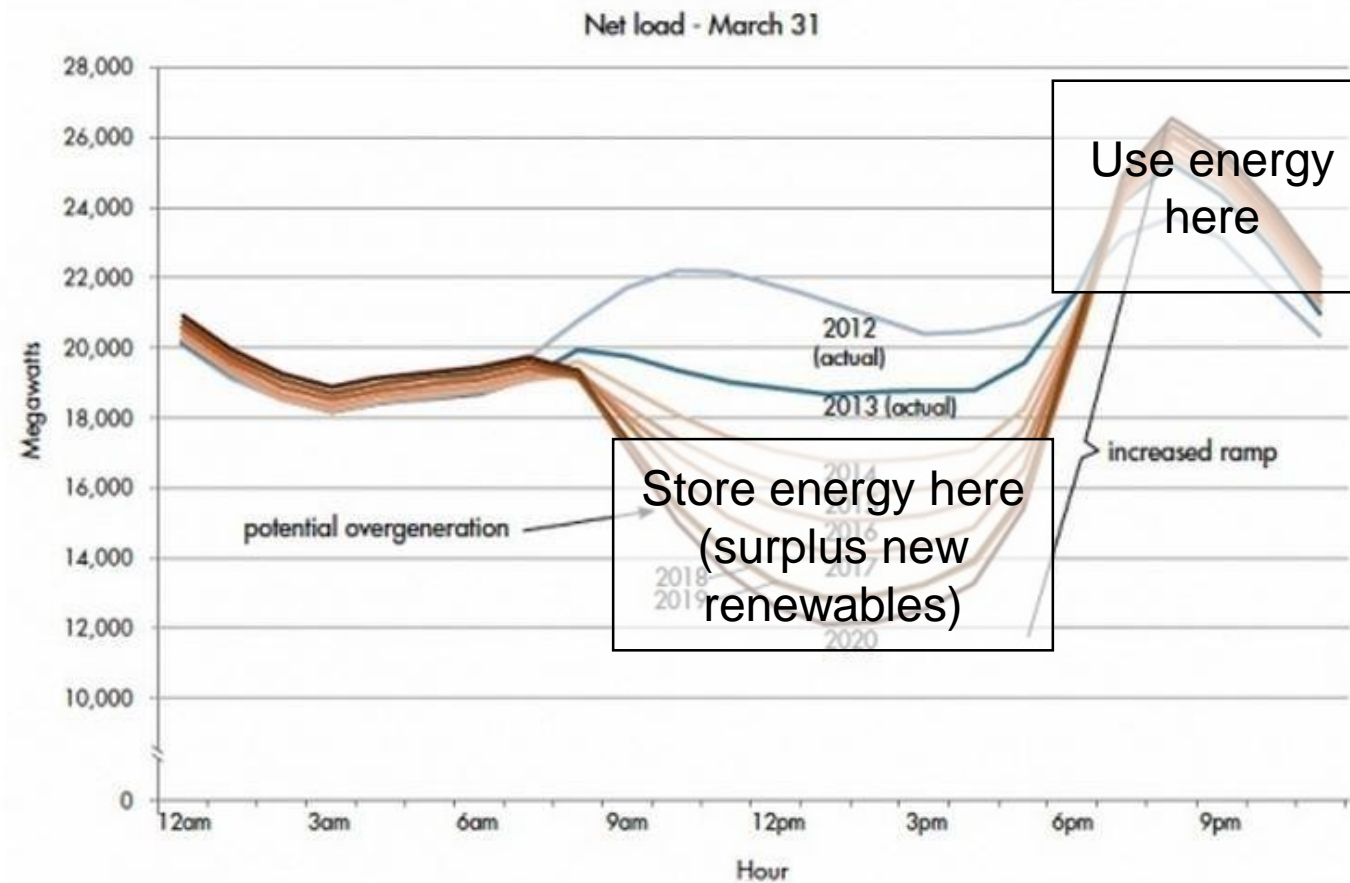


# The «California Duck curve»



Demand from traditional power generation during the day

# The main purpose of energy storage



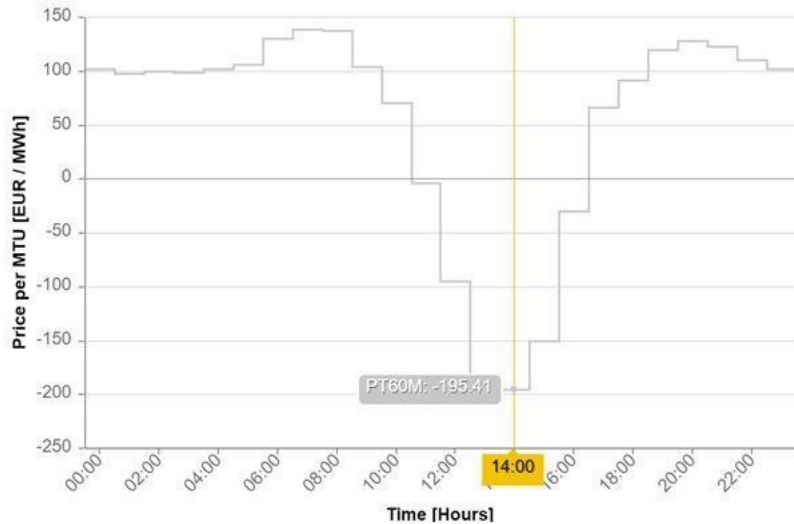
Demand from traditional power generation during the day

# High share of renewable energy can lead to negative energy prices

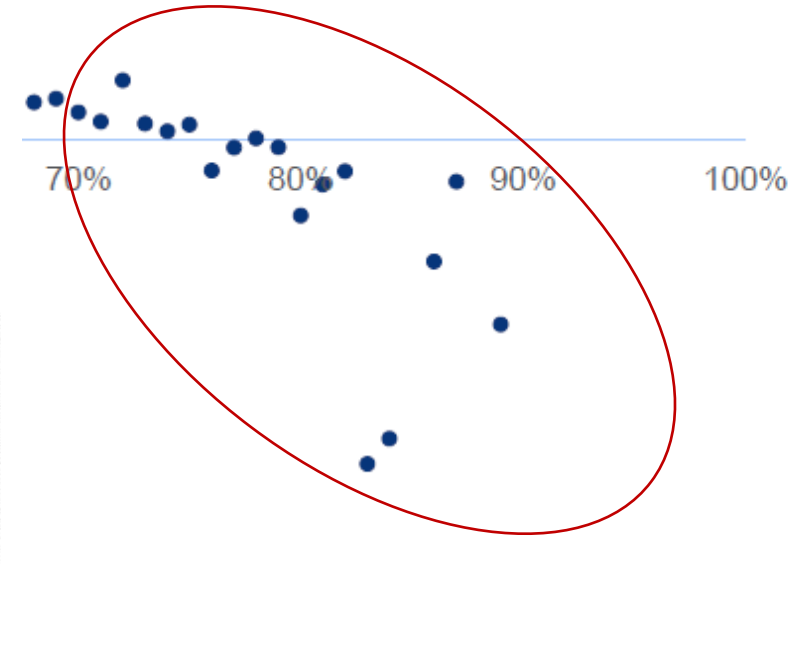
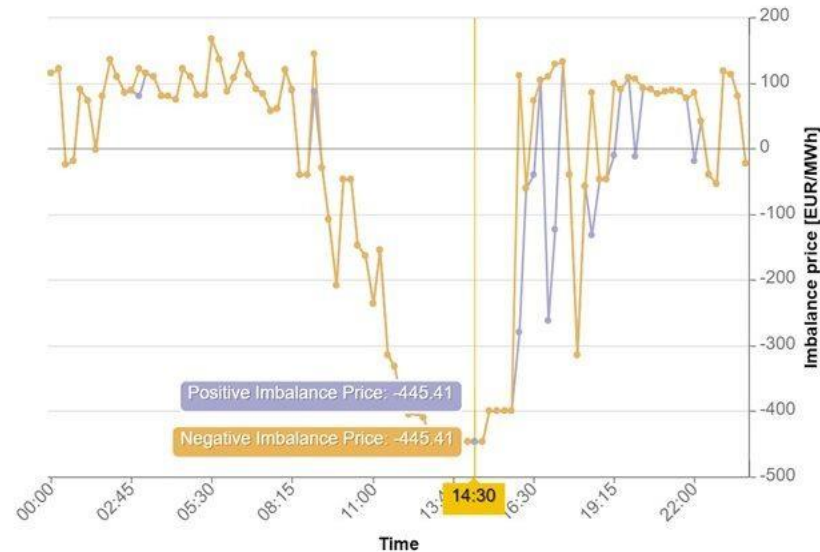


