IRENA INNOVATION WEEK 2023

Demand side management and storage:

Case studies

Organised in partnership with

METI
Ministry of Economy, Trade and Industry

27 September 2023 | 10:00-12:00

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Welcome remarks

Hideyuki Umeda
Director for International Policy on Carbon Neutrality
Agency for Natural Resources and Energy
Japan (METI)

IRENA INNOVATION WEEK 2023

Arina Anisie
Analyst Renewable Energy Innovation
IRENA

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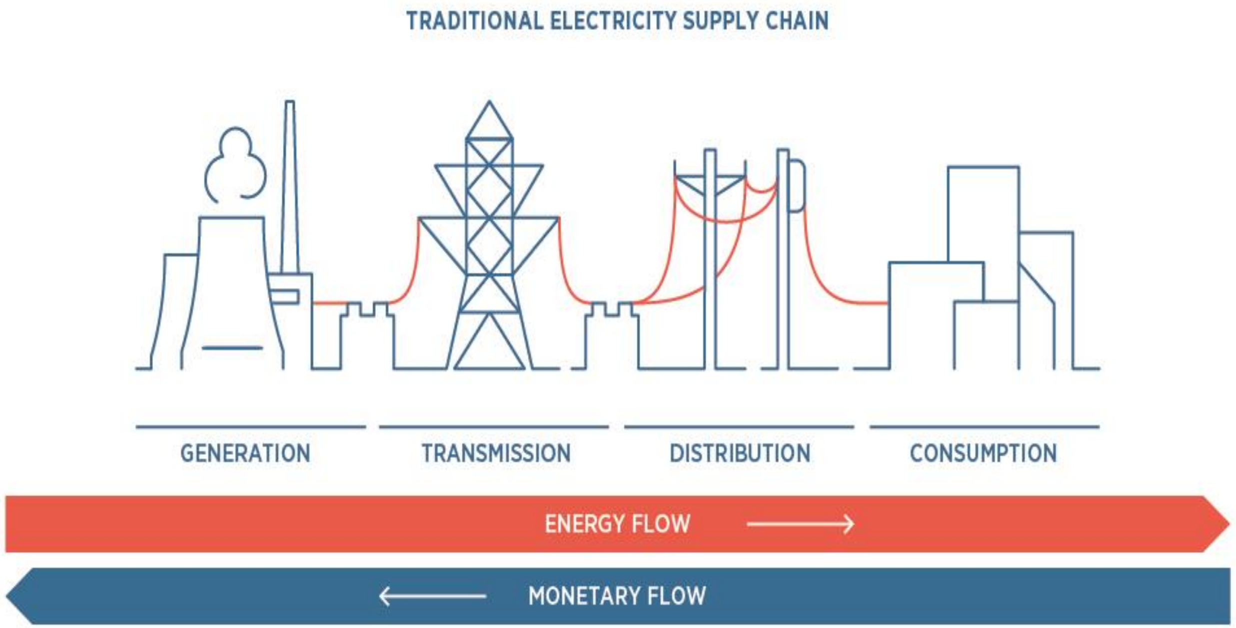
Ongoing Energy Transformation: Flexibility



Flexibility providers in the current system:

Flexible generation

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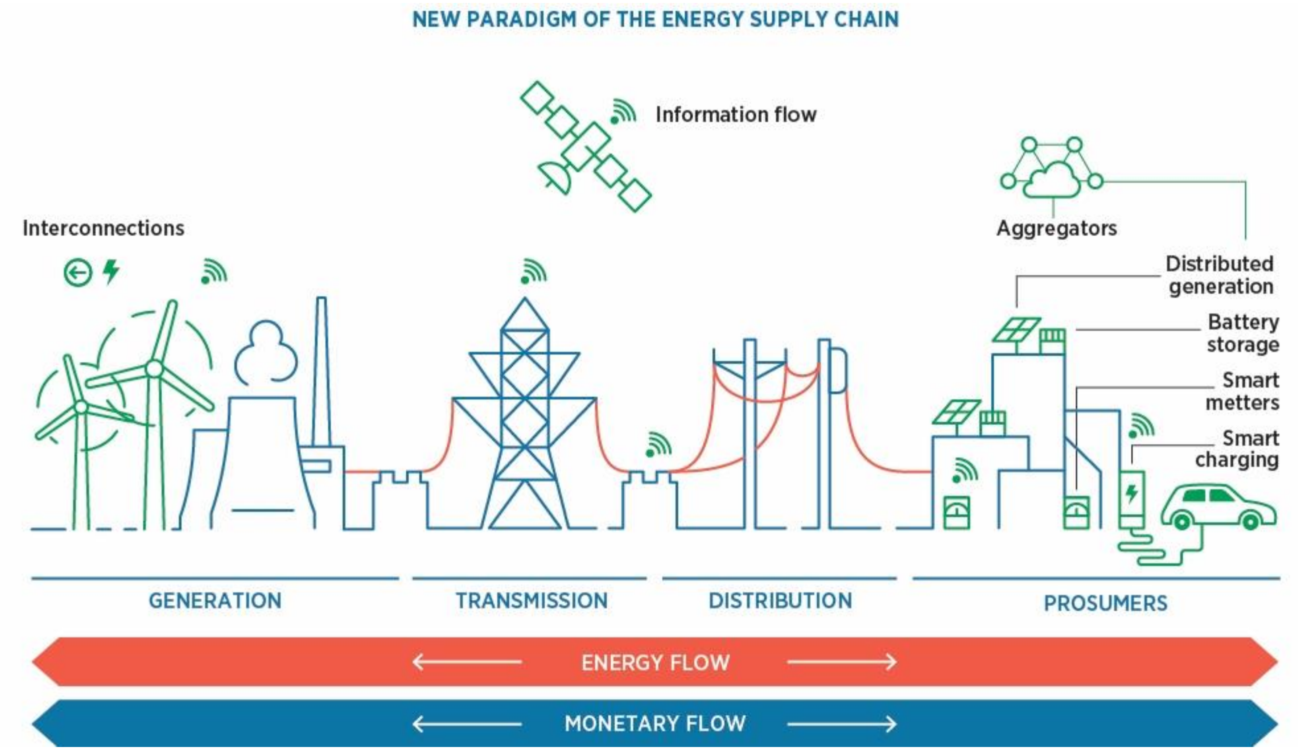
Ongoing Energy Transformation: Flexibility



Flexibility providers in tomorrow's system:

Flexible generation,
Regional markets,
Demand response,
Storage, Power-to-X.

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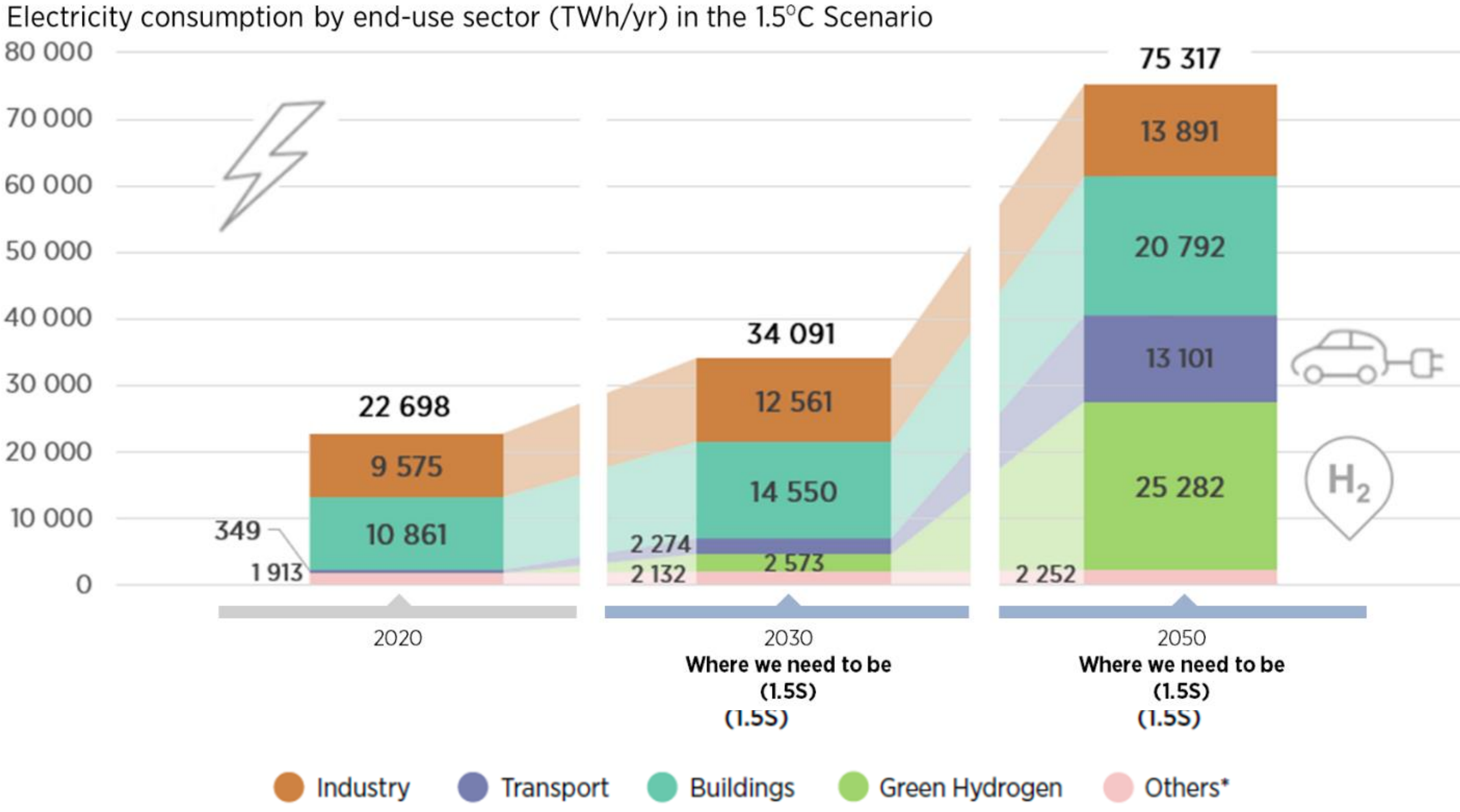
Session Overview

- Setting the Scene
- Case studies from Europe
- Case studies from Asia
- Case studies from US
- Closing Remarks

Impact of demand side management and smart electrification for the power system

Juan Pablo Jimenez
Analyst
IRENA

Context: Massive electrification requires smart approach



Smart electrification enables

(1) power systems to accommodate new loads in a cost-efficient manner and creates

(2) flexibility in power systems, which allows the integration of a larger share of renewables, reduce peak loads, minimise investment needs

(3) the most cost-effective solution for decarbonising these sectors.

Context: Innovation landscape report

- How to electrify end-use sectors with renewable power while minimising the impact on the grid and unlocking flexibility ?
- How to formulate smart electrification strategies suited to each context?

Context: Innovation landscape report: Flexibility at the center

Many innovations in both heating and cooling and transport sector relates to flexibility and demand side management across all dimensions:

Power to mobility

- EV cars and batteries
- Dynamic tariffs
- Smart charging for local/system flexibility.
- Operational flexibility in power systems to integrate EVs
- Management of flexible EV load to integrate VRE
- Management of flexible EV load to defer grid upgrades
- EV aggregators
- Shaving of EV peak loads using DERs

……

Power to heat

- Heat pumps
- Thermal energy storage
- Digitalisation as a flexibility enabler
- Dynamic tariffs
- Flexibility provision for thermal loads
- Flexible power purchase agreements
- Coupling cooling loads with solar generation
- Smart operation with thermal inertia and seasonal storage
- Combining heating and cooling demands in district systems
- Distributed energy resources for heating and cooling demands