2023-04-19

NL: Day-Ahead Electricity Price



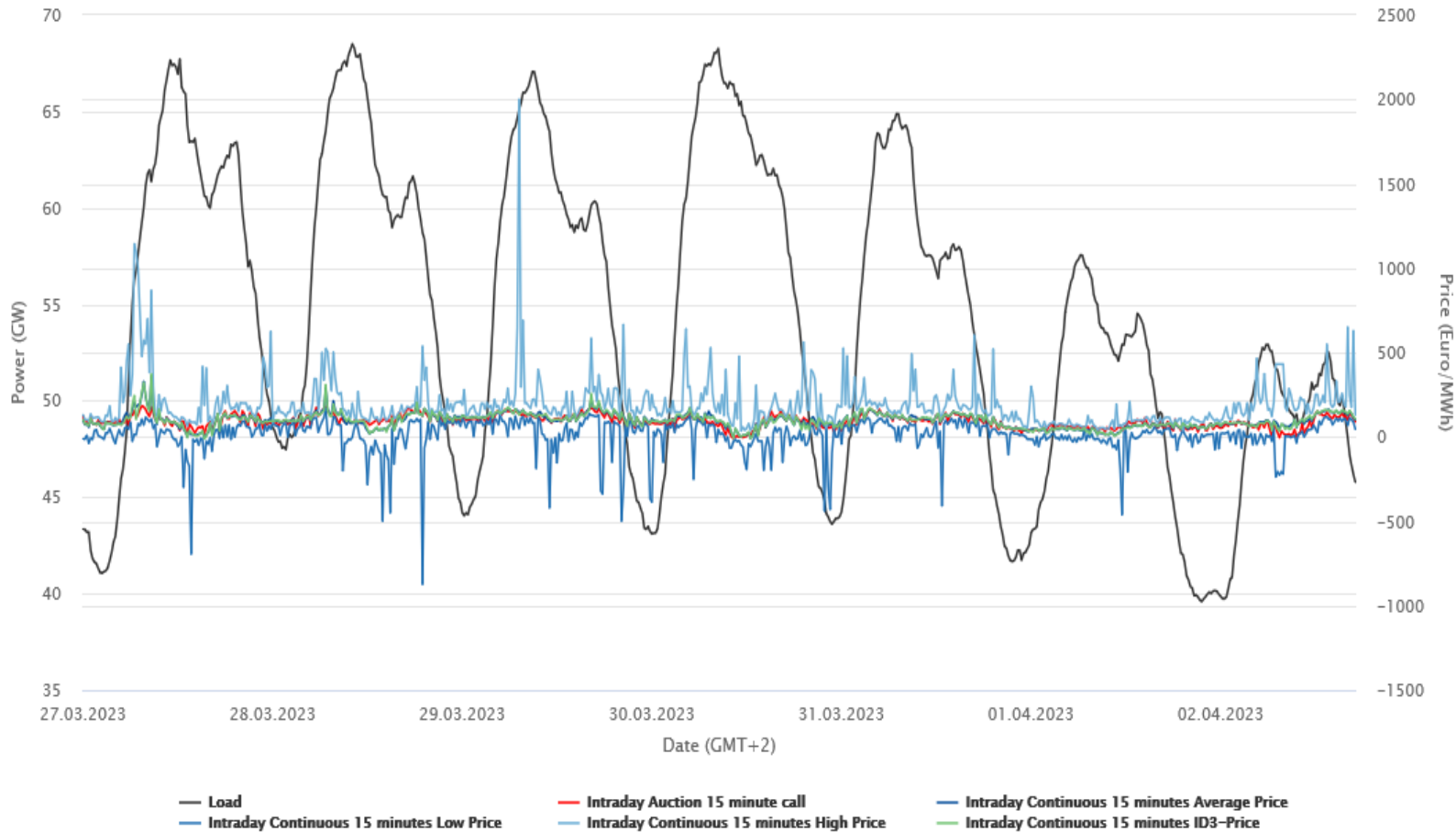
NL: Intra-day Imbalance Price





# Arbitrage as a source of income for industrial (and domestic) BESS

Electricity production and spot prices in Germany in week 13 2023



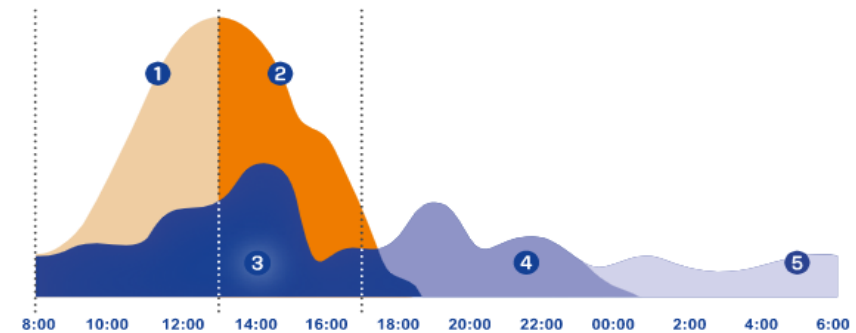
Energy-Charts.info; Data Source: 50 Hertz, Amprion, Tennet, TransnetBW, EEX, EPEX SPOT; Last Update: 09.04.2023, 00:14 MESZ

- Spot Market Trading on EPEX in Paris (European Power Exchange)
- Short-term trading up to 5 min before delivery
- Trading of different time contracts
- Without storage, speculation can only be made on price changes in the same order book.
- **With storage system, trades can be made across different order books and thus the potential for greater price fluctuations can be exploited**

# The PV self consumption opportunity



- **Additional time of use cost reductions**
- Charge batteries when electricity rates are low
- Support loads from battery when electricity rates are high

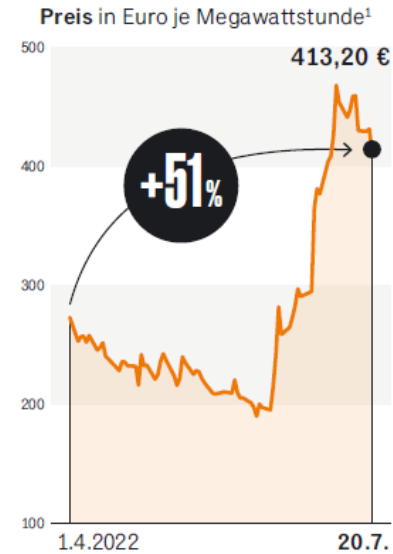


- 1 and 2 - Charging batteries when energy production exceeds self-consumption
- 3- Self-consumption from PV
- 4- Self-consumption from batteries
- 5- Self-consumption from grid

# Development of energy prices in Europe

Increasing energy prices make PV generation and optimization of own consumption an attractive business case

## Strompreis

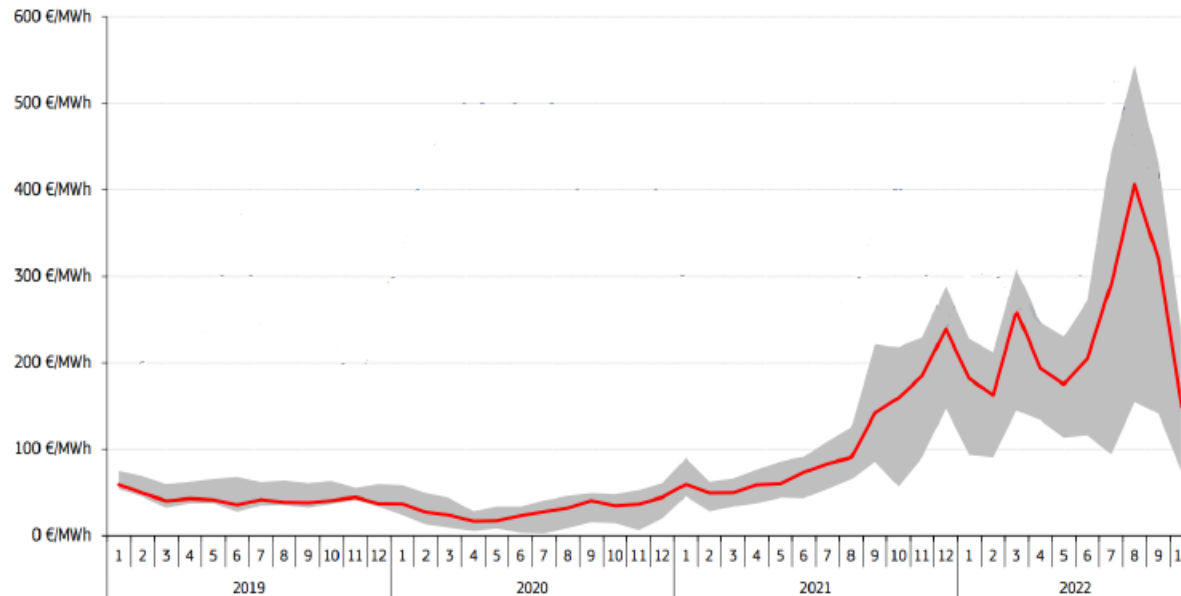


EU-27 Durchschnitt	23,69
Italien	23,60
Zypern	23,04
Österreich	22,85
Portugal	21,70
Frankreich	20,22
Luxemburg	19,89
Griechenland	19,74
Lettland	18,86
Tschechien	18,83
Finnland	18,40
Slowenien	17,11
Slowakei	16,24
Rumänien	16,02
Polen	15,74
Litauen	14,77
Niederlande	14,49
Estland	13,39
Malta	13,17
Kroatien	13,13
Bulgarien	10,91
Ungarn	10,01

Strompreise für Haushaltskunden <sup>2</sup> im 2. Halbjahr 2021 in EU-Ländern in Cent pro Kilowattstunde	
Dänemark	34,48
<b>Deutschland</b>	<b>32,34</b>
Belgien	29,94
Irland	29,74
Spanien	28,16
Schweden	26,04 <sup>3</sup>

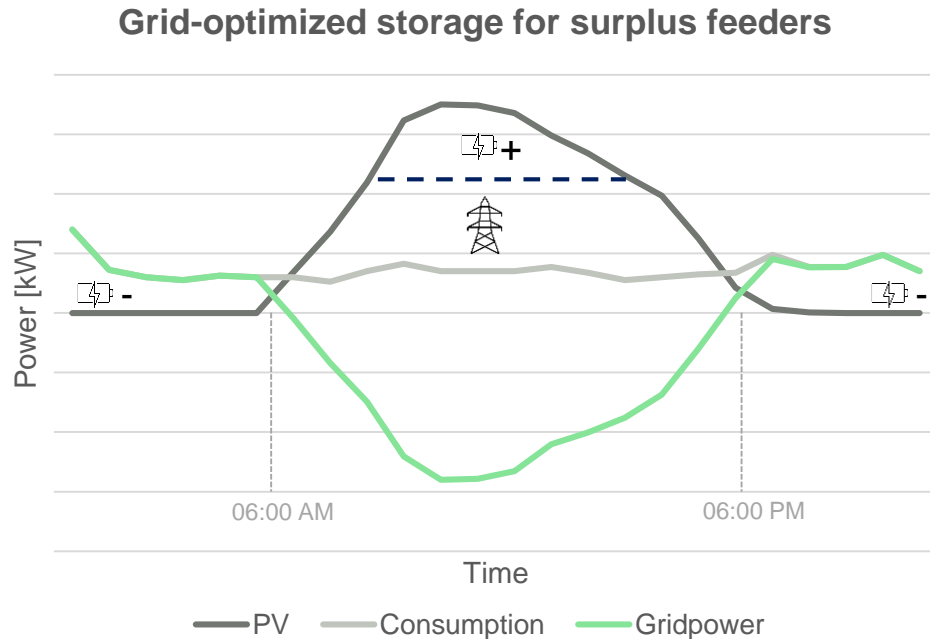
Figure 1 – Evolution of lowest and highest regional wholesale electricity prices in the European day-ahead markets 2019-2022



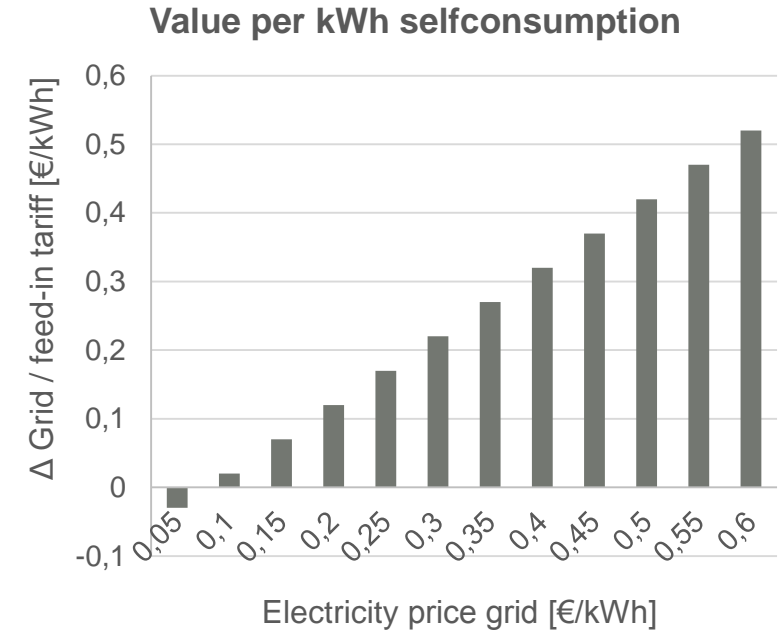
Source: European Commission, [Quarterly report on European electricity markets](#), Q3 2022, based on S&P Global Platts. The shaded area delineates the spectrum of prices across European regions.

1) Phelix Baseload (Grundlast) an der EE; 2) 2.500 kWh bis 5.000 kWh, alle Steuern und Abgaben inbegriffen; 3) Schätzung; **Quellen:** Bloomberg, Eurostat

# Storage in use with PV plants



- Storage size depends on PV power [kWp] and location
- Grid-serving storage relieves the load on the grid



- Assumed feed-in tariff per kWh: 0,08 €
- History shows a further increase in electricity prices

1. **The higher the electricity price from the grid, the lower is normally the feed-in tariff**
2. **and the higher the self-consumption rate, the quicker the investment in a BESS pays for itself**



An aerial photograph of a high-voltage power line tower standing in a dense forest. The tower is a lattice structure, and several power lines extend from it across the landscape. The forest is lush green, with some trees showing early autumn colors. The lighting suggests a bright day, with shadows cast on the ground.