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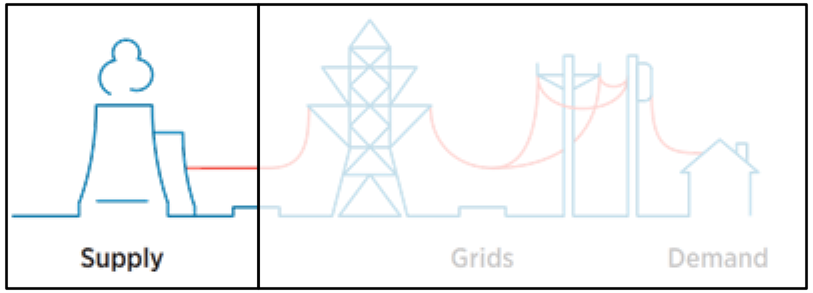
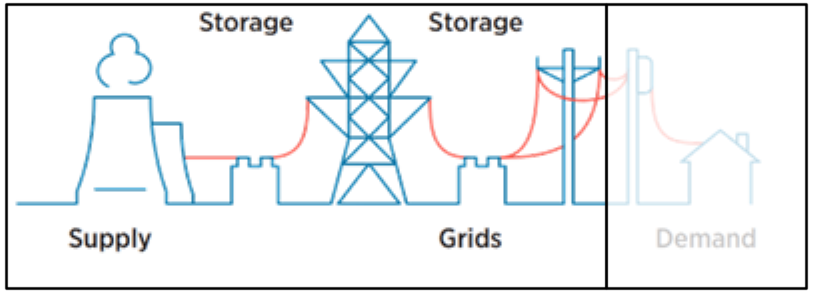
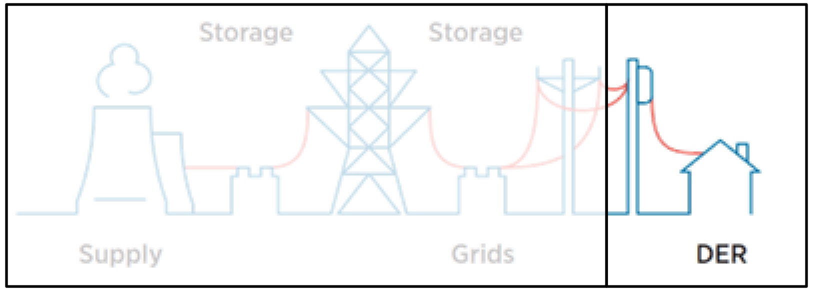
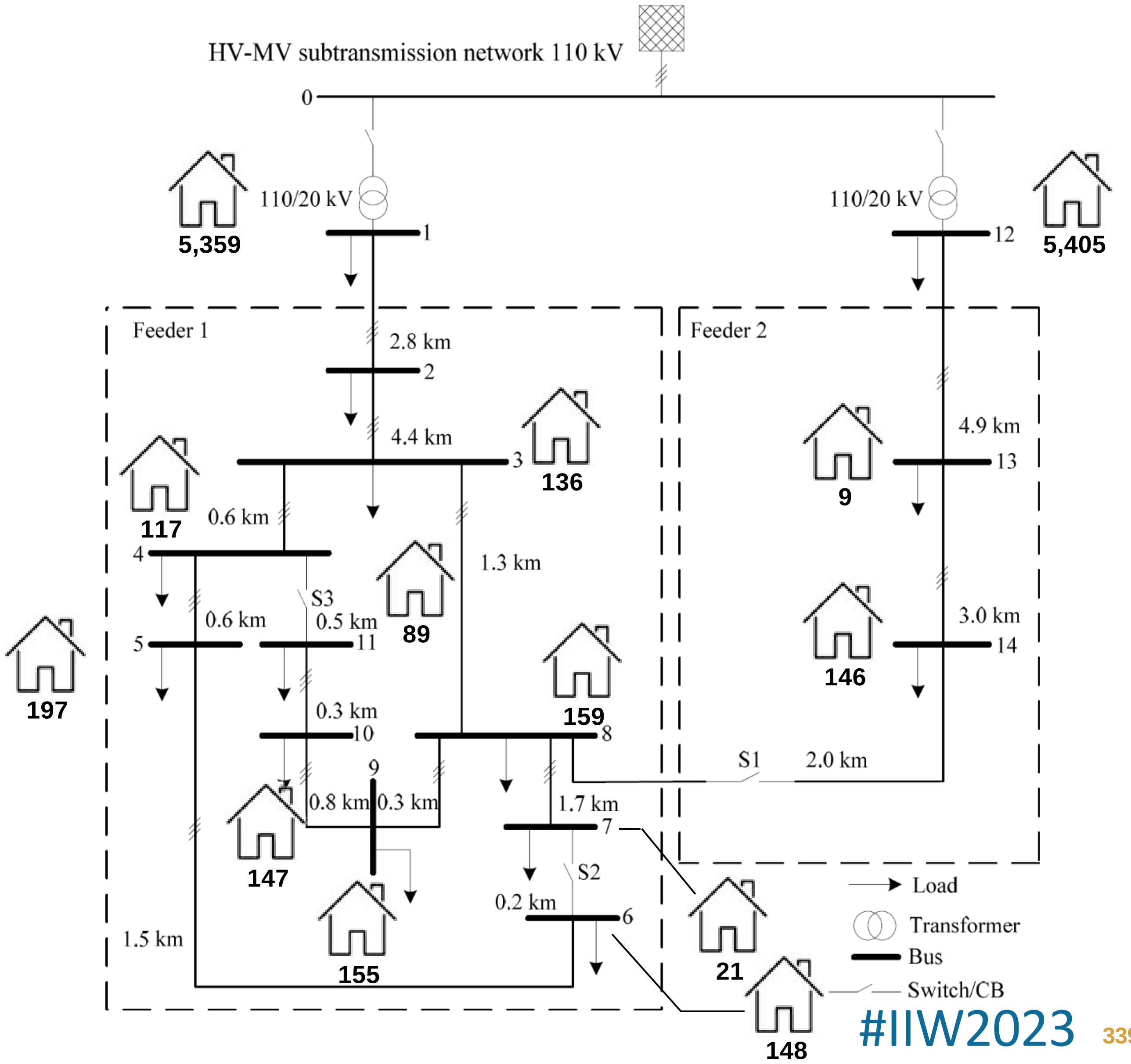
Scope: Distribution grids

<table>
<tr><th></th><th></th><th>Flexibility options</th><th>Assessment</th></tr>
<tr><td>Generation</td><td>
</td><td>▪ Ramp ups/downs
▪ RES curtailment
▪ Hydro</td><td></td></tr>
<tr><td>Transmission</td><td>
</td><td>▪ Power-to-X technologies
▪ Seasonal storage
▪ Large scale batteries
▪ Aggregators</td><td>Cost-benefit analysis on flexibility assets: Power-to-X technologies and sectoral storage</td></tr>
<tr><td>Distribution</td><td>
</td><td>▪ Decentralized energy resources
▪ Power-to-X technologies
▪ Sector coupling storage</td><td>Optimal operation of distribution grids and grid reinforcements</td></tr>
</table>

Case study

- MV network
  - 2 HV/MV transformers (2 feeders)
  - 14 nodes
  - 13 lines
  - 14 nodes with households, EV charging stations, heat pumps, and PVs
- The initial assumption is that demand is uncontrollable
- Demand in all nodes is the cumulative demand of all LV networks connected to that node

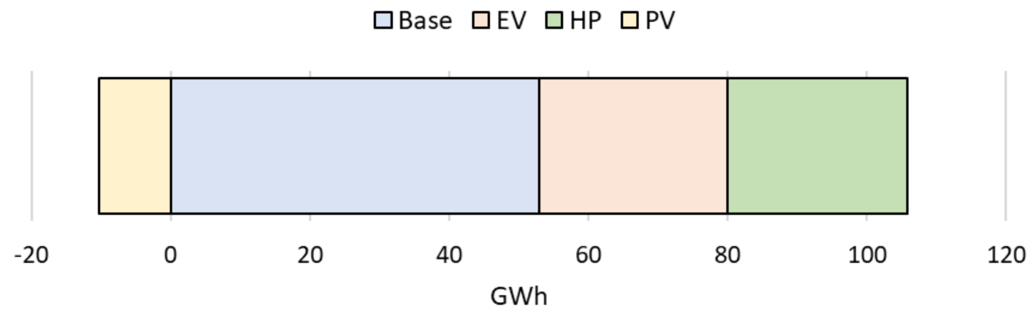


Case study

Number of households, EVs, HPs and PVs in each node

Node	Number of households	Number of EVs	Number of residential HPs	Number of locally installed PVs
1	5,359	1057	3034	1,404
2	0	0	0	0
3	136	27	77	35
4	117	23	66	31
5	197	39	111	51
6	148	29	84	39
7	21	4	12	5
8	159	31	90	42
9	155	31	88	41
10	147	29	83	38
11	89	18	50	23
12	5,405	1067	3060	1,416
13	9	2	5	2
14	146	29	83	38
TOTAL	**12,088**	**2,386**	**6,843**	**3,165**
Number of users	**26,594**			
Installed capacity		kWh	kW	kWp
		95,440	34,215	7,913
Number of units per				
100 households		**20**	**57**	**26**
100 users		9	26	12
Installed capacity per		kWh	kW	kWp
households		7.9	2.8	0.7
users		3.6	1.3	0.3

Energy consumption shares



- According to WETO 2023, the share of demand from electrified transport and **heating** in 2050 will be **73%** of total electricity demand in buildings and 52% in the transport sector.
- In our case study, HPs and EVs represents **52%** of the total electricity demand (53 GWh/yr)
- PV production represents 10% (34% foreseen in 2050) of the total electricity demand (~10GWh/yr.) with a total capacity of 8 MW_p (capacity factor: 14%[1])
- Number of members per household: 2.2[2]

[1] IRENA (2021). Renewable power generation costs in 2021

[2] Eurostat (2023). Household composition statistics

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Scenarios

Scenario	Heat Pump and Thermal Storage	V1G Charging	V2G Charging	Voltage regulation	Rooftop PV
BASE					
ThermalFlex	X				
V1G		X			
V2G			X		
V2G&Voltage Reg			X	X	
SMART	X		X	X	
SMART&PV	X		X	X	X

- Weekly consumption remains the same in all scenarios
- HPs demand can be increased or decreased up to 30% in every time period
- EV batteries capacity (40 kWh)[2]

[2] JRC (2018) Li-ion batteries for mobility and stationary storage applications

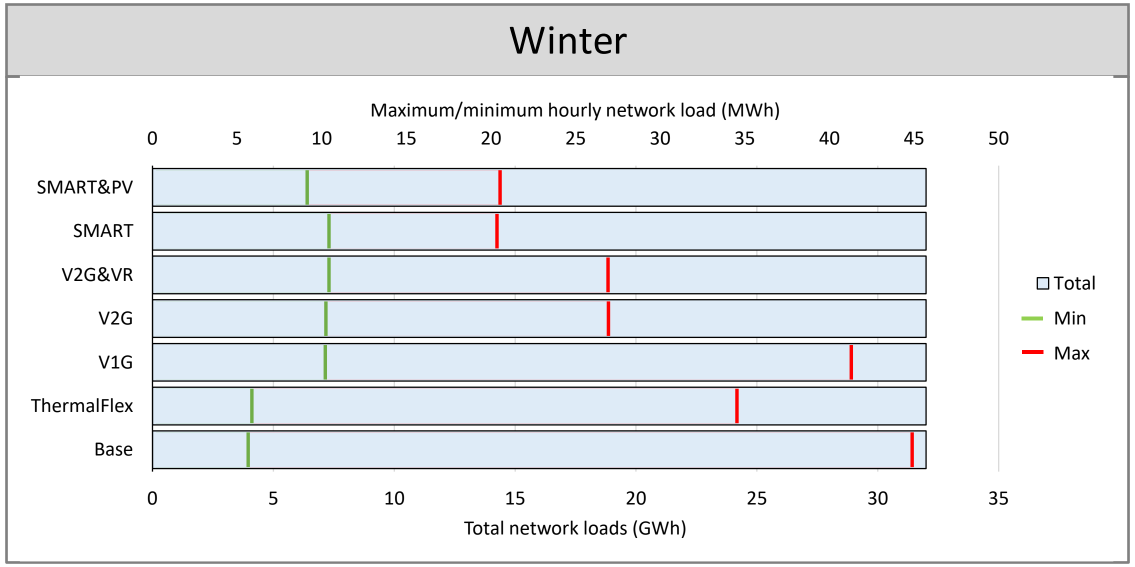
Model description

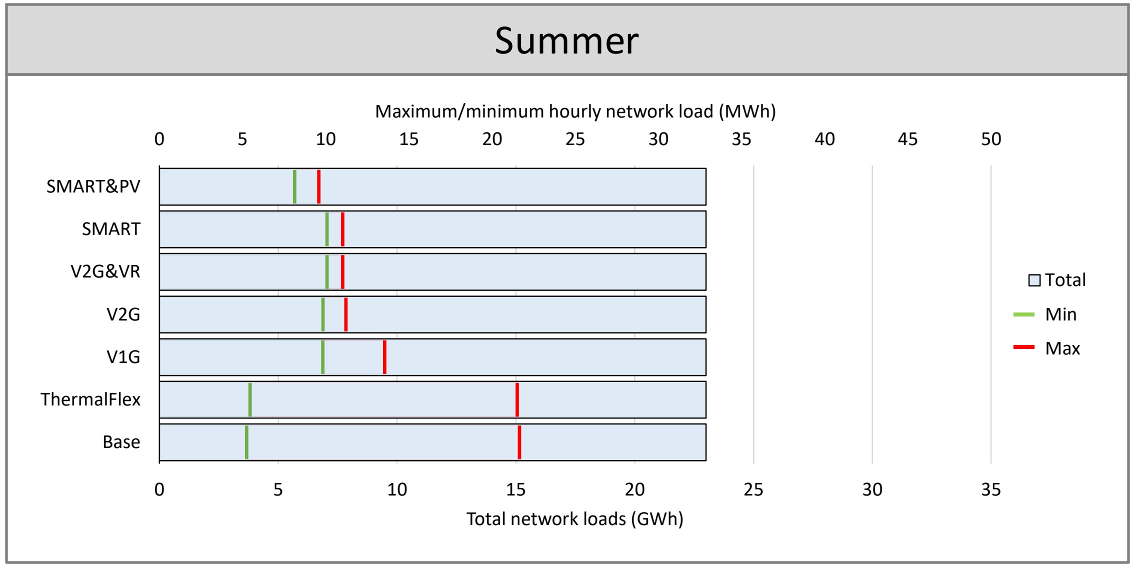
- Optimisation approach for determining the optimal demand dispatch
- Objective function – minimization of total network losses
- Optimal power flow model used in the model ensures minimal network losses without violating any technical constraints:
  - Node voltage magnitude: 90% - 110% of the nominal voltage
  - Power flow through a transformer – defined by transformer's nominal power
  - Power flow through a line – defined by line's capacity

Results – demand profiles

- Less fluctuations in the use of electricity grids, which leads to lower network losses.
- Flexibility is used to cover peak demand, and this is especially the case with local generation from EV batteries and PVs.
- Decoupled of PVs and demand. Roughly no contribution to reduce peak loads but on the lower demand ranges in winter.
- Heat pumps ramp up and down capabilities has no effect in summer.