# Frequency response market

Enable power systems to generate new revenue streams from flexibility markets

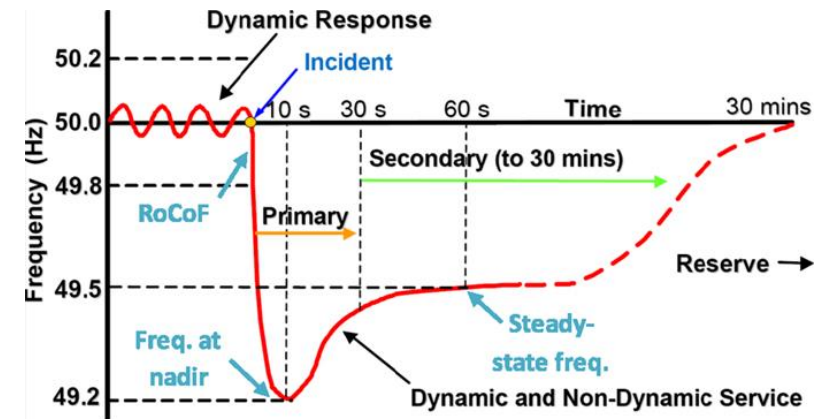
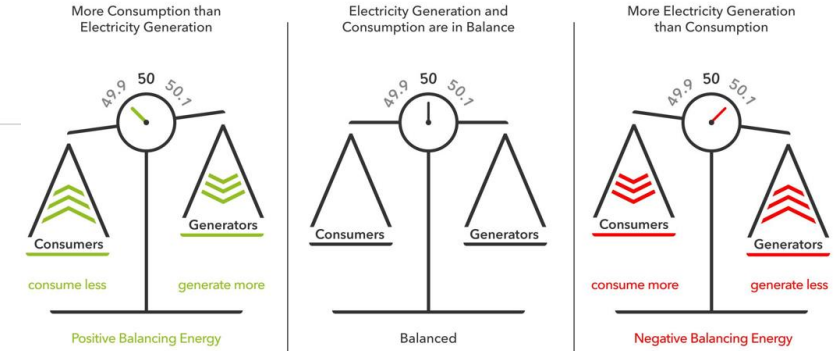
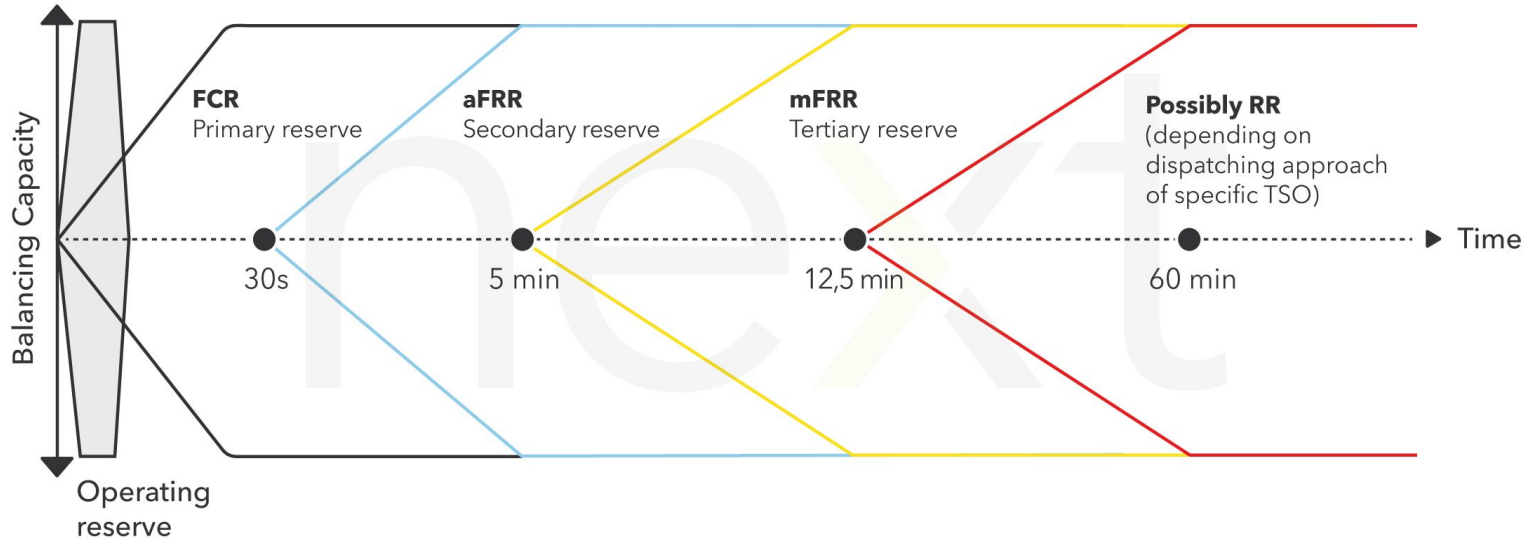


# Grid balancing and Frequency regulation







How does it work (different services)



## Balancing Services According to the System Envisaged by ENTSO-E

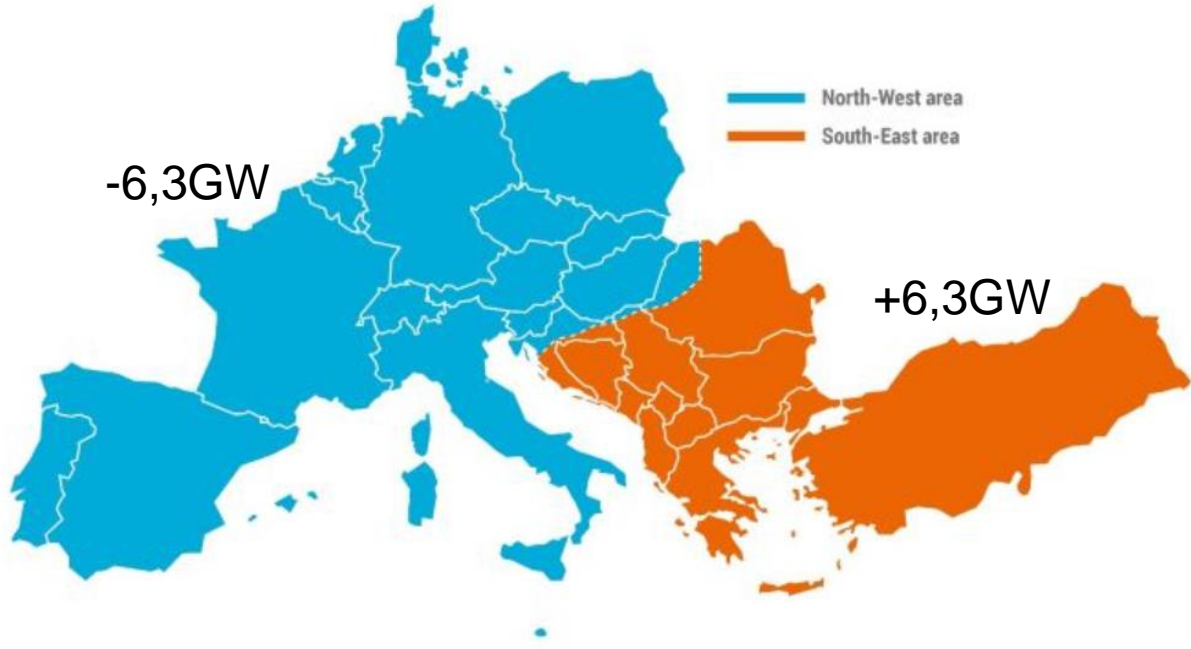


# Reserve market places in Finland

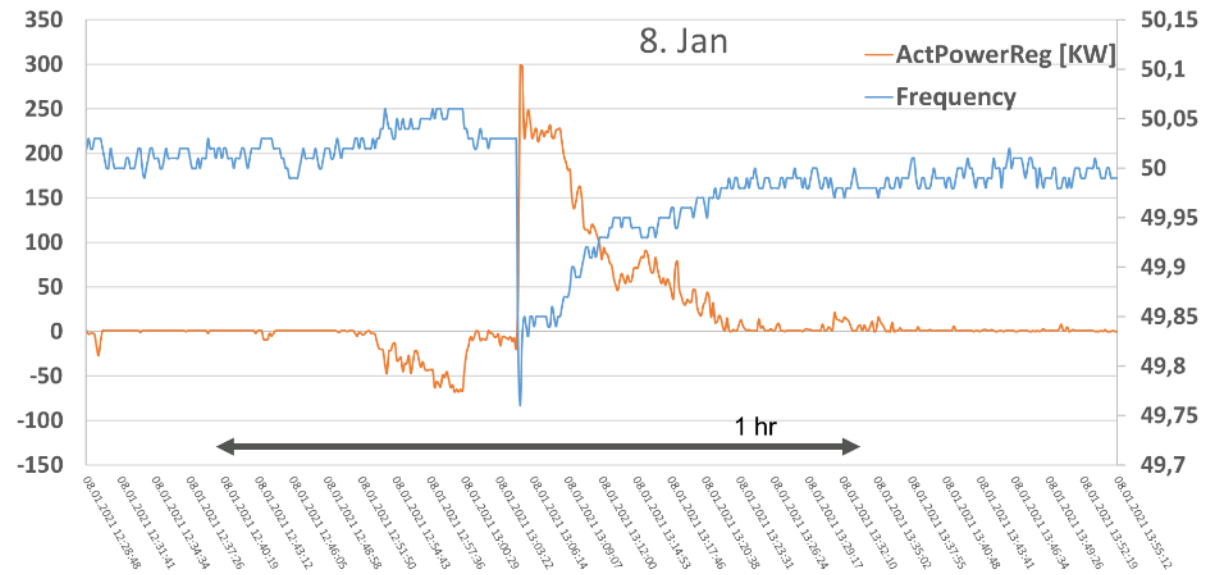
	<b>FFR</b>	<b>FRD</b>	<b>FCR-N</b>	<b>aFRR</b>	<b>mFRR</b>
	<b>Fast Frequency reserve,</b> Finland 20 %, In Nordics, total 0-300 MW (estimate)	<b>Frequency Containment Reserve for Disturbances,</b> Finland 290 MW, Nordics total 1450 MW	<b>Frequency Containment Reserve for Normal Operation,</b> Finland 120 MW, Nordics total 600 MW	<b>Automatic Frequency Restoration Reserve,</b> Finland 60-80 MW, Nordics total 300-400 MW	<b>Manual Frequency Restoration Reserve</b> Reference incident + imbalances of balance responsible parties
<b>Activated</b>	In big frequency deviations, In low inertia situations	In big frequency deviations	Used all the time	Used in certain hours	Activated if necessary
<b>Activation speed</b>	In a second	In seconds	In a couple of minutes	In five minutes	In fifteen minutes
					
					

**FINGRID**

# 8 Jan 2021 @14:04: Europe's Power Grid Close to a Massive Blackout



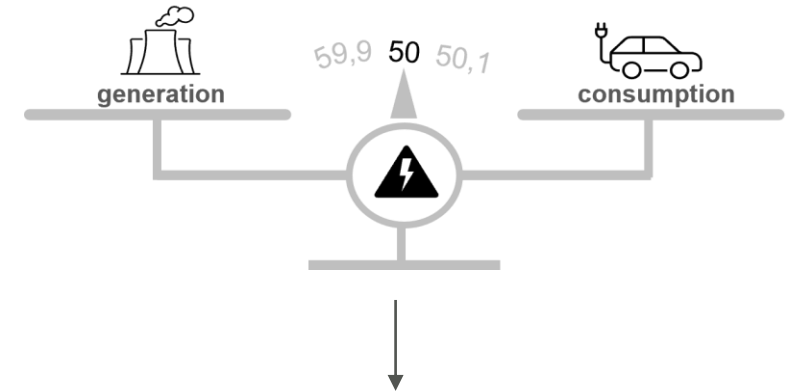
Energy storage came fast to rescue!