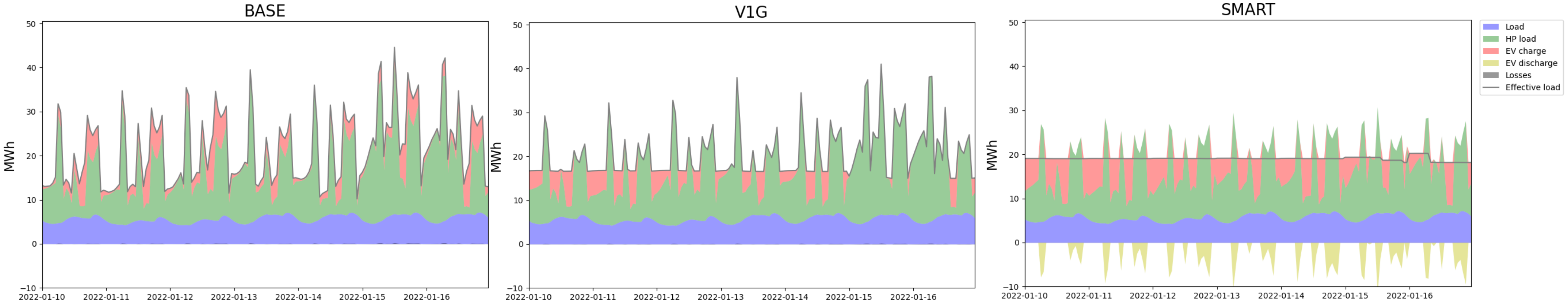
SMART&PV: **50%** peak demand reduction both in summer and winter

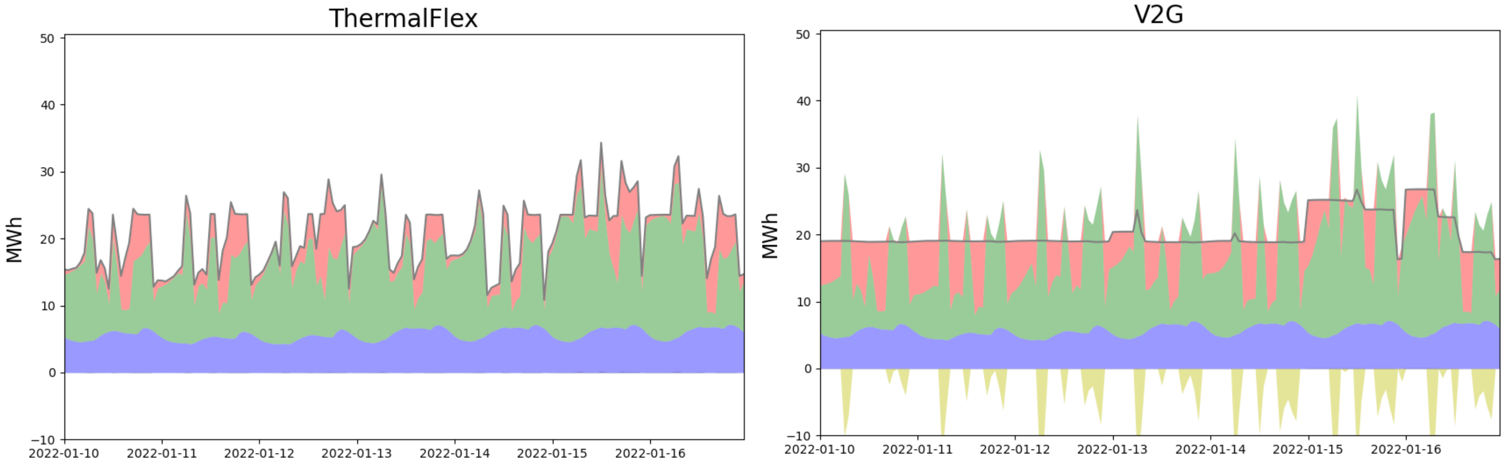




Results – demand profiles

Week in winter



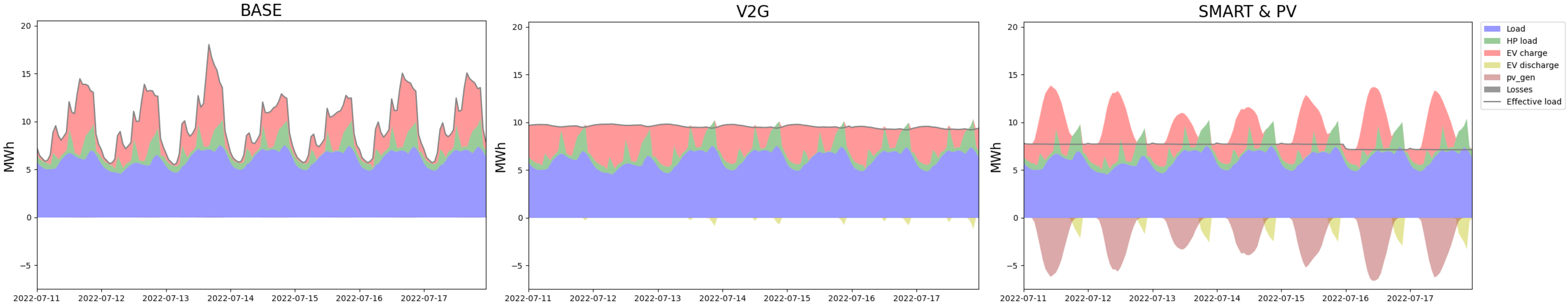


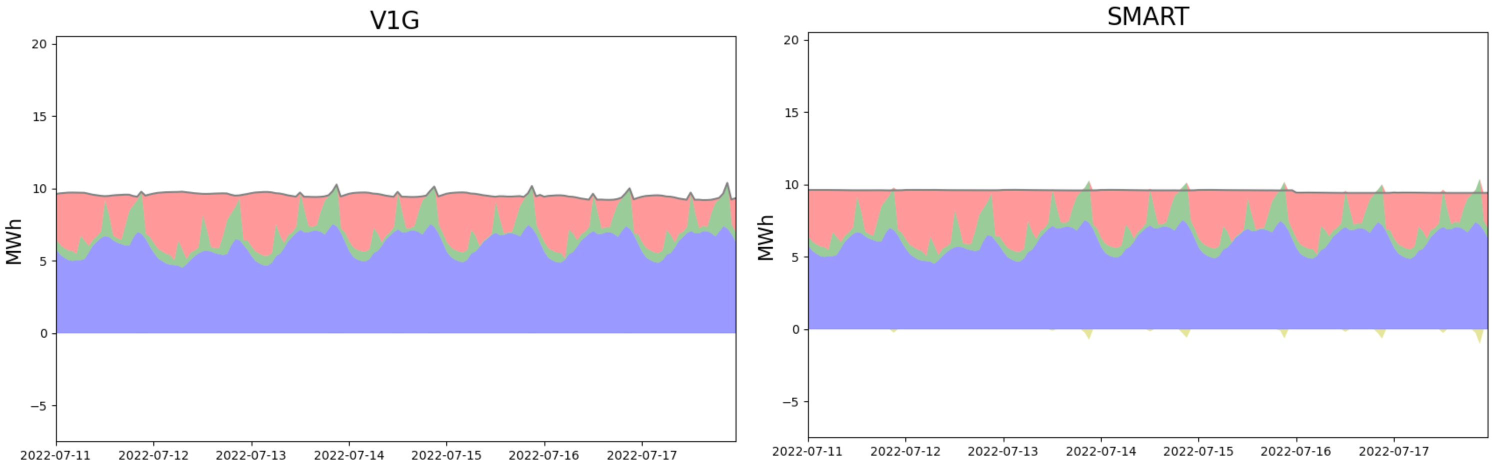
Key messages

- Flattening the demand curve
- Covering the peaks with local generation - HP load is absorbed by +/- 30% ramp up and EV discharging – reduction of 50% in peak demand

Results – demand profiles

Week in summer





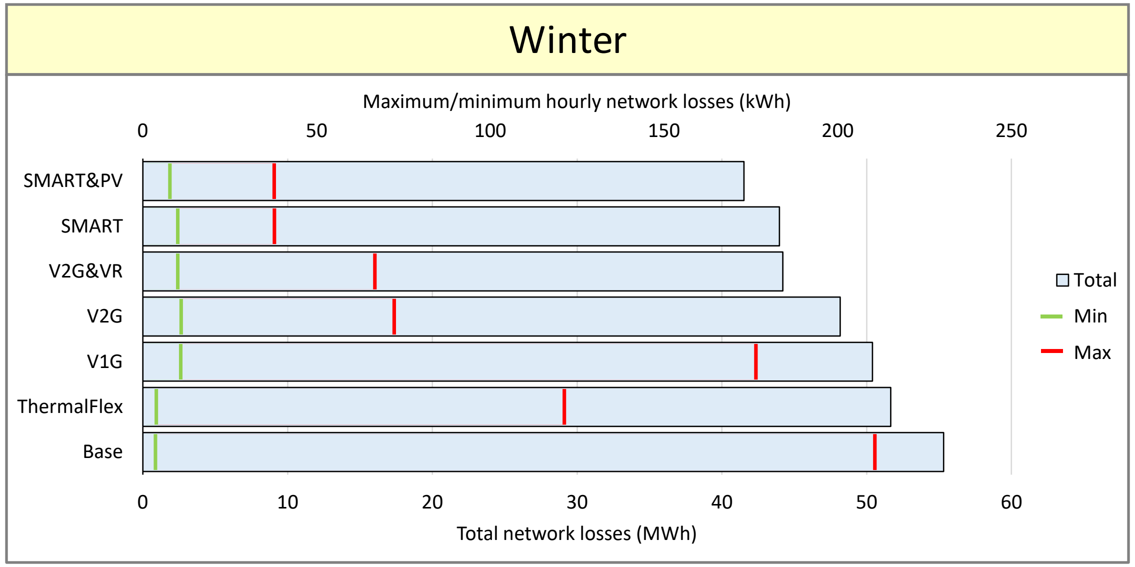
Key messages

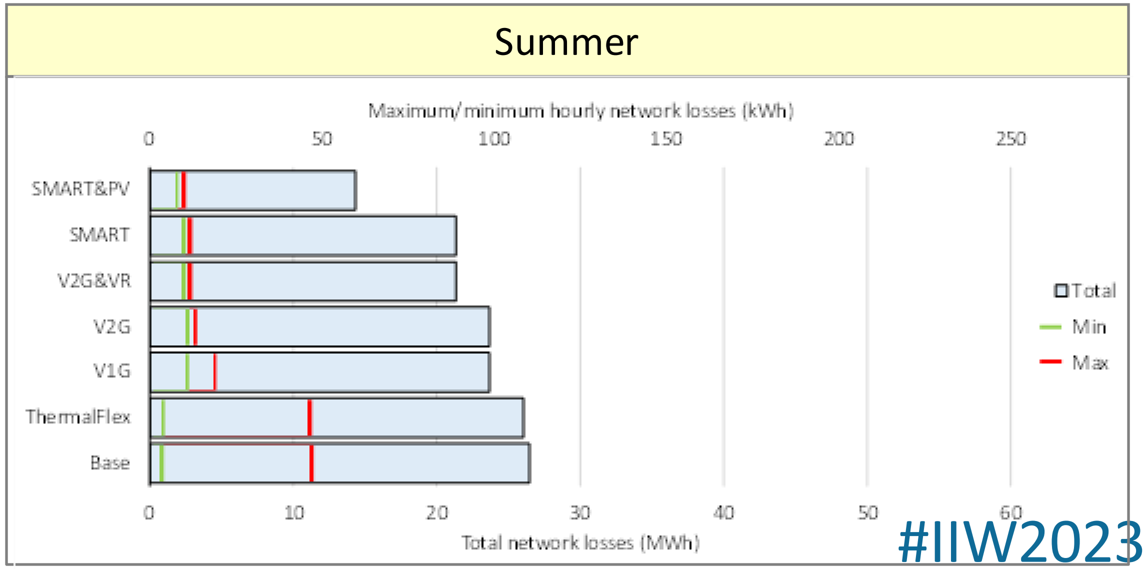
- PV production additionally decreases peak demand for more than 10 MW but also lowers the minimum demand
- Heat demand is not significant and therefore, there is less EV discharging when compared to winter

Results – network losses

- **High correlation** between demand profile and network losses → same conclusions
- Decreasing network losses is even more important than flattening the demand curve → economic cost of losses
- Smart electrification narrows the range of losses values, i.e., minimum and maximum values are closer to each other
- In summer months, minimum and maximum losses are almost the same → the network losses curve is a straight line

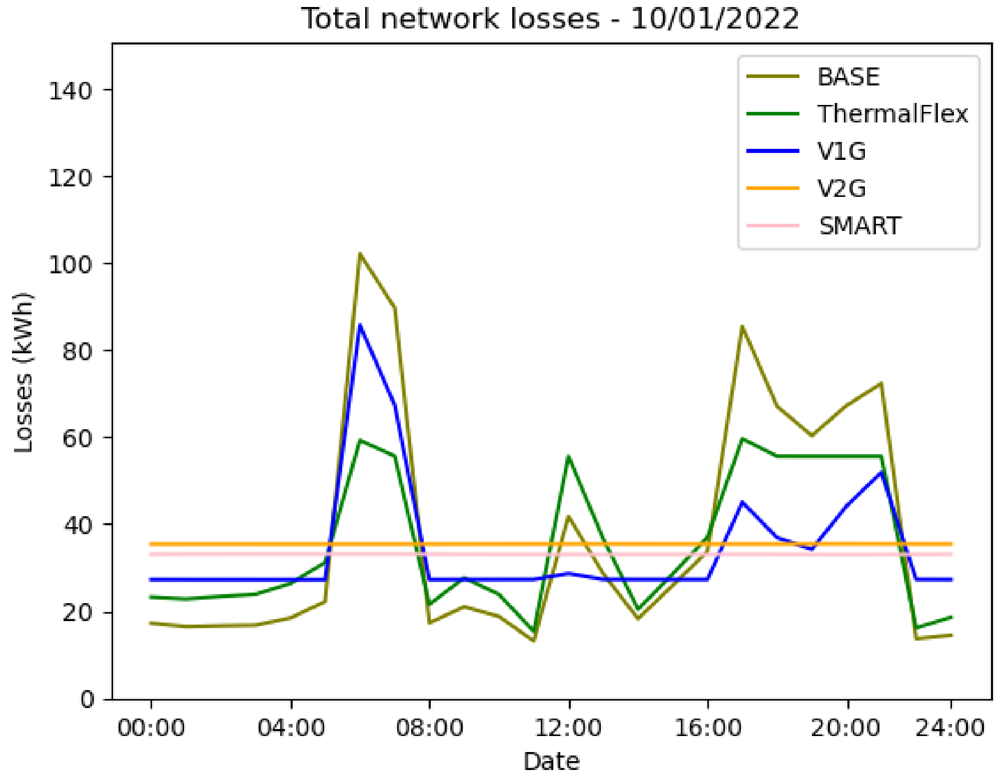
SMART&PV: **25%** losses reduction in wintertime