# The balancing power Market

- **Control energy as the most important instrument for maintaining voltage in the transmission grid**
- The Austrian, Belgian, Dutch, Danish, French, German, Slovenian and Swiss TSOs currently procure their FCR in a common market
- **The product characteristics in the cooperation are defined as follows:**
  - Symmetric product  
(*negative & positive FCR are procured together*)
  - Duration of product delivery: 6 timeslots per day, each 4 hours
  - **Minimum bid size: 1 MW**  
(*Smaller plants can also participate through plant pooling*)
  - Compliance of limits & requirements for the exchange of FCR
  - Activation time: 30 sec; deployment time: 30 sec. to 15 min.
  - Due to the support of system-relevant infrastructure, all plants must fulfil the necessary prequalification conditions (technical safety, reliability, etc.).
  - Plant pooling (aggregation) possible for systems (from 100kW) that do not have the required power of at least 1 MW.

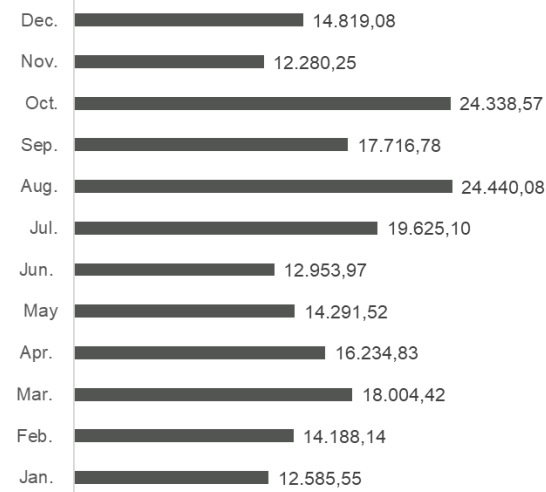


**Due to their technical characteristics, electric storage units are primarily suitable for the provision of Frequency Containment Reserve (FCR).**

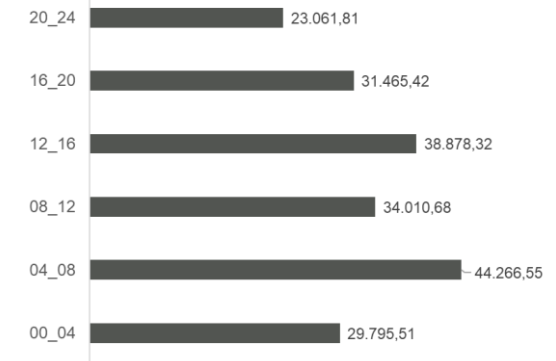
# Price factors for FCR in 2022

- The increased expansion of renewable, decentralised and weather-dependent generation plants has a significant influence on the voltage level in the grid
- Rising electricity demand due to increasing electrification in the electromobility & heating sector
- Systemically important infrastructure
- Increasing share of battery storage providing FCR
- High market entry barriers due to the prequalification process
- Reservoirs have good technical characteristics for the provision of FCR
- Grid operators are allowed to use but not own or have in their possession electricity storage systems  
(Article 36 (1) & 54 (1) Internal Electricity Market Directive, CEP)

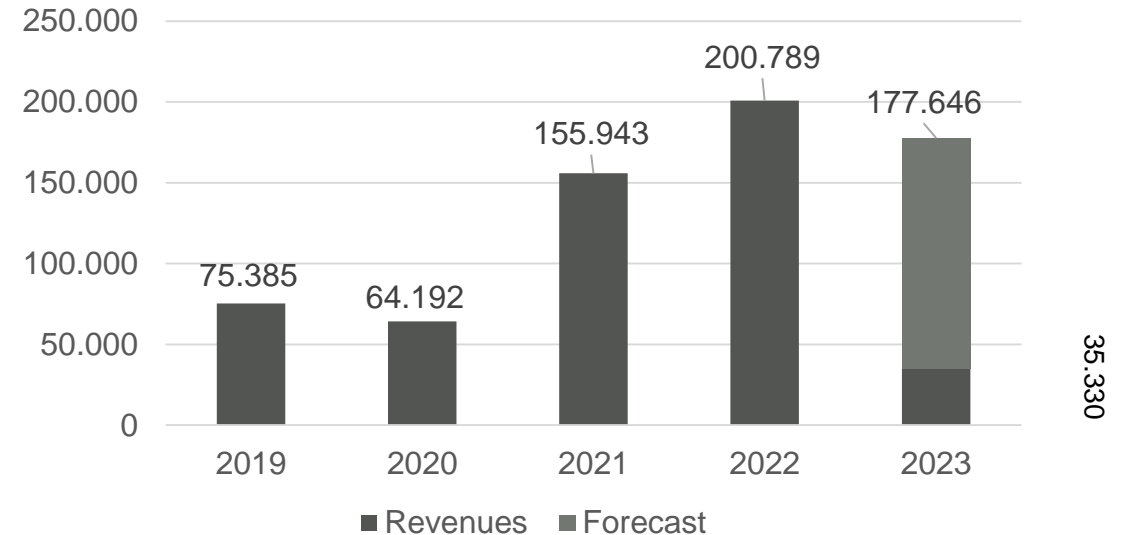
Ø FCR prices per month [€/MW] 2022



Ø FCR prices per timeslot [€/MW] 2022



Annual FCR prices [€/MW]

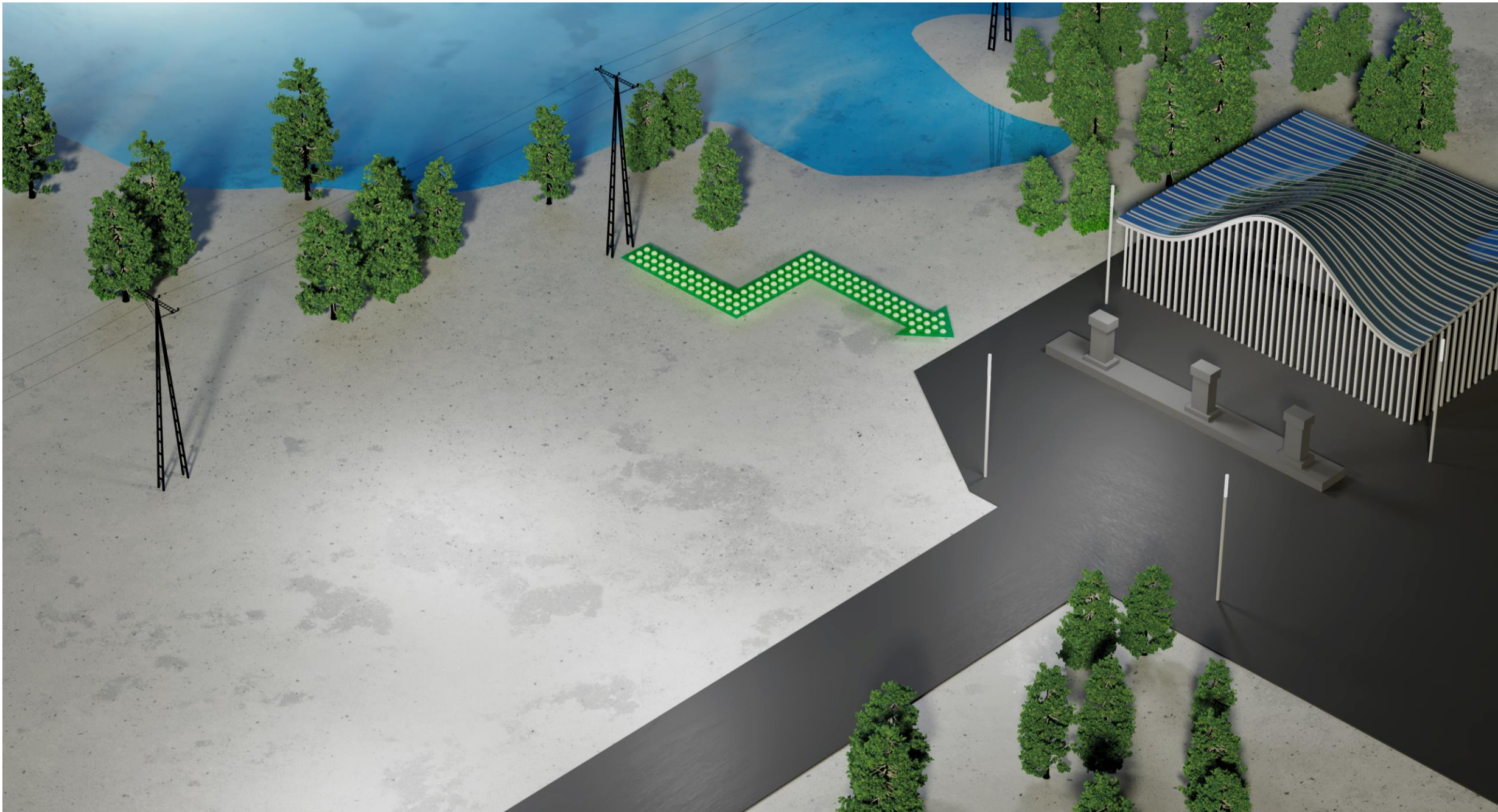


A technician in a blue uniform and cap is working on an electric vehicle charging station. The technician is wearing a blue polo shirt, a grey vest, and a black cap. He is holding a blue charging cable and appears to be connecting it to the station. The background shows a blurred car wheel and a building structure.