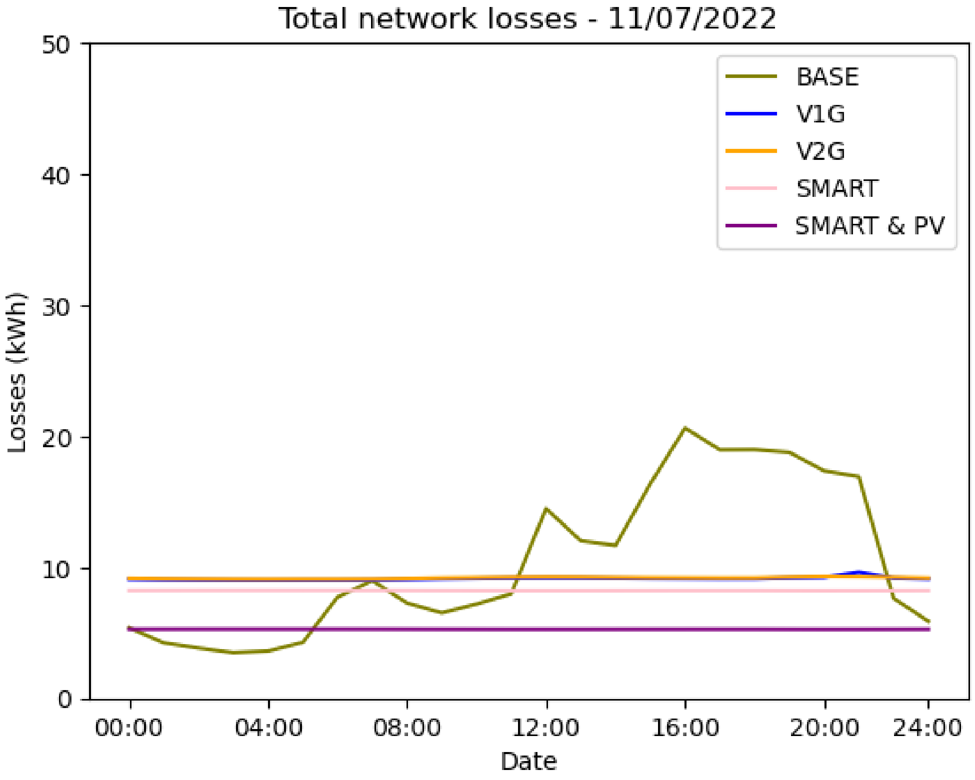


Results – network losses

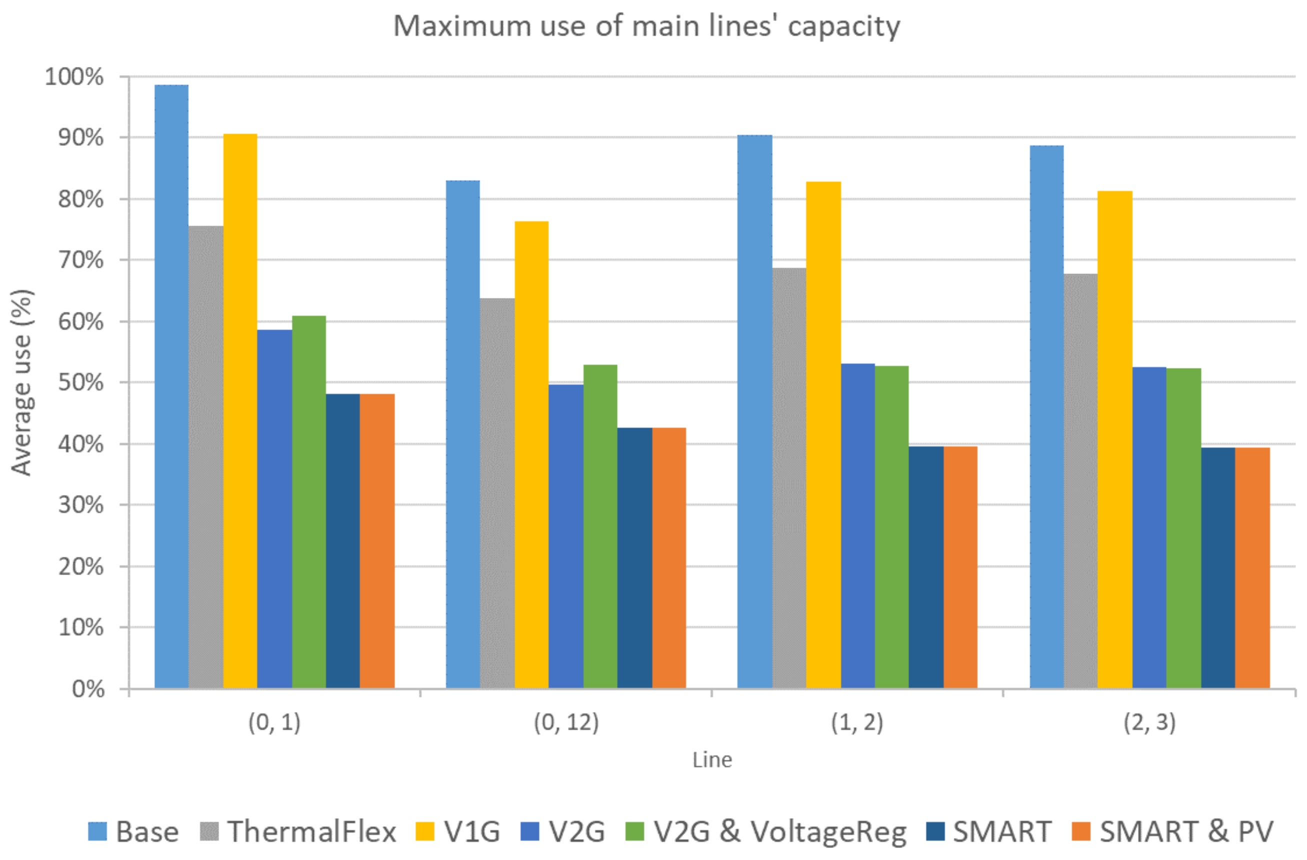
Winter

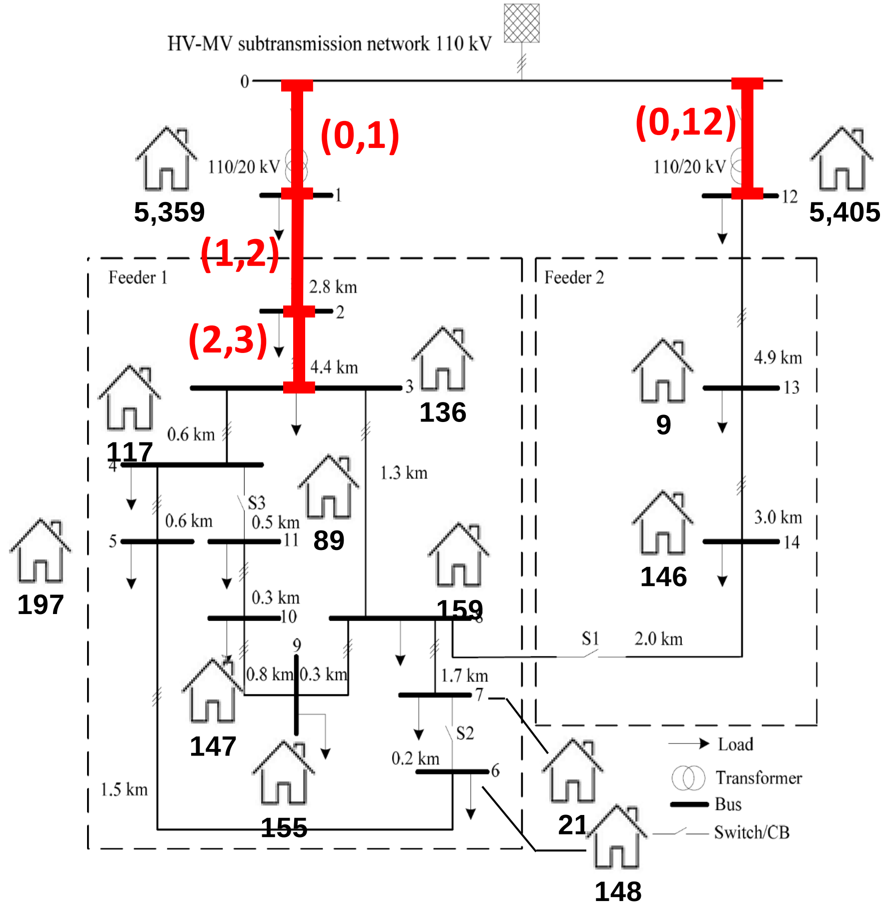


Summer



Results – power flow: use of lines





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Results – investment analysis

Line	Maximum use (%)	Length (km)	Capacity (MVA)	New capacity (MVA)	Cost of replacement (€)
0-1	98.71	/	25	50	≈ 800,000
0-12	82.98	/	25	50	≈ 800,000
1-2	90.37	2.82	5	10	65,000 - 215,000
2-3	88.67	4.42	5	10	105,000 -335,000
				TOTAL	≈2 000 000

Assumptions:

- All elements with the maximum use capacity higher than **80% will need to be replaced in a short time**
- The cost of transformers with nominal capacity 15 MVA – 50 MVA is around 800,000 € [4]
- The cost of underground cable per kilometer is between 30,000 and 75,000 euros [5]
- The cost of overhead line per kilometer is between 24,000 and 45,000 euros [5]

Key messages

- Smart electrification decreases maximum use of lines and transformers, no matter the scenario but combined they have an addition effect
- It allows postponing the investment and **save up to 2,000,000 € (or for system operators**

[4] Power Transformer: Learn the Purpose, Cost, and Lead Time to Procure
[5] How much does it cost to run a new electrical service line?

Thank you!

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Demand side management and storage: Case studies from Europe

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Emanuele Taibi
General Manager – Italy
Field

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The role of storage for power system decarbonisation

Emanuele Taibi, PhD
General Manager, Field Italia

FIELD

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Outline

01 Introduction to Field

02 Balancing demand and supply

03 Energy storage on the demand side

04 Policies and regulations to promote local balancing of demand and renewable supply

05 The need for utility-scale electricity storage

06 Market vs regulated solutions: UK and Italy

07 Real-life storage performance in the UK

08 Recommendations for successful storage market design and implementation

Field develops, builds and operates the renewable energy infrastructure needed to support the grid to get to net zero

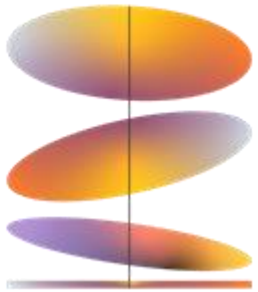
We are building a vertically integrated infrastructure business that will help to solve the urgent climate crisis.

We are starting with short duration battery storage, but want to play a broader role in the GB energy transition.

1

Develop

We develop projects ourselves from scratch, carefully assessing how our project will support the grid. We work directly with key counterparties throughout the project lifecycle, with one POC.



2

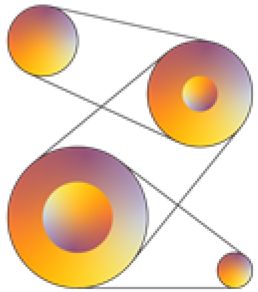
Build

Whilst we outsource construction to third party contractors, we have high quality in-house project managers and HSE oversight, ensuring our projects are delivered to schedule, and safely.

3

Operate

We have an in-house technology team building our own connection and optimisation platform, called Gaia. Defining trading actions, and providing better operational data/oversight.