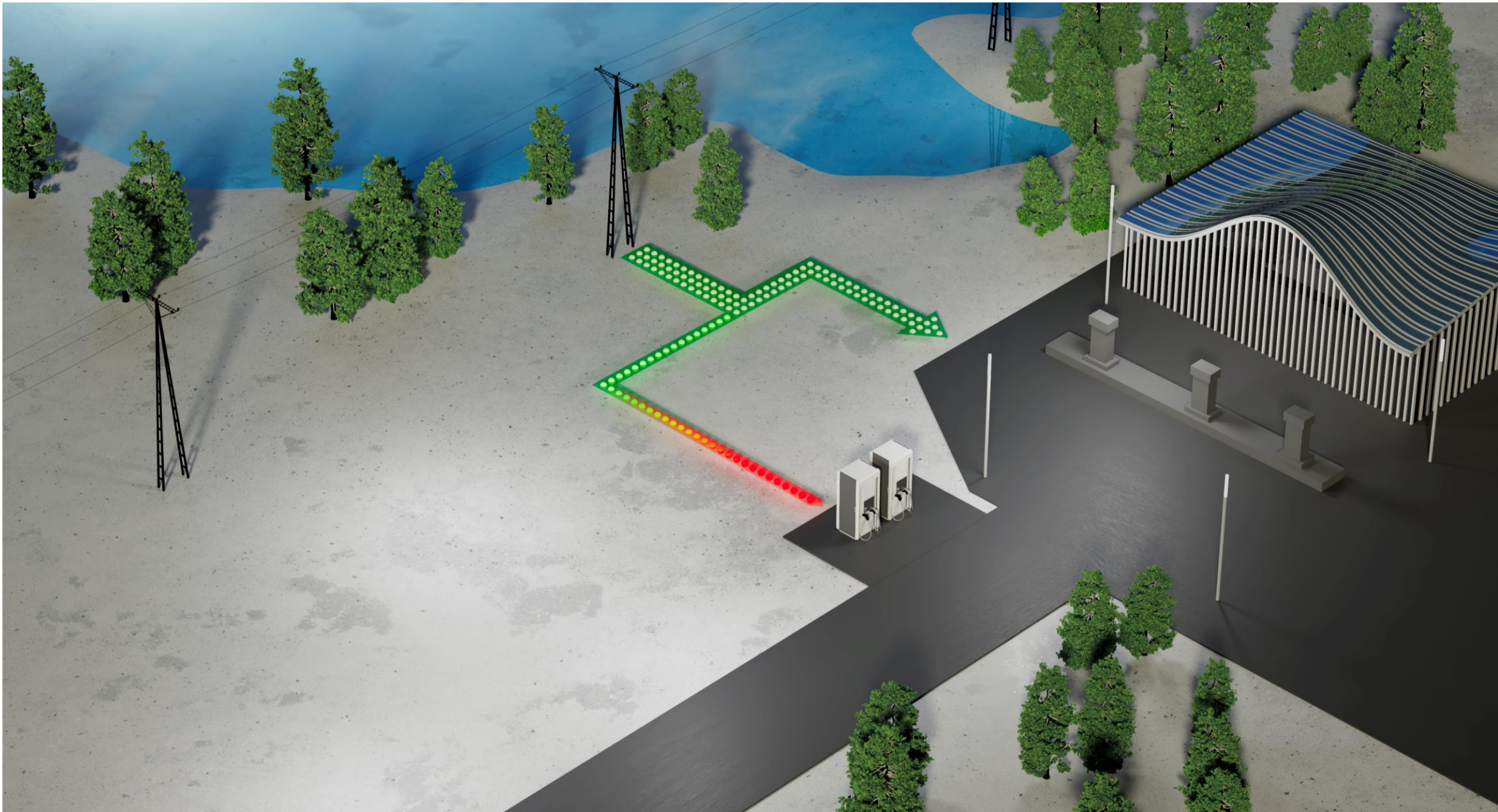
# EV Charging

Rapid adoption of EV is delayed by poor grid

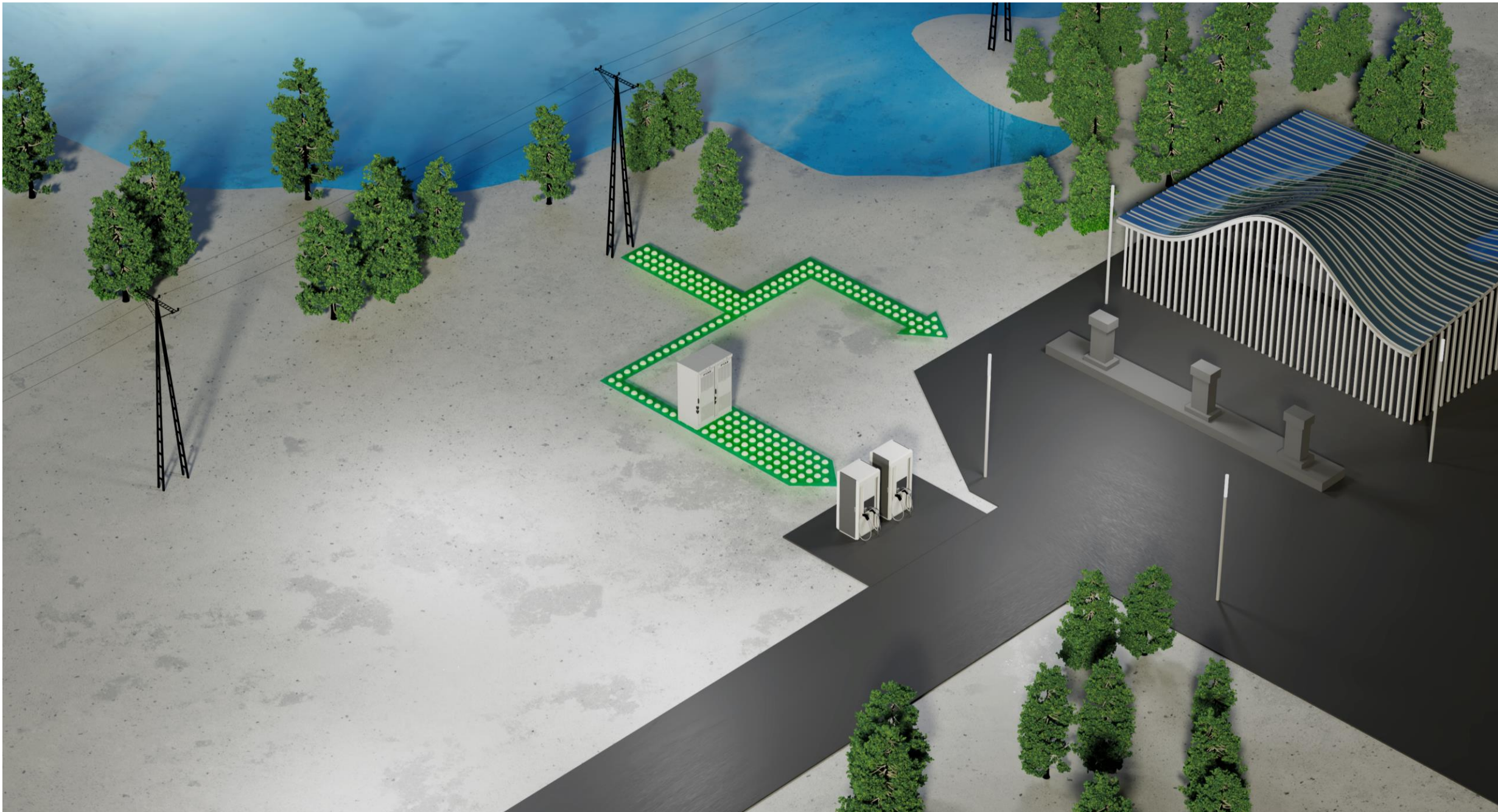




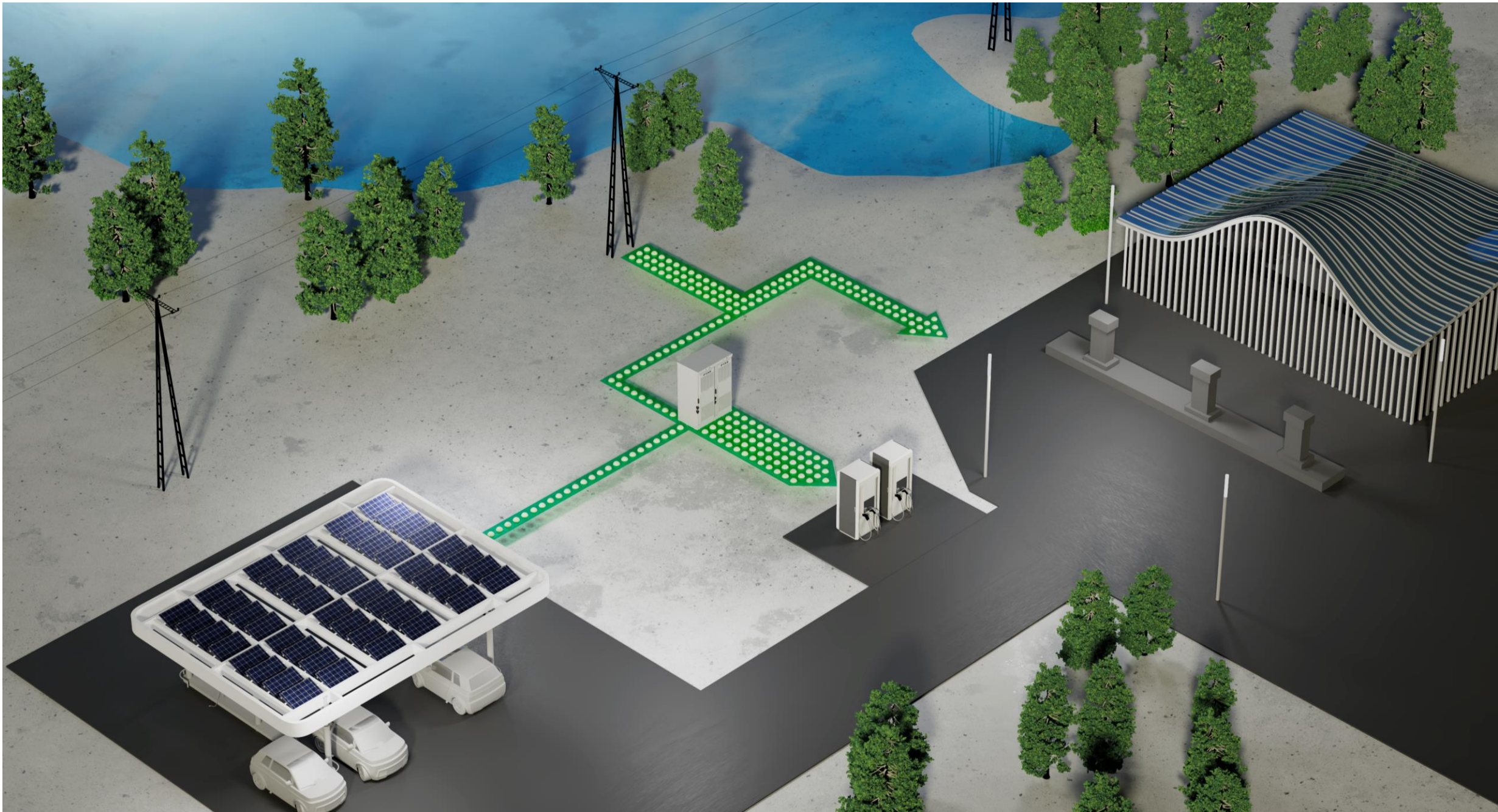




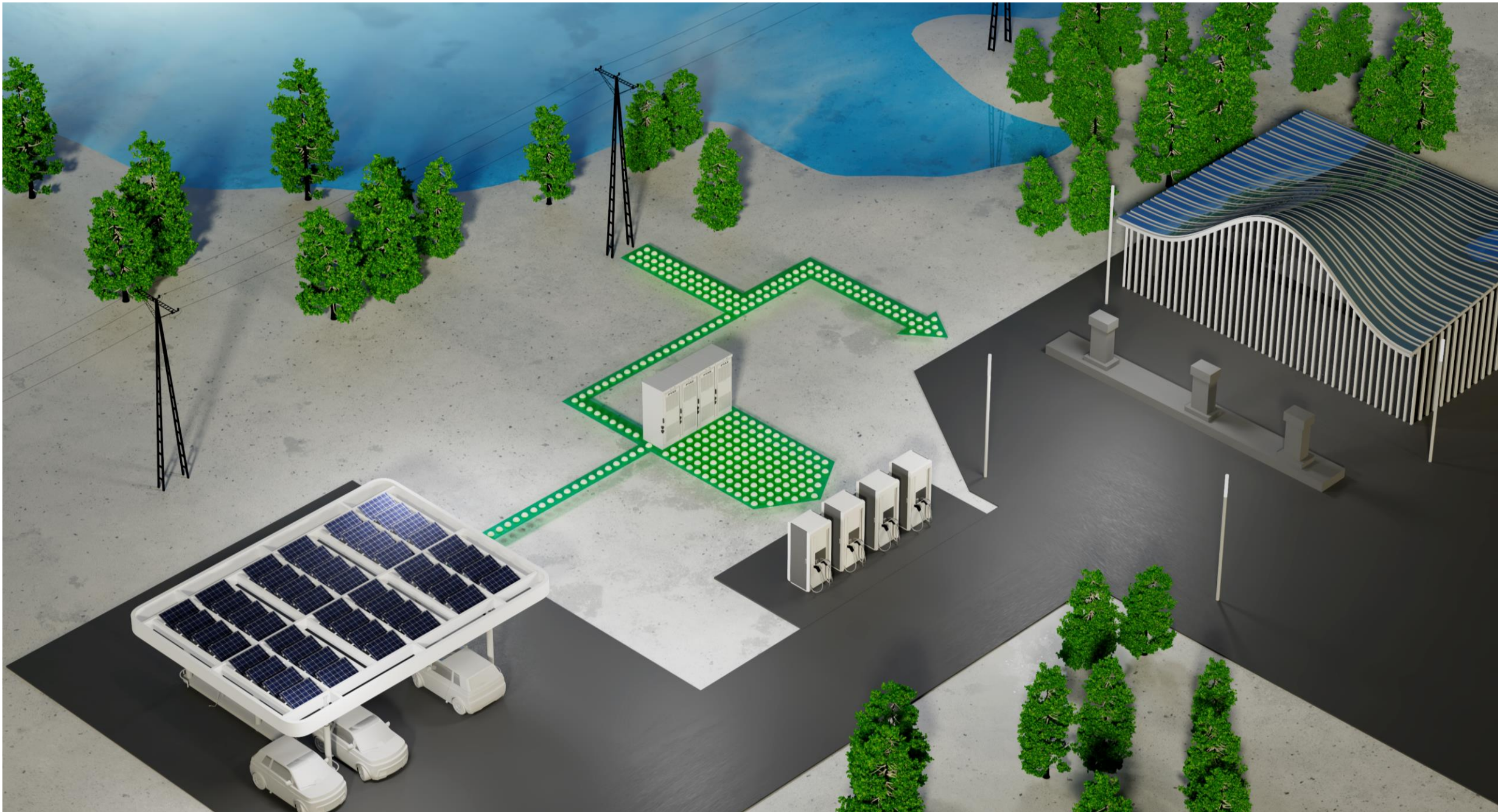