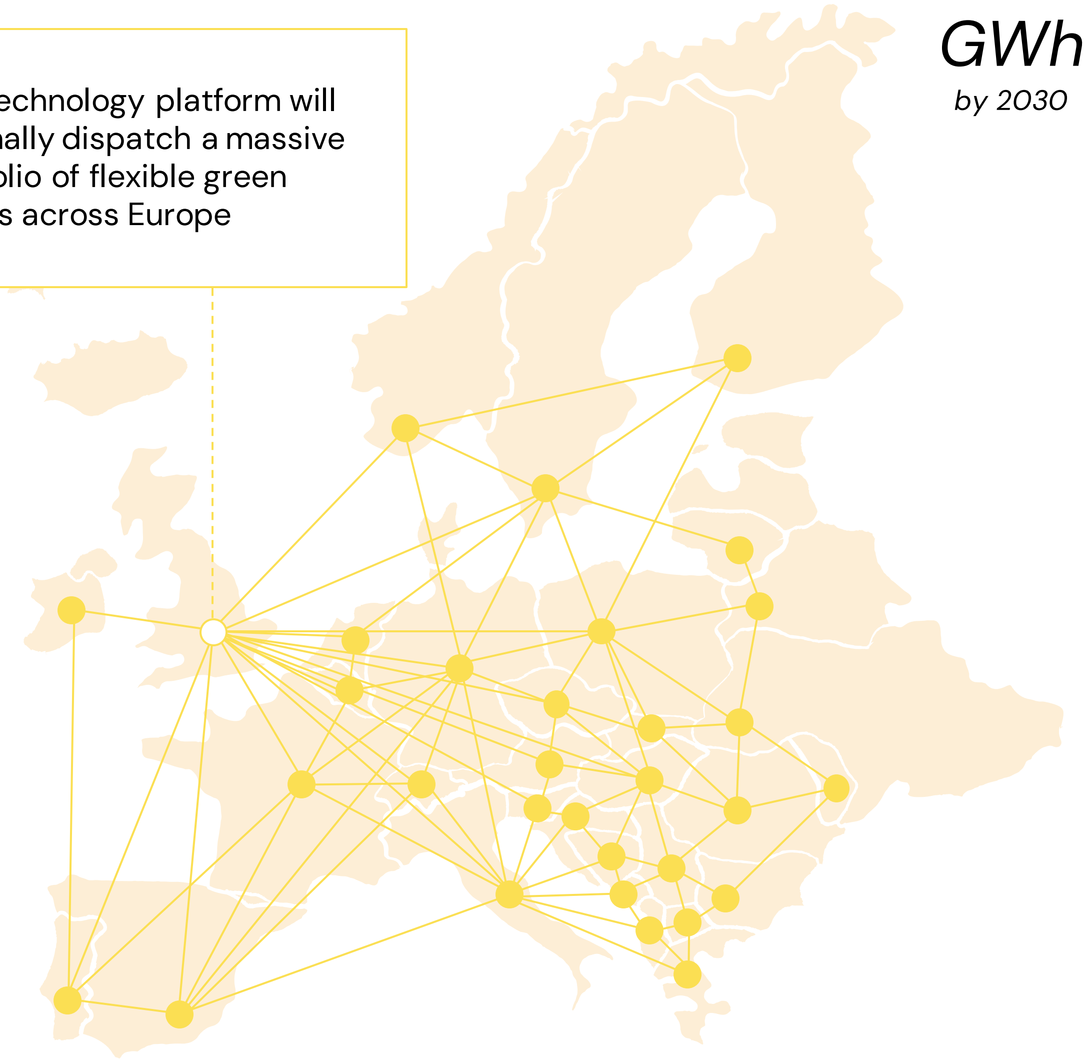


Field's vision is to become *the* renewable energy infrastructure & trading company of the future

We are starting with battery storage in the UK – but we are on a path to becoming a major vertically integrated flexibility player.

WE WILL OWN AND OPERATE A MASSIVE PORTFOLIO OF GREEN ASSETS ACROSS EUROPE

Our technology platform will optimally dispatch a massive portfolio of flexible green assets across Europe

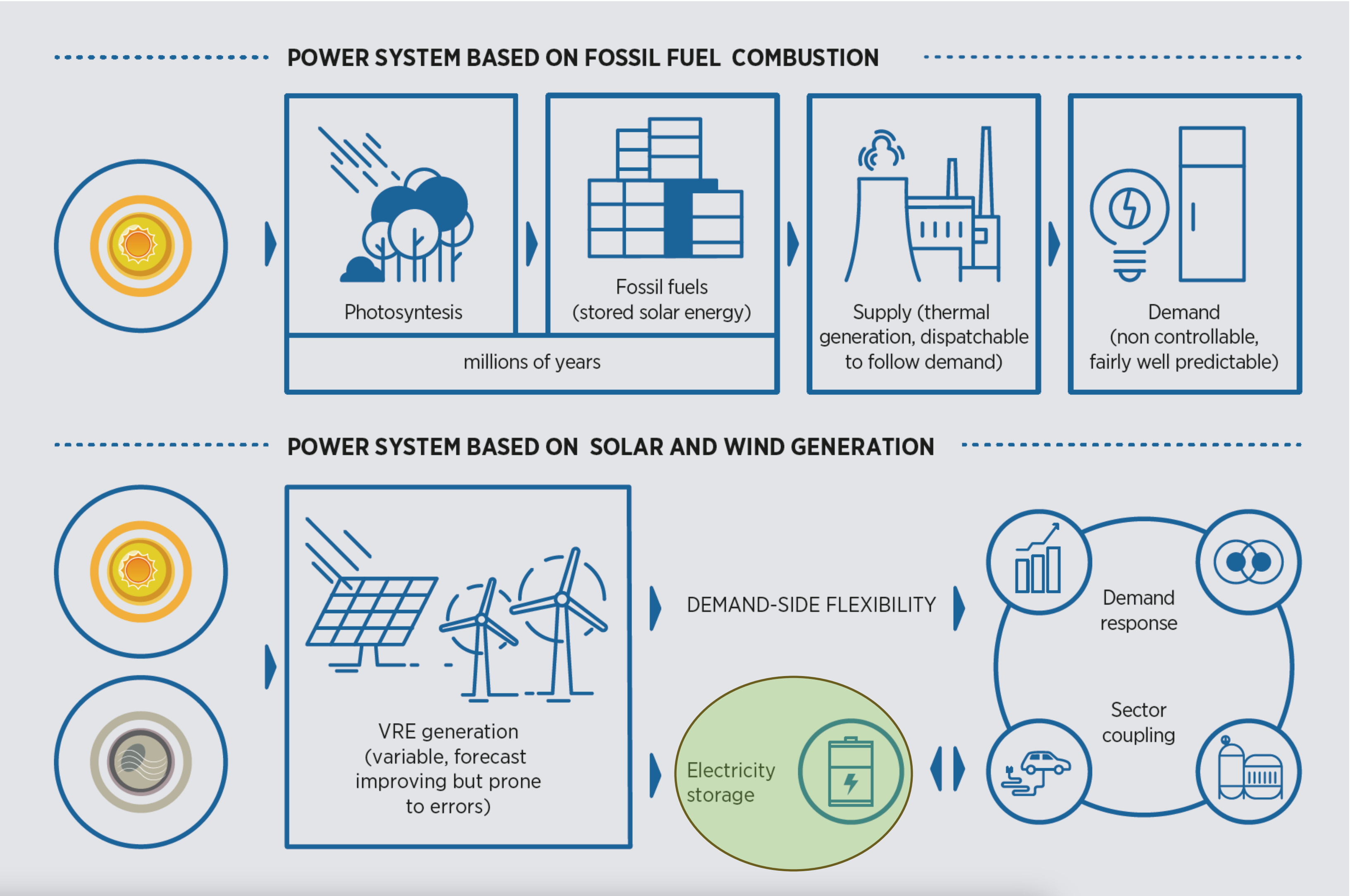


11–12 GWh by 2030 ↗ **60–70** million tonnes of CO_2e saved over 20 years[1]

- Short duration storage
- Co-located storage
- Long duration storage
- Hydrogen storage?
- Carbon capture?

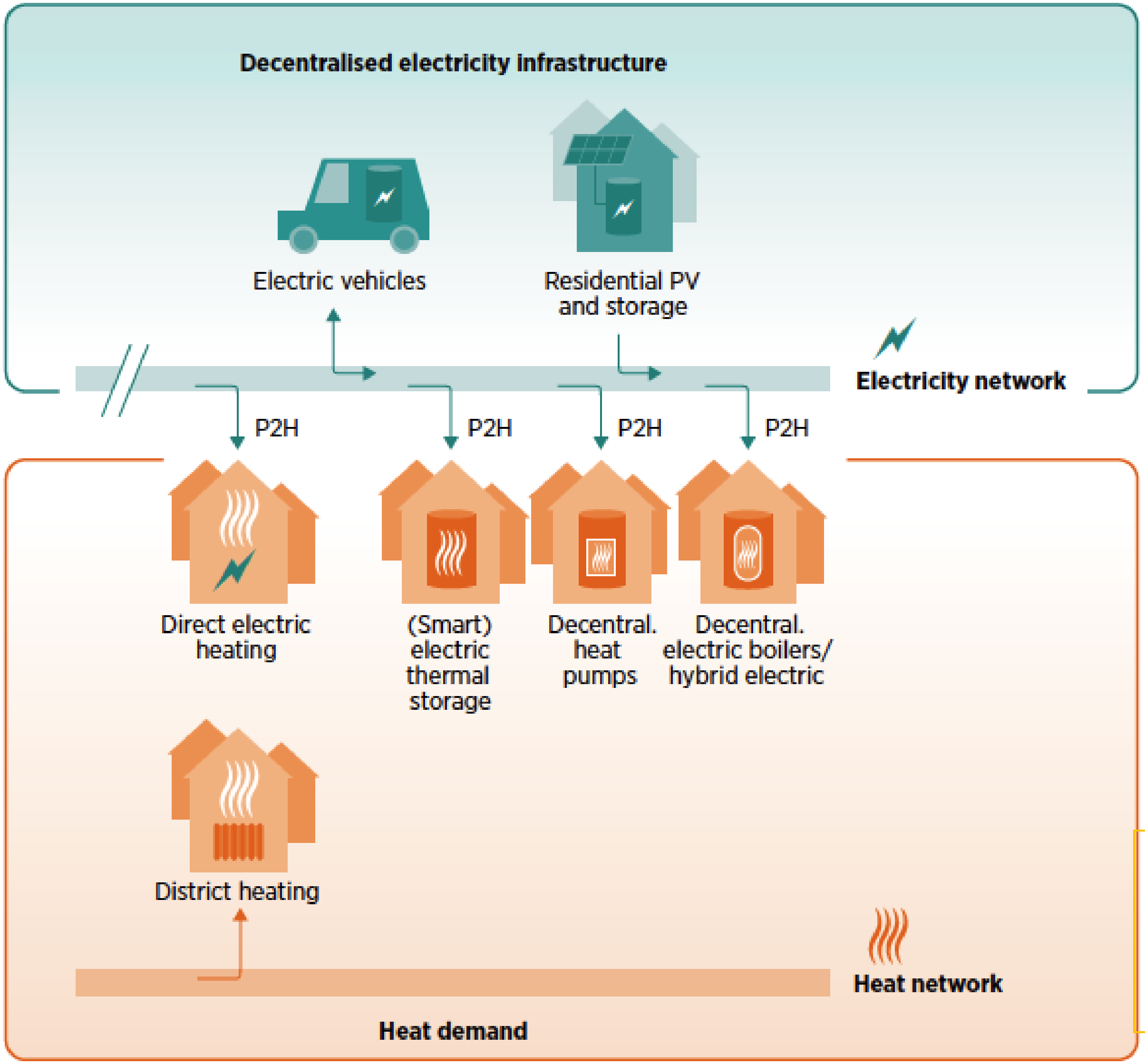
[1] Uses figures from Field's Oldham CO2e cradle-to-grave life-cycle assessment (independently verified by DNV), and applies the annual average CO2e saved/MWh to 12 GWh of assets over 20 years. 11-12 GWh figure includes GB and Italy pipeline's only

2. Balancing demand and supply



Source: Demand-side flexibility for power sector transformation. IRENA, 2019
https://www.irena.org/Publications/2019/Dec/Demand-side-flexibility-for-power-sector-transformation

3. Energy storage on the demand side



Source: Innovation outlook: Thermal energy storage. IRENA, 2020
https://www.irena.org/Publications/2020/Nov/Innovation-outlook-Thermal-energy-storage

- Battery storage is already being deployed in largest volumes in EVs -> key to make sure this is a source of flexibility
- Increasingly, residential, commercial and industrial PV systems are deployed with battery storage to maximise self-consumption
- Significant volumes of thermal energy storage exist in (electric) hot water tanks, rarely controllable to provide flexibility to the system
- Heat pumps are going to be the main driver of thermal storage deployment, increasing the size of hot water tanks
- District heating, when powered by heat pumps and resistors, can provide very large volumes of thermal storage

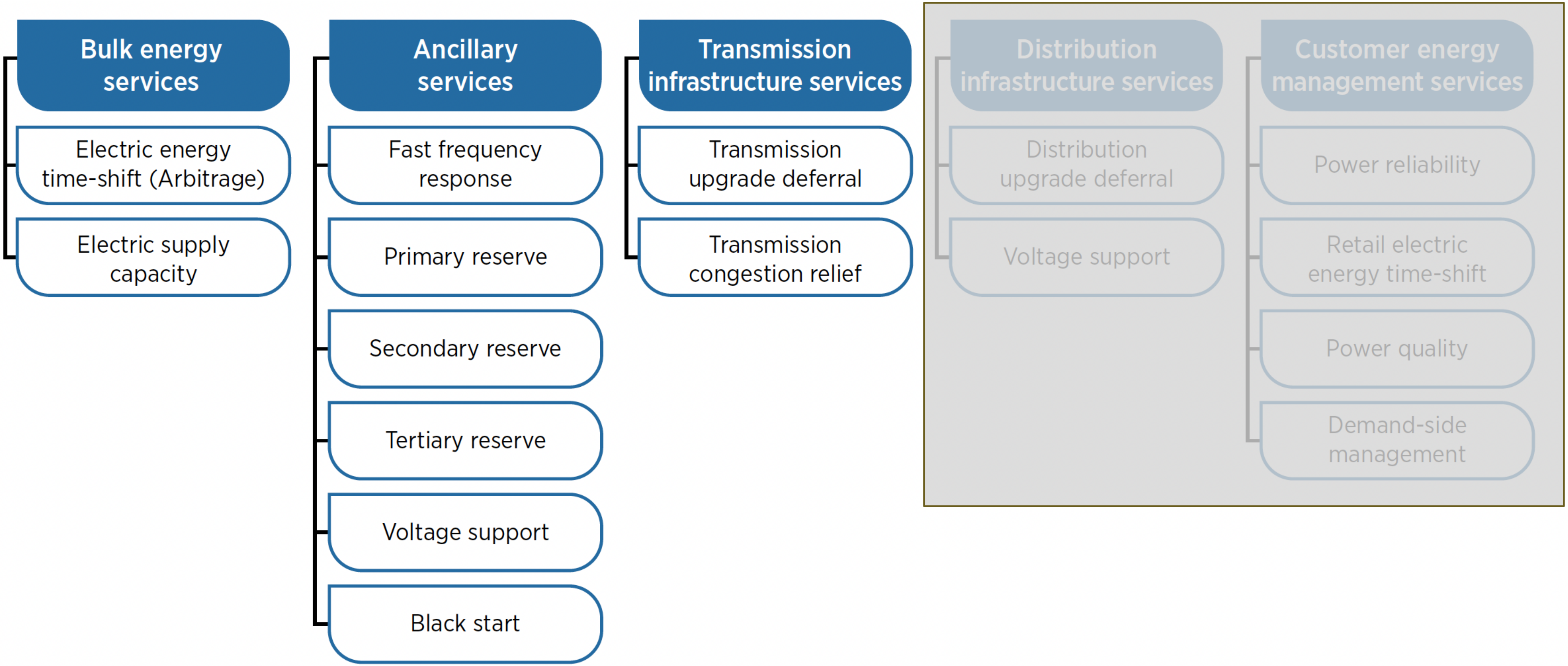
All these energy storages are largely uncontrollable today!

4. Policies and regulations to promote local balancing of demand and renewable supply
Energy communities in Italy

Electricity consumers can now join each other to produce locally, through renewable sources, the electricity necessary for their needs, 'sharing' it. This is thanks to the entry into force of the **decreto-legge 162/19 (articolo 42bis)** and following regulations like **delibera 318/2020/R/eel** from ARERA and
DM 16 settembre 2020 from the Ministry of Economic Development

Source: TP24.it
https://www.tp24.it/immagini_articoli/10-08-2022/1660119495-0-rinnovabili-oltre-300-comuni-fanno-istanza-per-creare-comunita-energetiche-in-sicilia-nbsp.jpg

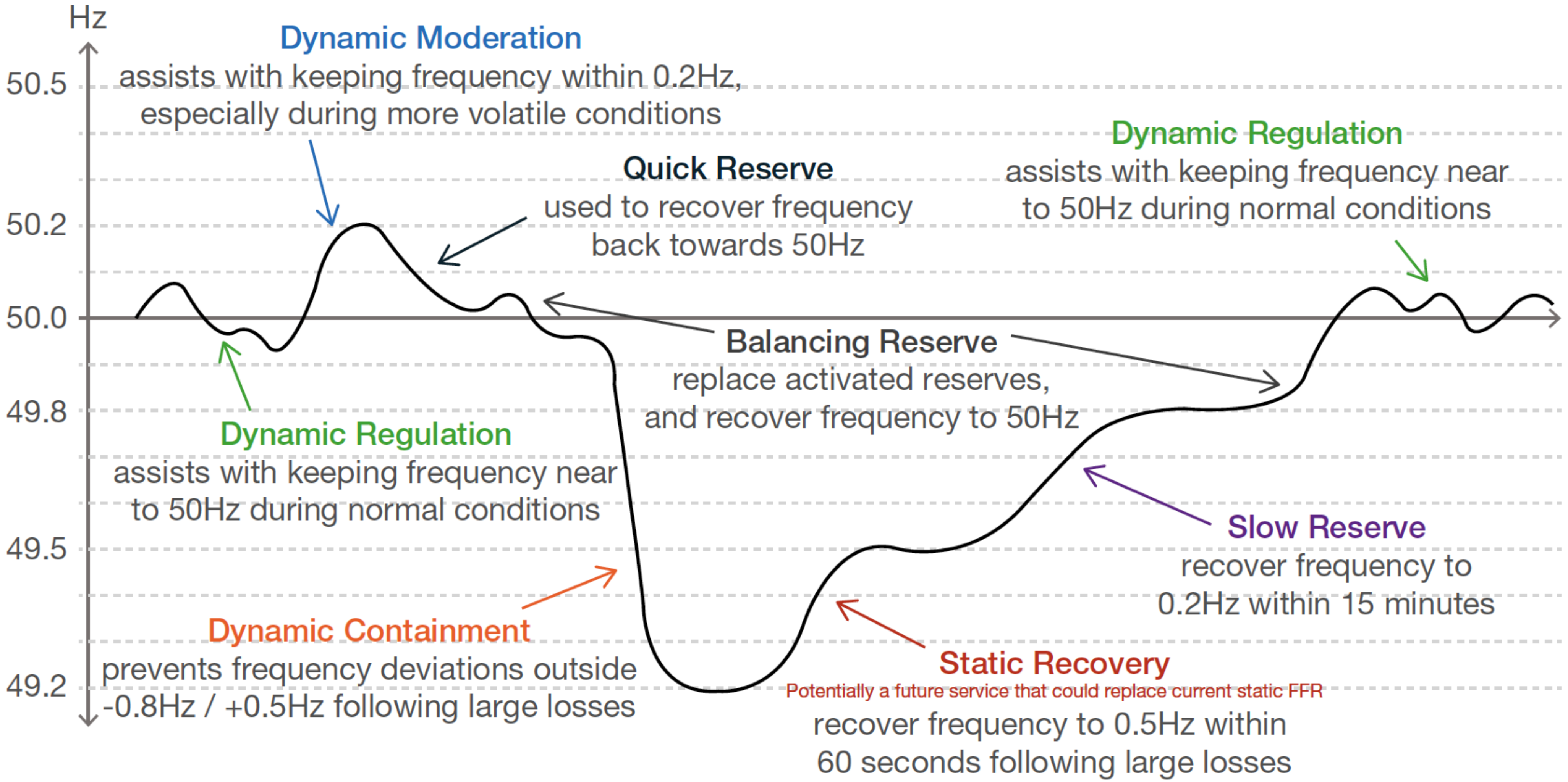
5. The need for utility-scale electricity storage



Source: IRENA, 2020
https://www.irena.org/publications/2020/Mar/Electricity-Storage-Valuation-Framework-2020

6. Market vs regulated solutions: UK and Italy

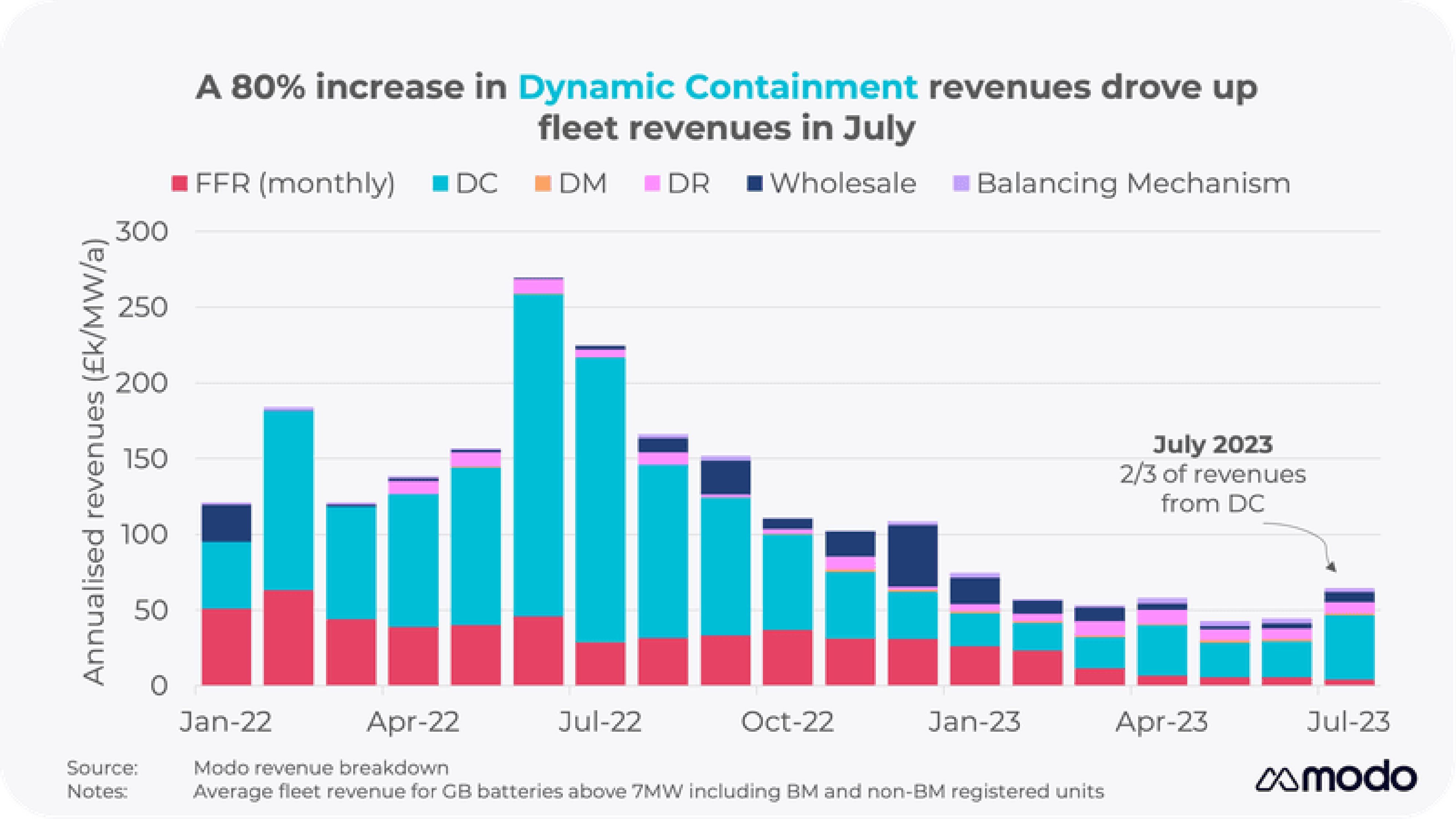
Evolution of grid services in the UK



Source: NGESO Markets Roadmap 2023 https://www.nationalgrideso.com/document/278301/download

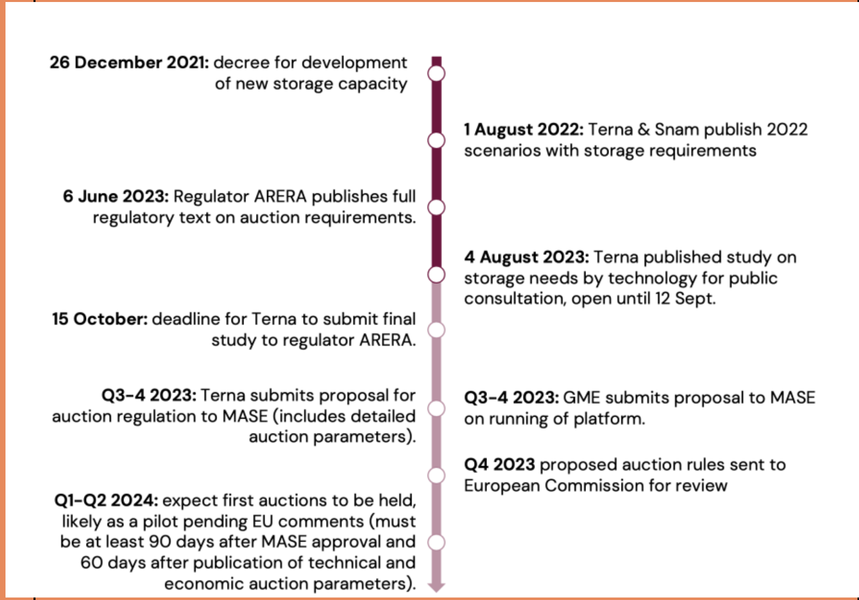
6. Market vs regulated solutions: UK and Italy

Stacked revenues for storage assets in the UK: the importance of grid services for storage



Strong momentum on storage time shifting auctions in Italy

first pilot auction expected in Q1-Q2 2024



↗ [ARERA 247/2023]