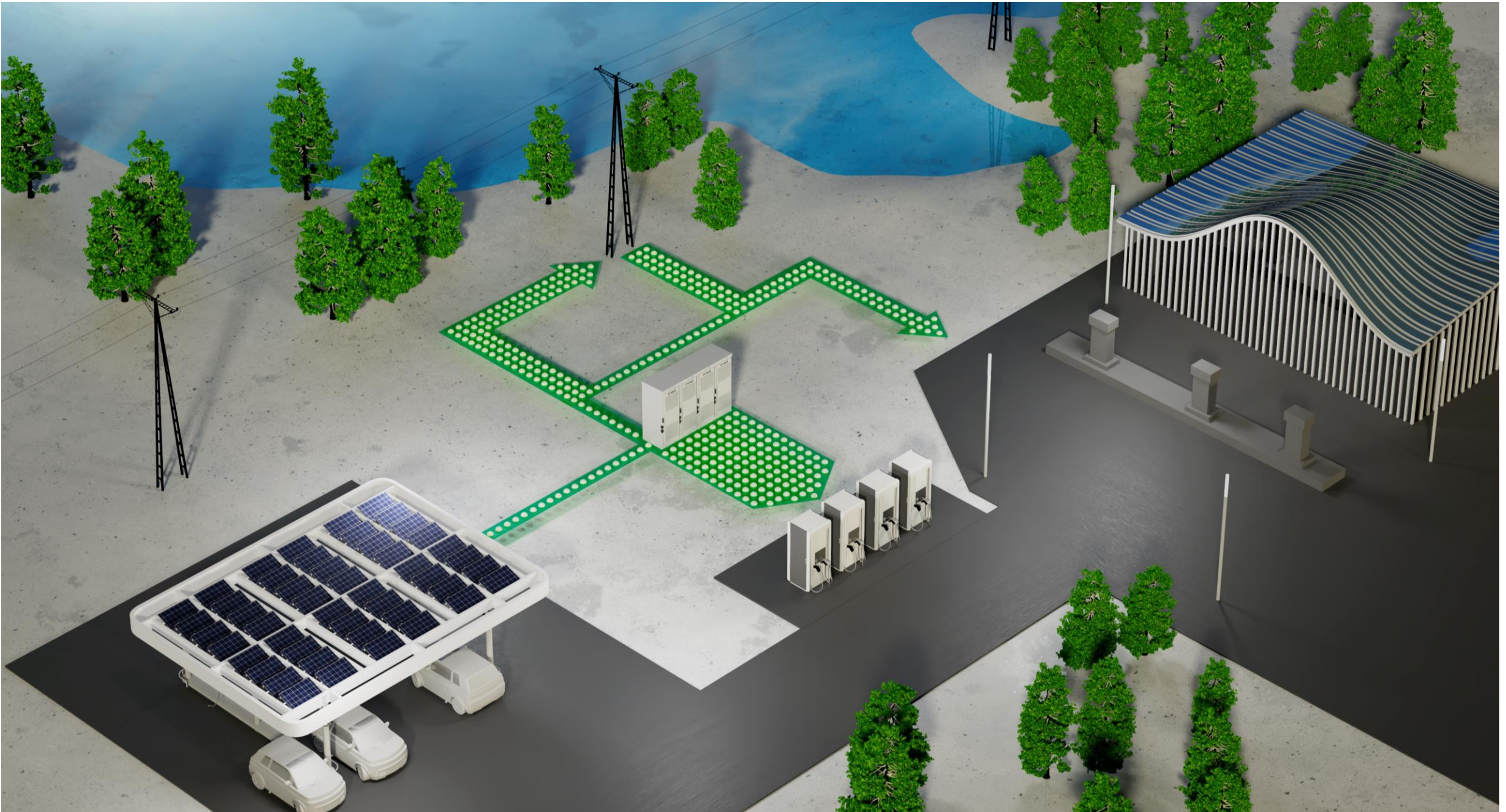














# Innovating the future of EV charging

## Challenge

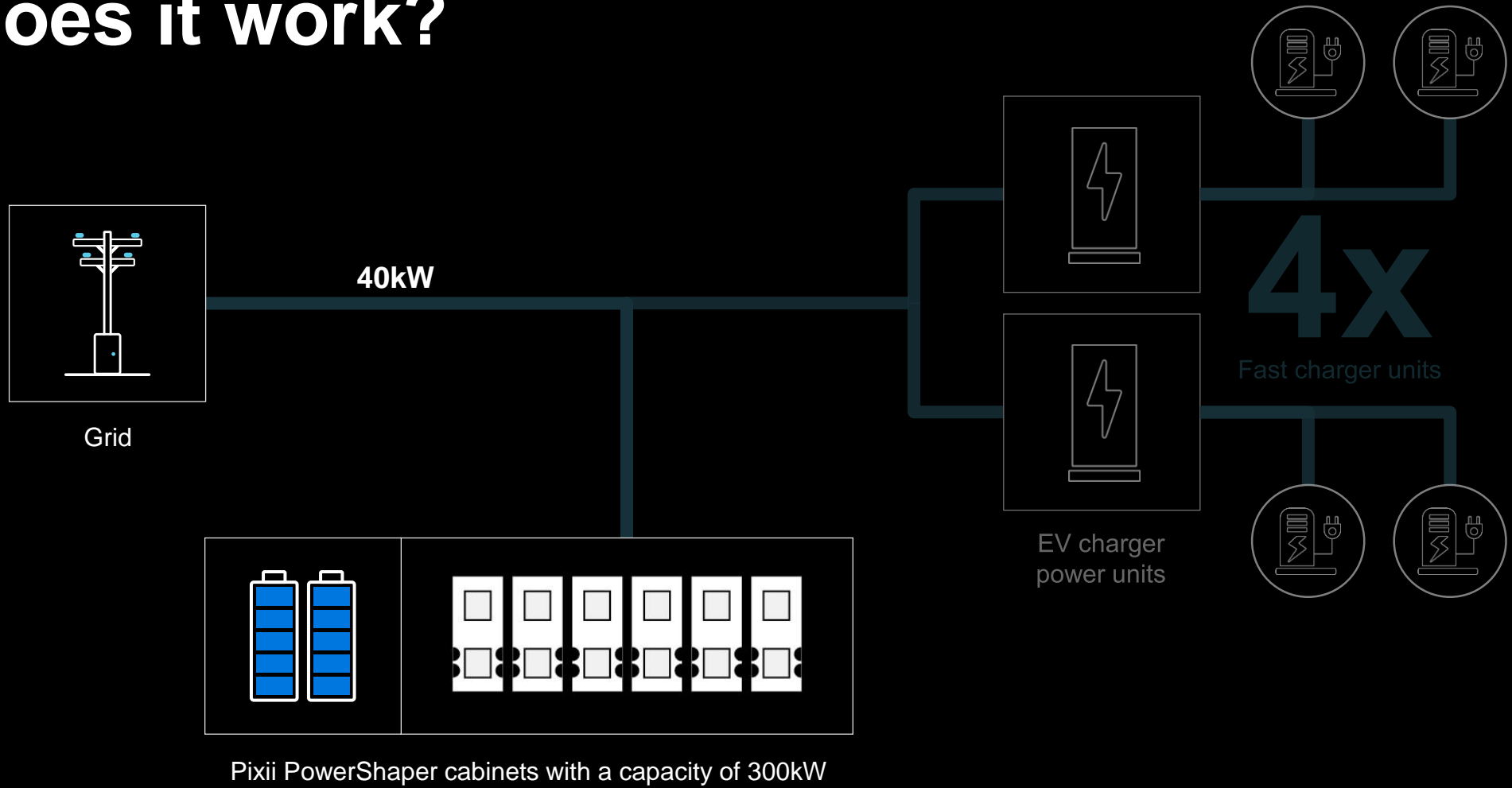
Widespread adoption of EVs is challenged by inadequate charging infrastructure and insufficient capacity of the grid.