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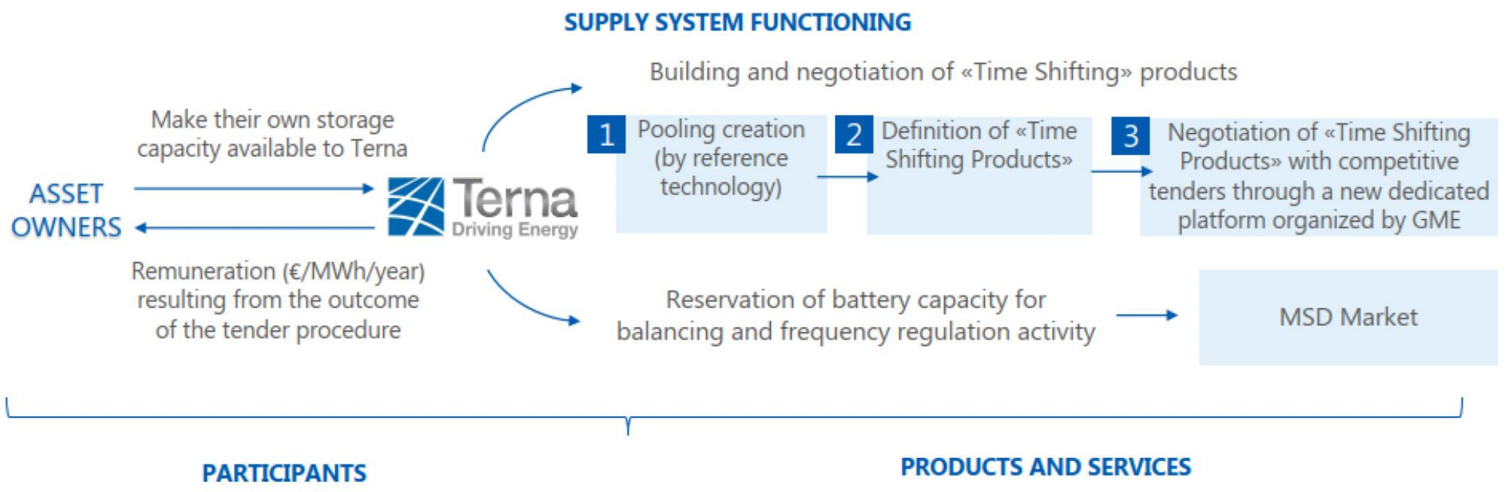
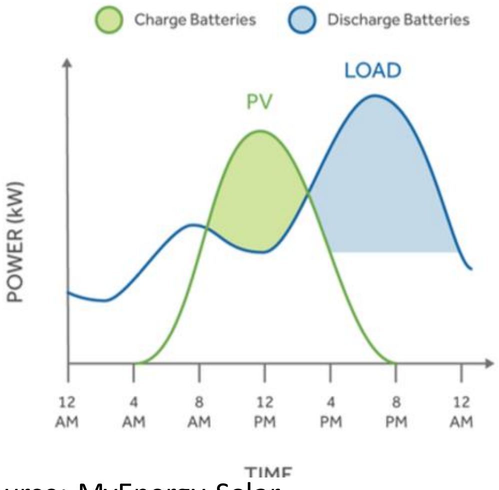
6. Market vs regulated solutions: UK and Italy

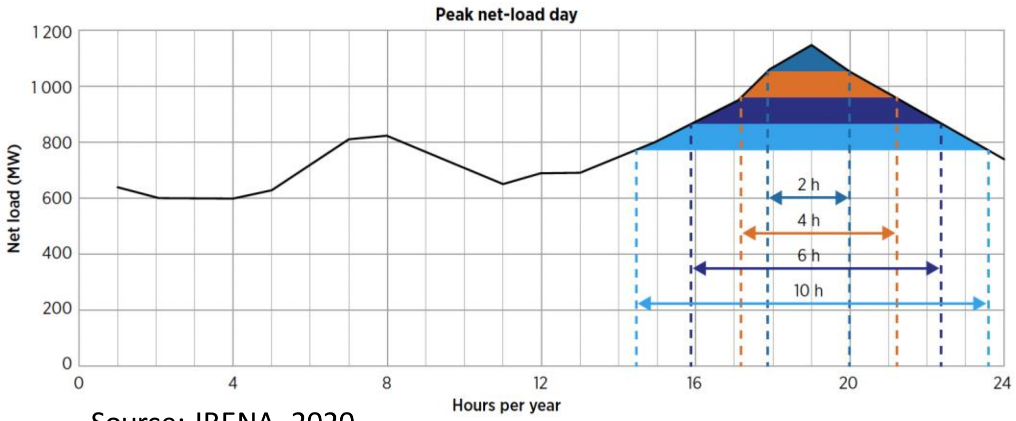
New mechanism for storage procurement developed in Italy



Source: Fichtner, 2023



Source: MyEnergy Solar, https://www.myenergysolar.com.au/hybrid-energy-systems



Source: IRENA, 2020 https://www.irena.org/publications/2020/Mar/Electricity-Storage-Valuation-Framework-2020

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Reducing the cost of net zero, depends on increasing revenue certainty

CONTEXT

- Most net zero infrastructure has high upfront costs and low opex
- Financing is one of the biggest costs, especially for smaller companies who can't use their balance sheet (e.g raising money via bonds) to finance projects
- Financing costs depend on ***perceived risk*** → high revenue uncertainty → high interest rates → high financing costs
- Technology risk has fallen away – now all about ***certainty of income***
- Storage provides both wholesale, ancillary and network services
  - Wholesale – deeper market but high uncertainty
  - Ancillary services (response/reserve) – saturation
  - Network – shallow market / highly locational yet high value in terms of avoided network cost

Ideas of how to reduce risk for flexible assets, whilst supporting the grid

1	Longer contract durations	• Stability Pathfinder Phase II & III good examples - although some issues with revenue stacking • Art. 18 in Italy
2	Low carbon flexibility market	• Flexibility is inherently duration limited, but still has a big role to play • Critical is speed of response and ramping up quickly when needed, and ramping down quickly when not – UK dynamic service

3	Non-wire solutions to network constraints	• Cost of energy falling yet cost of transporting it rising
		• Need massive focus on non-wire solutions/network deferral.
		• TSOs not incentivised to look at non-wire solutions (needed at all voltage levels)
		  ◦ Storage ideal for network asset deferral at lower voltages
		  ◦ Difficult at transmission voltages due to much higher energy volumes but can still help - e.g run closer to system limits, use of Dynamic/seasonal Line ratings to remove uncertainties in short time scales / remove rotor angle stability limits

4	Recognise multi-service potential of assets	• Recognise underlying potential of assets rather than looking service by service - otherwise risk building assets (e.g. synchronous compensators) which only get used for quarter of asset life • TSOs needs to look at what will be built ***anyway*** and how it can be used. • Need to avoid creating markets for high capex, single-purpose assets (e.g. synchronous compensators) unless there's no alternative. Consumer will bear cost - financially, or visually: ◦ Batteries are low risk → Multiple uses when connected to TSO e.g time shifting, response, dynamic voltage regulation, fault infeed, droop control, frequency containment, regulation and restoration.

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Emanuele Taibi, PhD

General Manager, Field Italia

http://field.energy

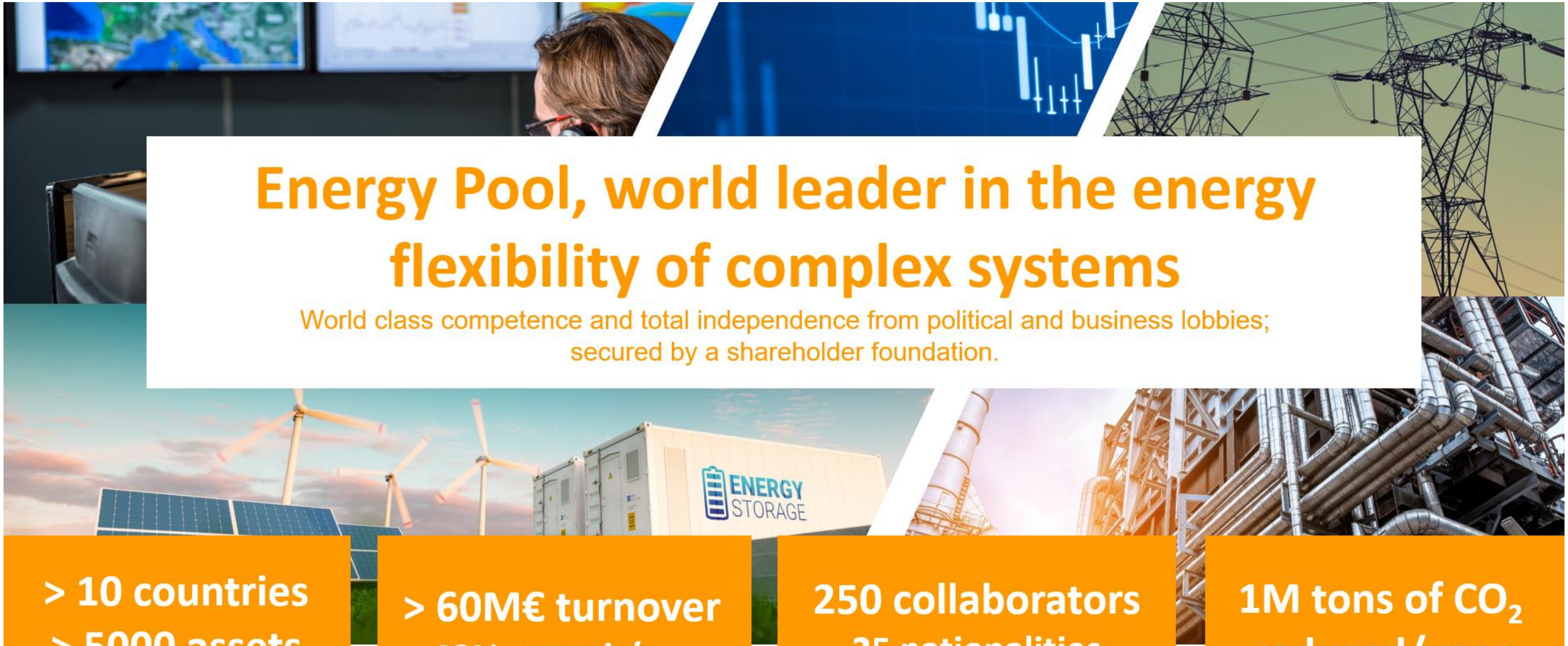
FIELD

Sylvie Tarnai
Chief strategy Officer
Energy Pool

Demand-side management in France and software solutions empowering “prosumers”

Sylvie Tarnai, Energy Pool
sylvie.tarnai@energy-pool.eu

Introduction to ENERGY POOL



Energy Pool, world leader in the energy flexibility of complex systems

World class competence and total independence from political and business lobbies; secured by a shareholder foundation.

> 10 countries
> 5000 assets
> 6 GW

> 60M€ turnover
+40% growth/year

250 collaborators
25 nationalities

1M tons of CO_2 reduced/year

Introduction to ENERGY POOL

Services & solutions

Energy Pool
Smart Energy Management

Flexibilities management & operational services

- Design of complex systems flexibilities, from real time to medium/long term
- Strategic advisory for maximizing revenues and reliability
- Technical enablement, contracting & 24/7 operations of aggregated portfolios

Software Solutions & microgrids

- Industrialized and Scalable Software solutions for distributed energy resources management
- Flexible solution adapted to different contexts: VPP, Demand response, microgrids, hybrid power plants
- Optional consulting and operation services

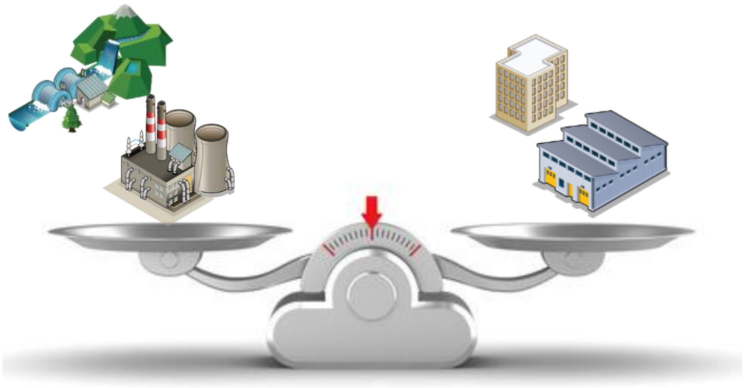
Consulting

- High level advisory on market design and regulatory
- Technology and economic feasibility expertise
- Operation design

Process Transformation and hybridization

- Advising end-users of electricity in their strategy to reduce CO_2 emissions
- Design of hybridization & electrification plans, including flexibilities monetization
- Projects deployment and operations

Enabling DSM: a change of paradigm of our power system



CHALLENGE

Ensuring security of supply while balancing the power system at lowest cost and min. CO_2 emissions

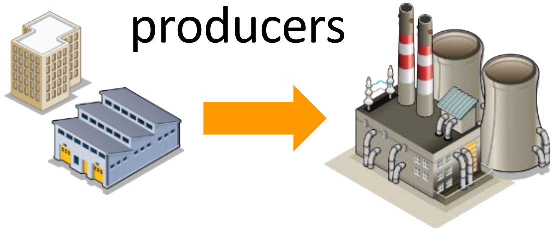
BEFORE

~ 2010

Energy was abundant and dispatchable.

Consumption drove Production

System balanced with few producers



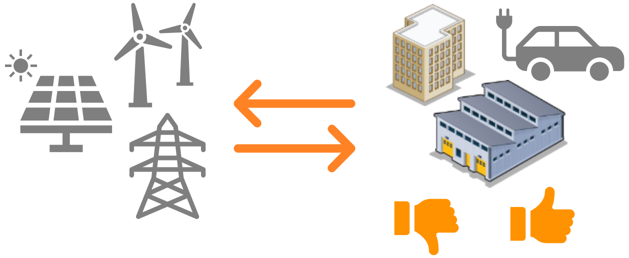
TOMORROW

~ 2030

Energy is intermittent and forecastable. Grids becomes scarce ressource.