- Current infrastructure in many remote areas don't have sufficient capacity for fast charging
- To costly or time consuming to upgrade old grid infrastructure
- The need for fast charger has exponential growth
- Time consuming to build sites from ground up

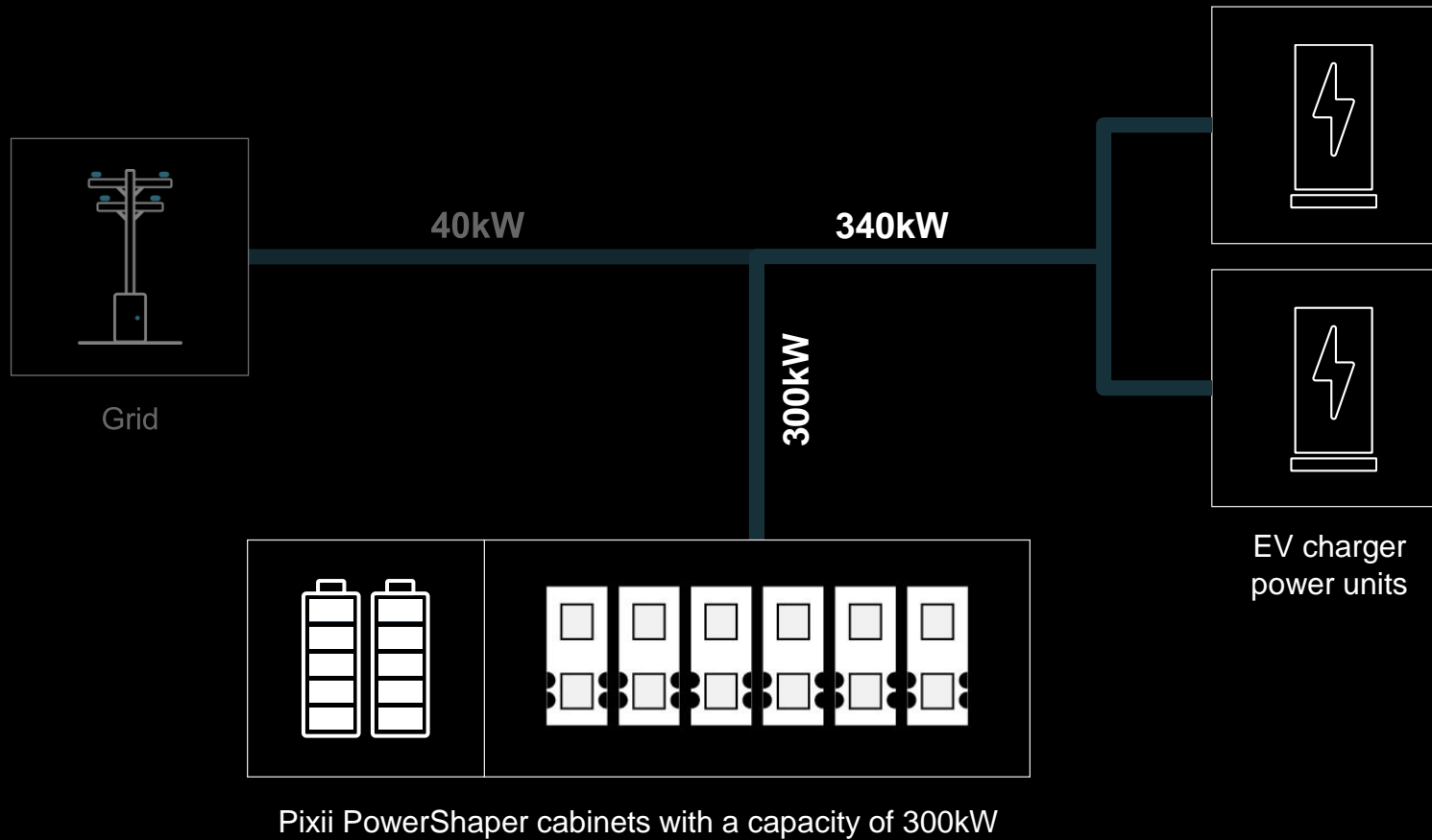




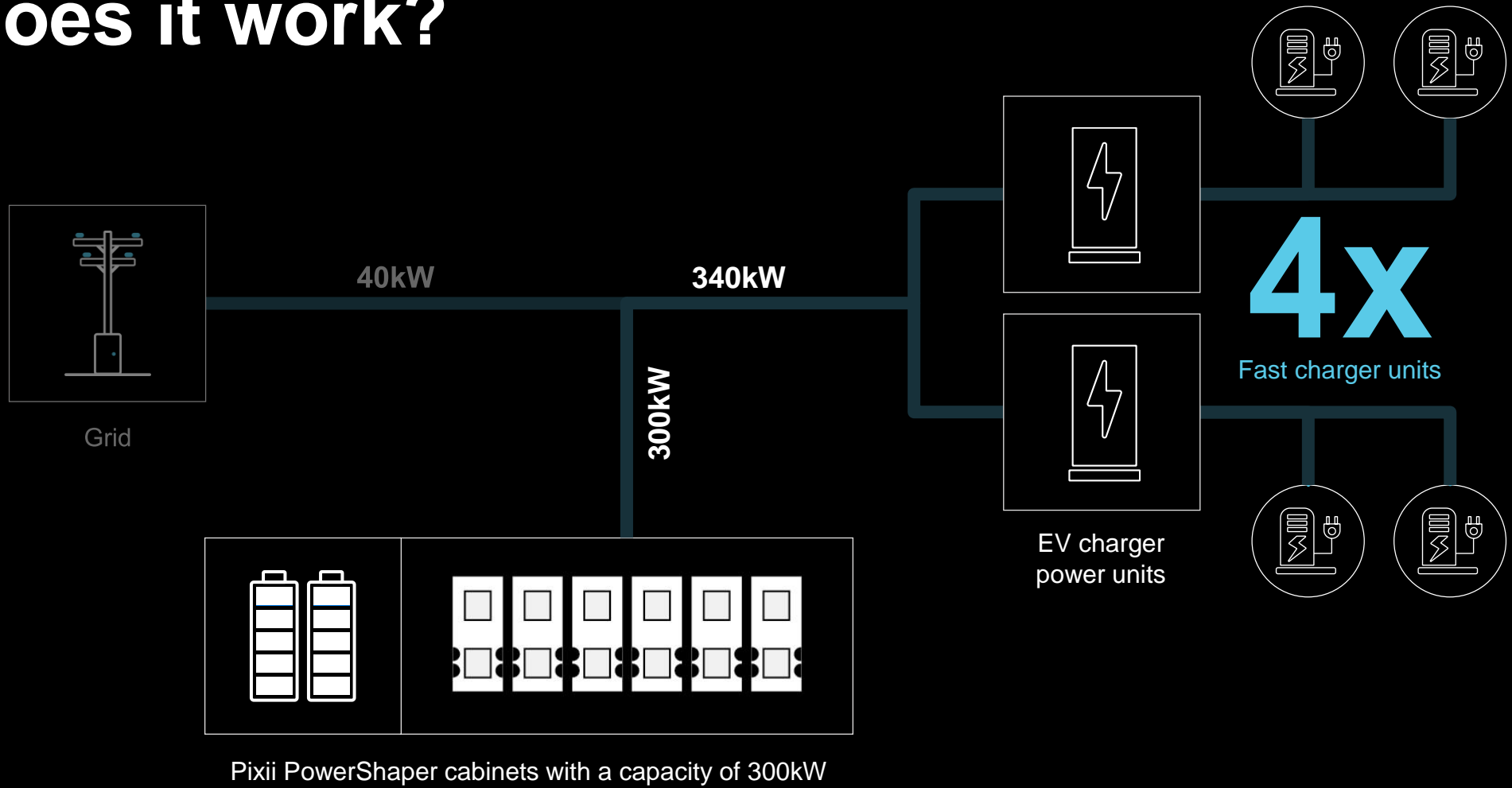
# How does it work?



# How does it work?

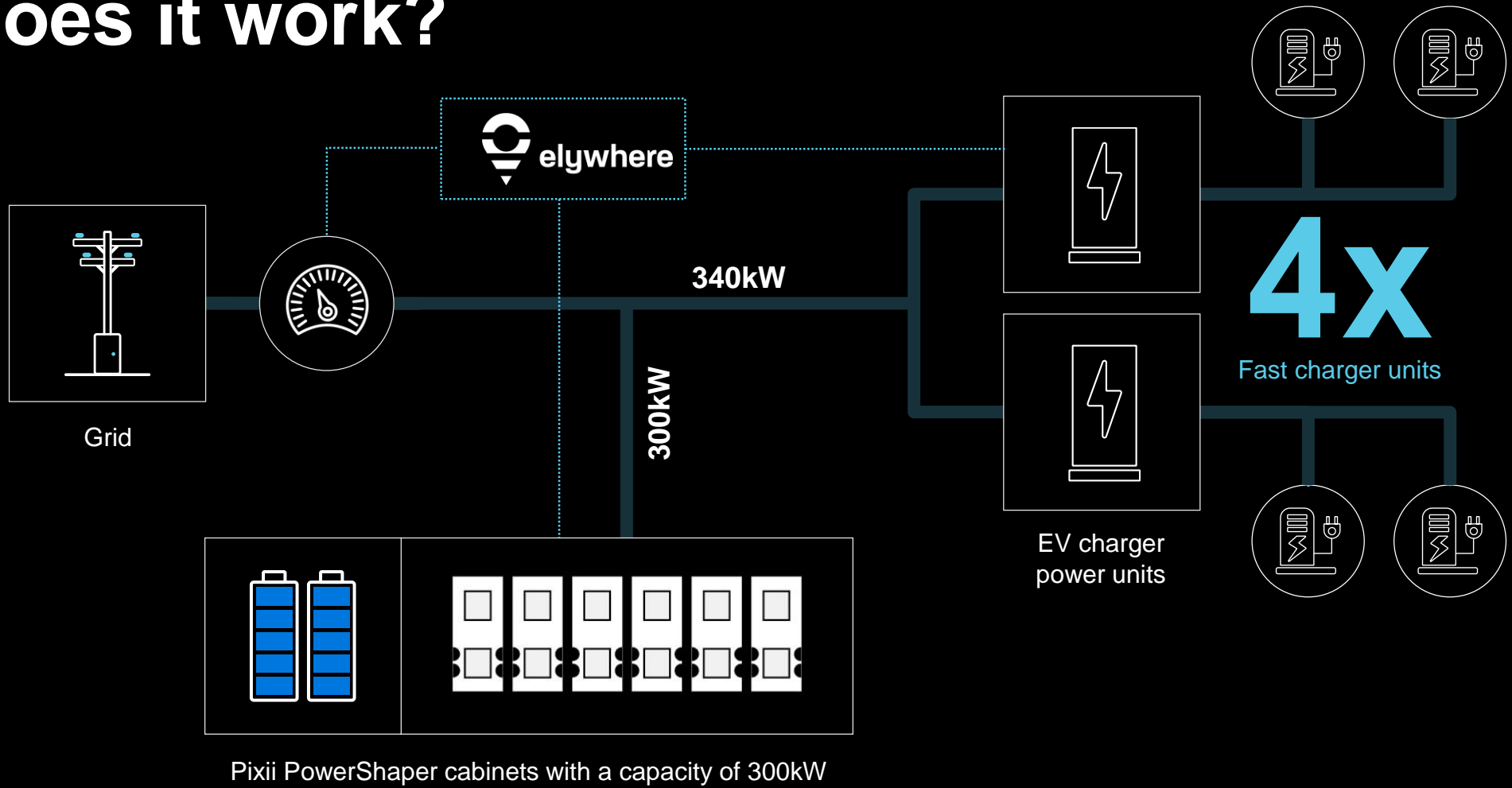


# How does it work?

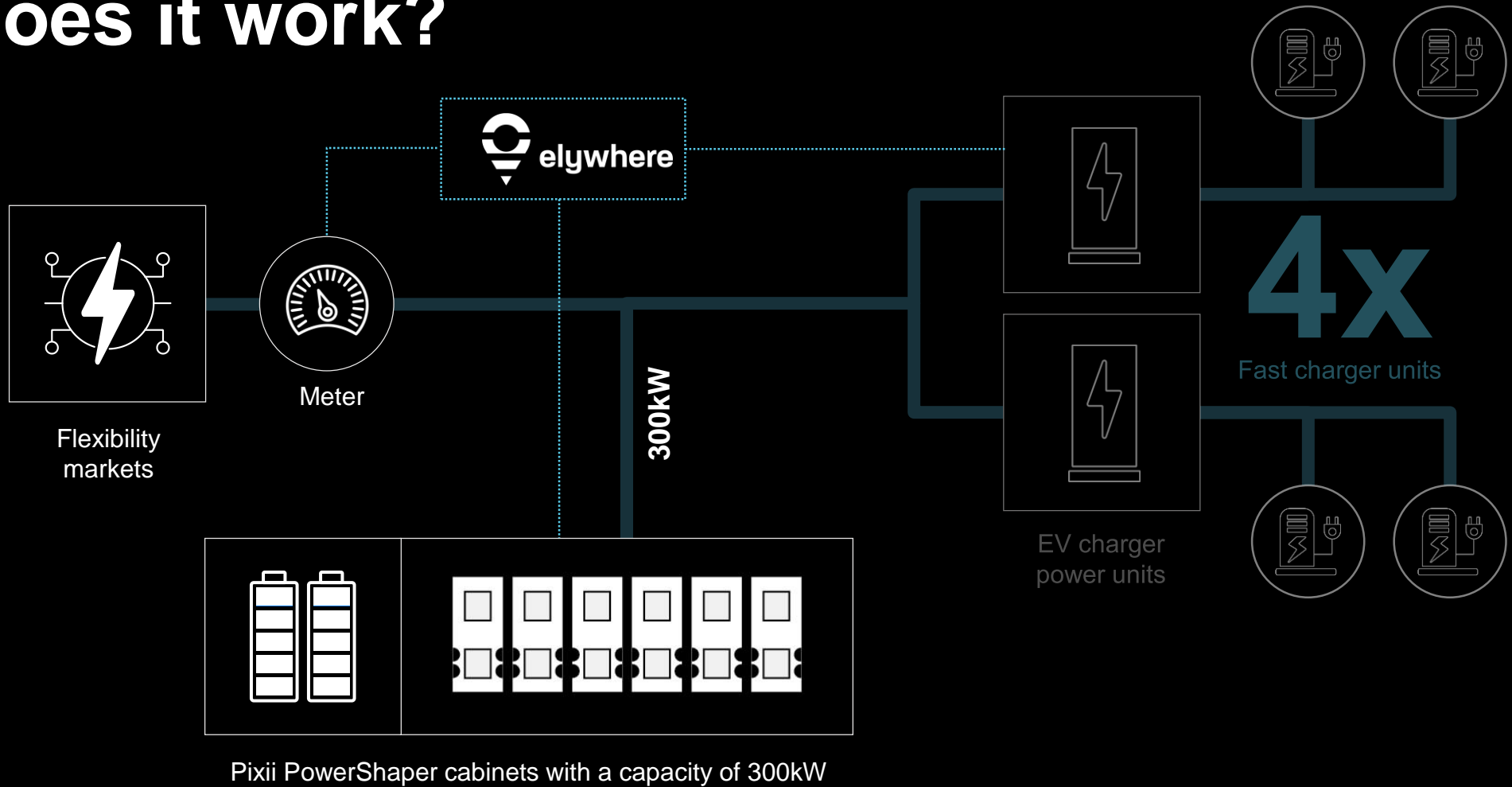




# How does it work?



# How does it work?



# Innovating the future of EV charging

## Benefits

- Modular and all-in-one design
- Pre-wired design enable quick deployment
- Factory tested before roll-out
- Mobile and easy to relocate
- Easy for Elywhere to scale fast
- Works with all PV installations

## Result

Demand for charging has grown to 60-70 charging sessions a day, with up to 1 MWh per day being sold.

This level of performance would have been impossible without battery energy storage.







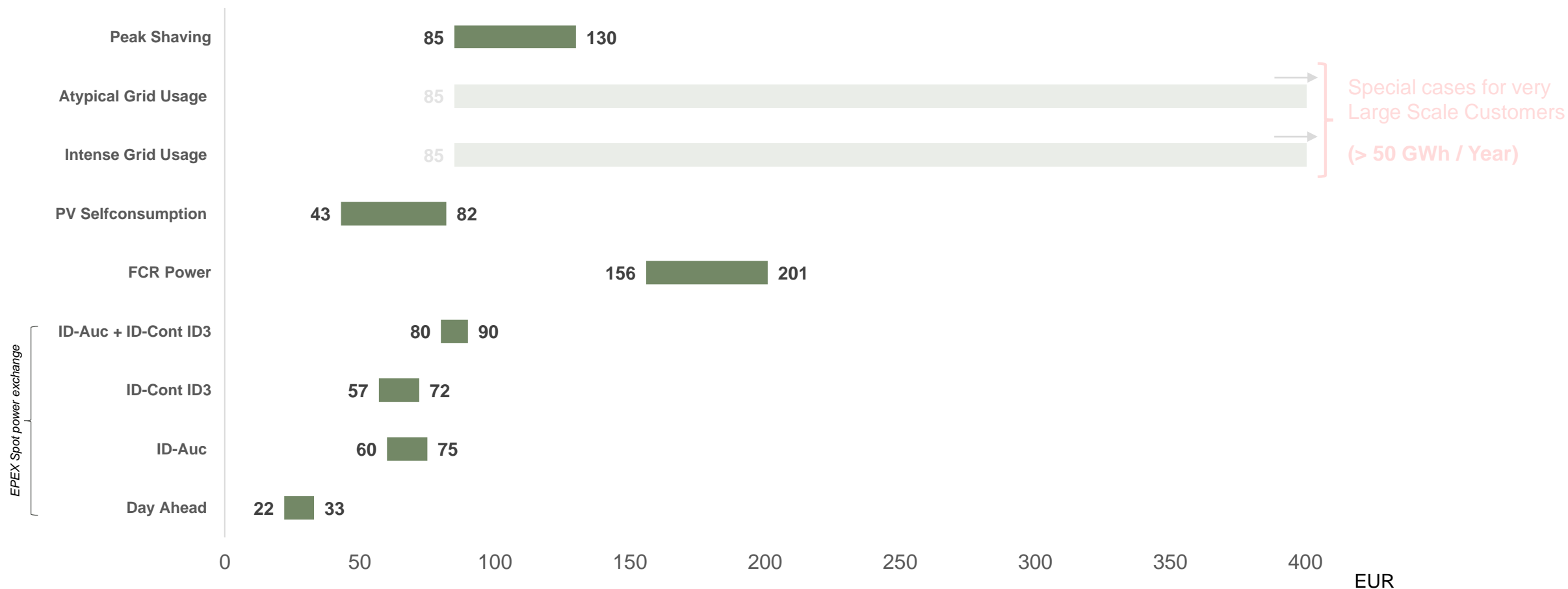
# SUMMARY

Battery Energy Storage (BESS) a possible multitool for energy revolution challenges ?



# Indicators for value creation potential with BESS (Germany + NL)

Annual revenue or savings [€] per installed kW



Peakshaving:  
Reduction by 80 % of installed storage capacity

Individual grid fees:  
value depends largely on the load profile

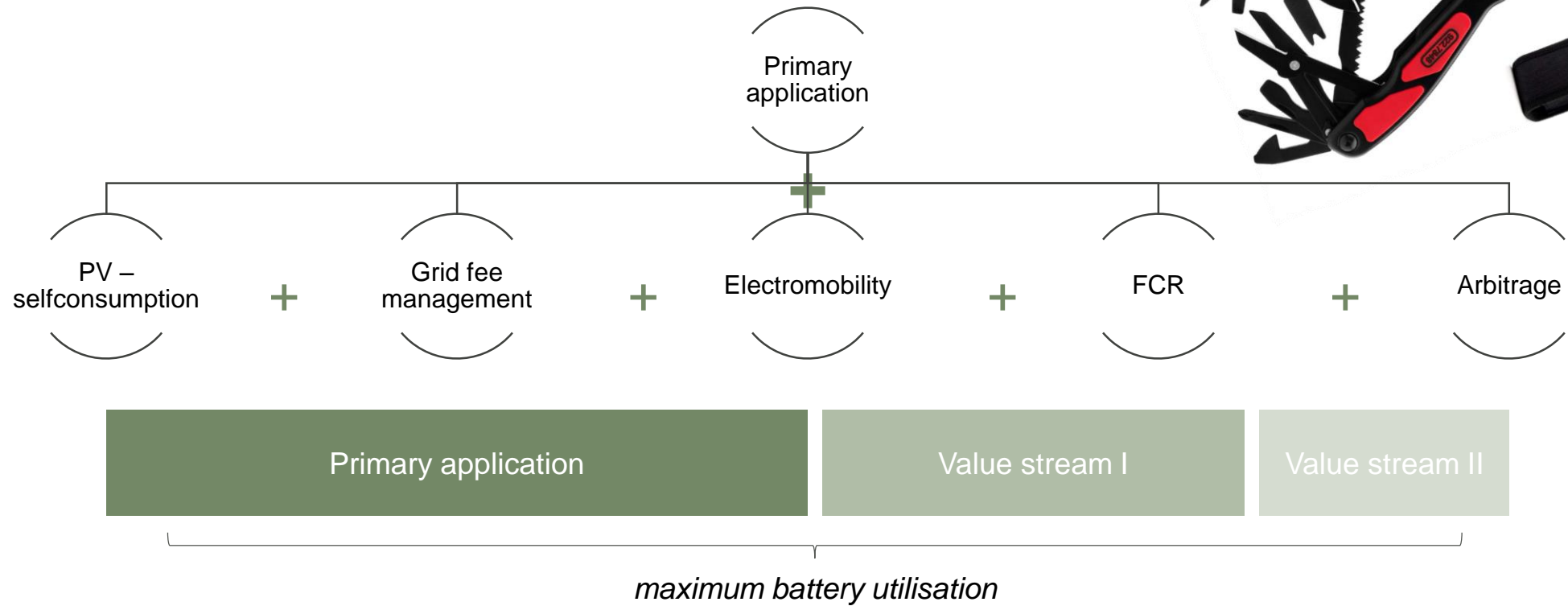
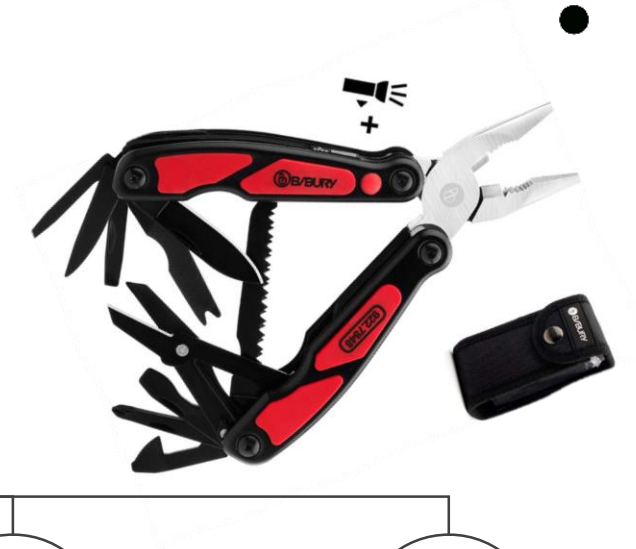
PV:  
Feed in tariff: 0.08 €  
Price Range per kwh: 0,25 – 0,4 €  
Proportion of year with overproduction: 70%

FCR:  
Historical market data 2021 & 2022

Arbitrage:  
Difficult to forecast  
Data based on historical data 2020 / 2021 / 2022

# BESS a Multitool for Multiuse

→ Exploit storage capacity and increase the customer profit



**Maximize the benefits of the storage systems and reduce the payback period by building individual business models**



# MODULAR ENERGY STORAGE

Flexibility made  
simple