Production & Grid availability drive Consumption

System balances with all actors



Demand-side and storage Flexibility part of the solution

EU: Demand-side flexibility potential and policy goals

A still small role given to DSM with diversity of national policies

European Commission

« Around 21 GW of demand response has been active in the system in 2019. Some estimations highlight a potential of more than 130 GW of demand-side flexibility in 2030. Today, this potential is not being developed at the speed and scale required to support our decarbonization targets, nor equally within EU Member States »

COMMISSION STAFF WORKING DOCUMENT (released on 14th March 2023)
Reform of Electricity Market Design

For Europe by 2030:

- Impact assessment for the CEP: potential of 160 GW
- Study from DNV GL: 164 GW upward flexibility and 130 GW downward flexibility

Future Energy Scenarios (RTE)
DSM 3,7-16 GW by 2035

3,9 GW demand-side Flex capacity in 2022, target of 6,5 GW by 2030

German TSOs scenarios framework for NDP 2037/2045
DSM 5,0-7,2 GW by 2037

No voluntary policy

Mechanisms allowing Demand-side Flexibility in France

Several mechanisms allow contribution of consumption Flexibility to system stability:
(implemented by RTE, French TSO)

Capacity market (for security of supply)

Remuneration of capacities availability in peak periods + energy in case of realized curtailment

Long-term call for tenders (specific to curtailment)

Remuneration complement for availability on tense days + energy in case of realized curtailment

System services (towards RTE)

Balancing market: capacity commitment for balancing service + energy if activated

FCR and aFRR: capacity commitment for regulating service + energy if activated

Spot market in D-1 (towards other market party)

"NEBEF" mechanism allowing bid of curtailed loads directly on the power market under private agreements

➔ Aggregators allowed to pool consumers' flexibility and offer it on different mechanisms, regulatory uncertainty on downward regulation (load stimulation)

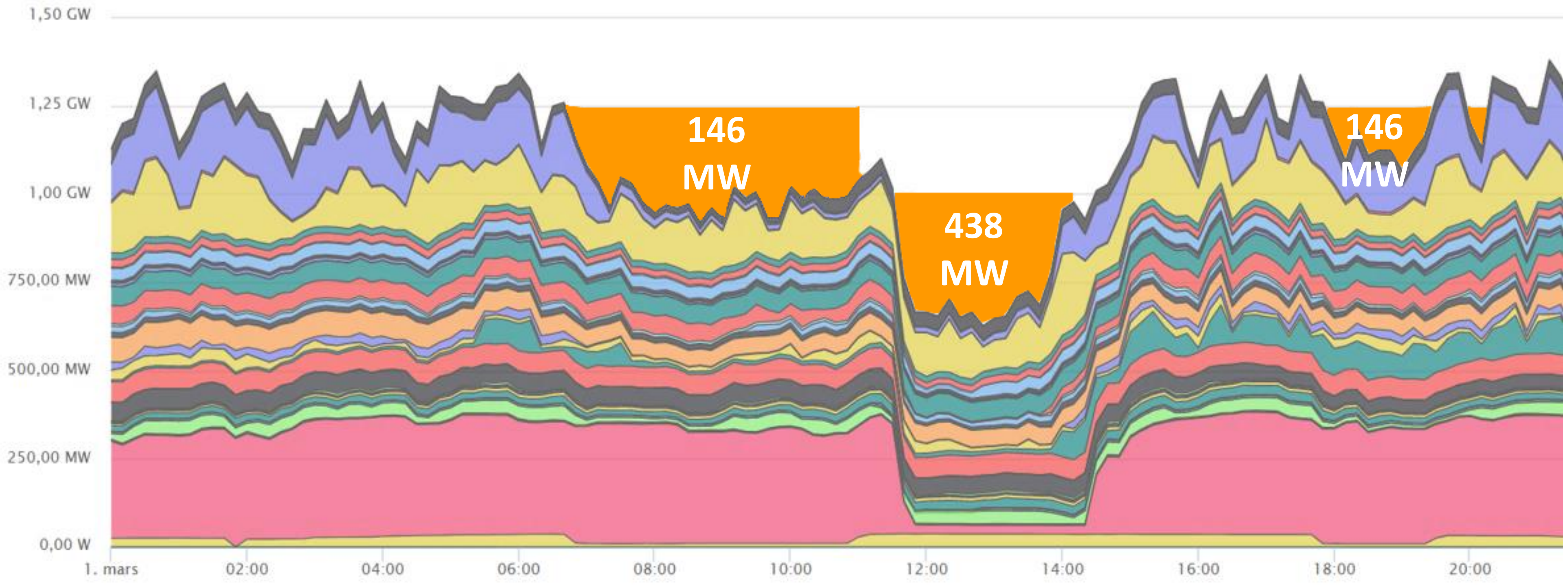
Peak-shaving in France

Load reduction delivered by Energy Pool to French TSO RTE on March 1st 2018

Cold wave in France

Consumption peaks 90GW (11h)

Very low system margins

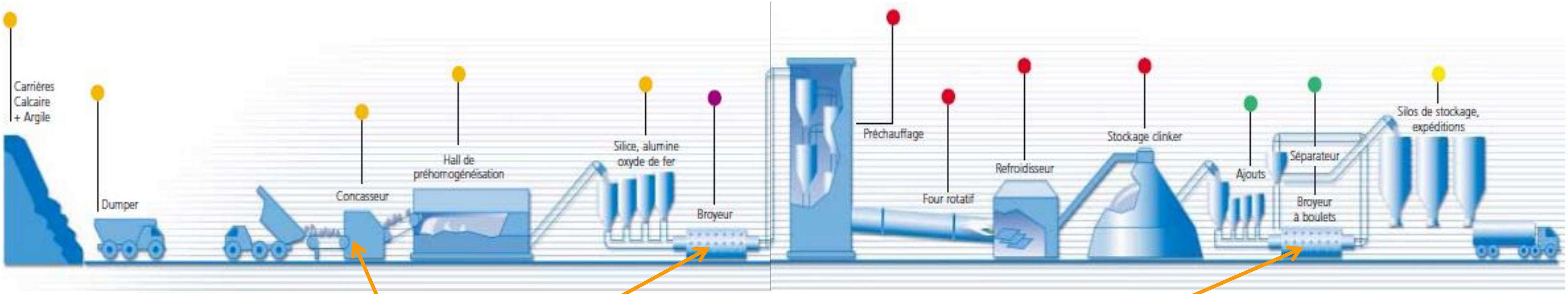


438 **MW (max)** curtailed
Total energy requested by RTE **1,7 GWh** on March 1st 2018

106
sites participating

Case study of an industrial consumer

Our mission: valuing flexibility potential from a Cement plant



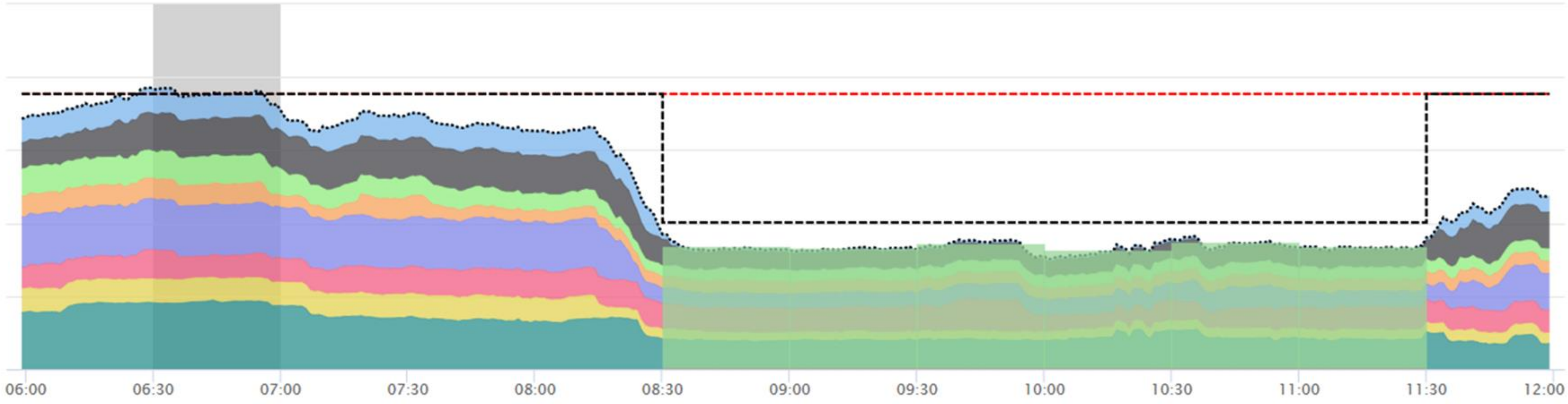
Extracting → **Crushing** → **Raw grinding** → Homogenization → Heating → **Cement grinding** → Conditioning → Delivering

- Storage capacities
- Quick stops and restarts
- No production losses

Significative flexibilities potential from processes

Case-study: Reactive cement plants contributing to peak-shaving

Activations of capacities by RTE in November 2019



➔ 8 cement plants were called at 7 a.m. for load shedding from 8:30 am to 11:30 am.

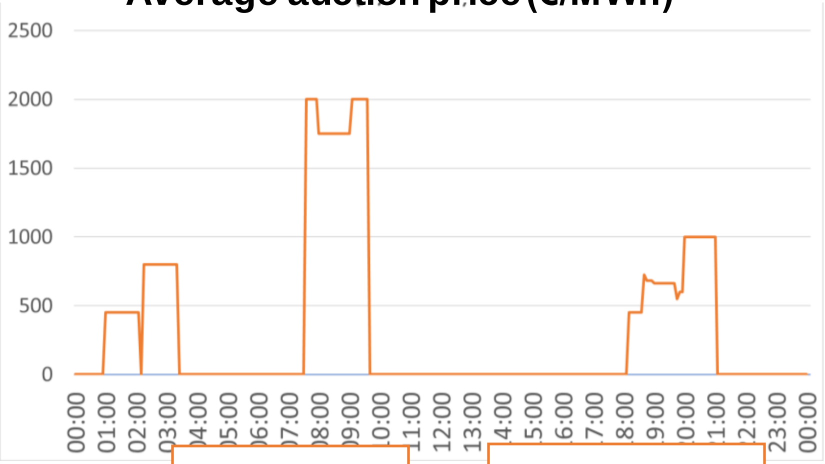
➔ **All sites participated in load shedding by reducing their output by an average of 48 MW.**

Case-study: Energy optimization supporting grid balancing

Balancing market activities in Q1 2023: with right signals, consumer reacts

Activation periods (step of 5')

Average auction price (€/MWh)



7h30/10h00

18h00/21h00

- Upward activations on the Balancing energy market
- Activations duration from 1 to 2 hours
- Activation leadtime: up to 30 minutes
- Bidding price: 300-2000 €/MWh based on Energy Pool's market expertise, own prediction tools and real-time market monitoring

Q1 2023			
Number of activations	Average available load	Value creation for consumer	Value creation for power system
20	10 MW	3-4% of electricity bill	+++

Up to 10-15% of energy bill reduction with remuneration of flexibility across mechanisms

Case-study: Energy optimization with load-shaping

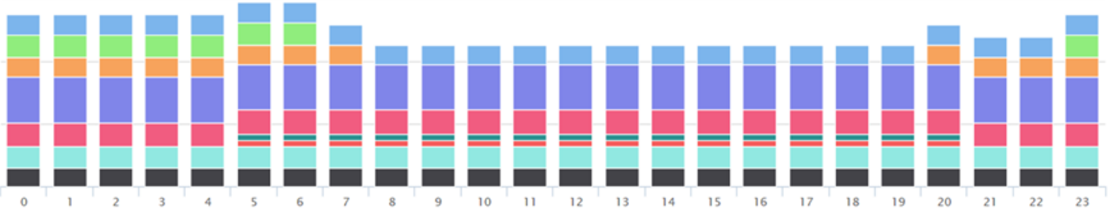
With spot price signals, consumer can react to anticipated system situation

- Provision of **a spot price forecast** before market closing (day ahead)
- Provision of a **programming tool** for each plant's various workshops
- **Aggregation of running programs** to define overall consumption
- **Notification to the supplier** of forecasted consumption
- Provision of a **reporting tool** to monitor forecast quality

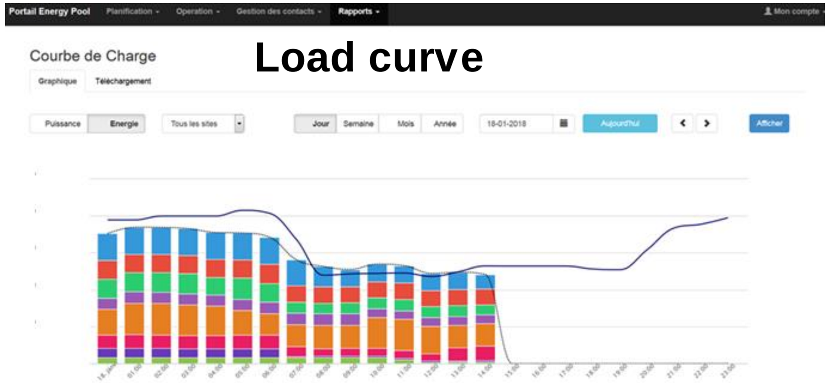
Possibility to send signals or directly pilot consumption assets based on flexibility & spot markets opportunities

Customer portal for monitoring

Production plans



Load curve



Development of the Flex pool: new assets and digital infrastructure

Flexibility and Energy Management integrated solution

Distributed Energy Resources Management Platform / EMS / VPP

Data Storage | Machine learning | Optimisers | Iot secured infrastructure | Applications | Portals | Cyber Security

Forecasting
- Generation
- Consumption
- Prices

Aggregation & optimization
- Loads
- Distributed generation
- Batteries

Flexibility management
- Ancillary services
- Balancing
- ToU, peak shaving, …

Energy management
- Portfolio optimization
- Microgrids
- Hybrid power plants

Monetization
- Link with markets
- Billing
- Reporting

Integrated, industrialized, scalable and secured cloud platform

MQTTs

MQTTs

Flex-Box

Assets connectivity solutions

Flex-Box

More diversified assets

End-users (consumption), storage, EVs, renewable production, electrolyzers

TSOs

Solutions for Behind-the-meter Demand-side optimization

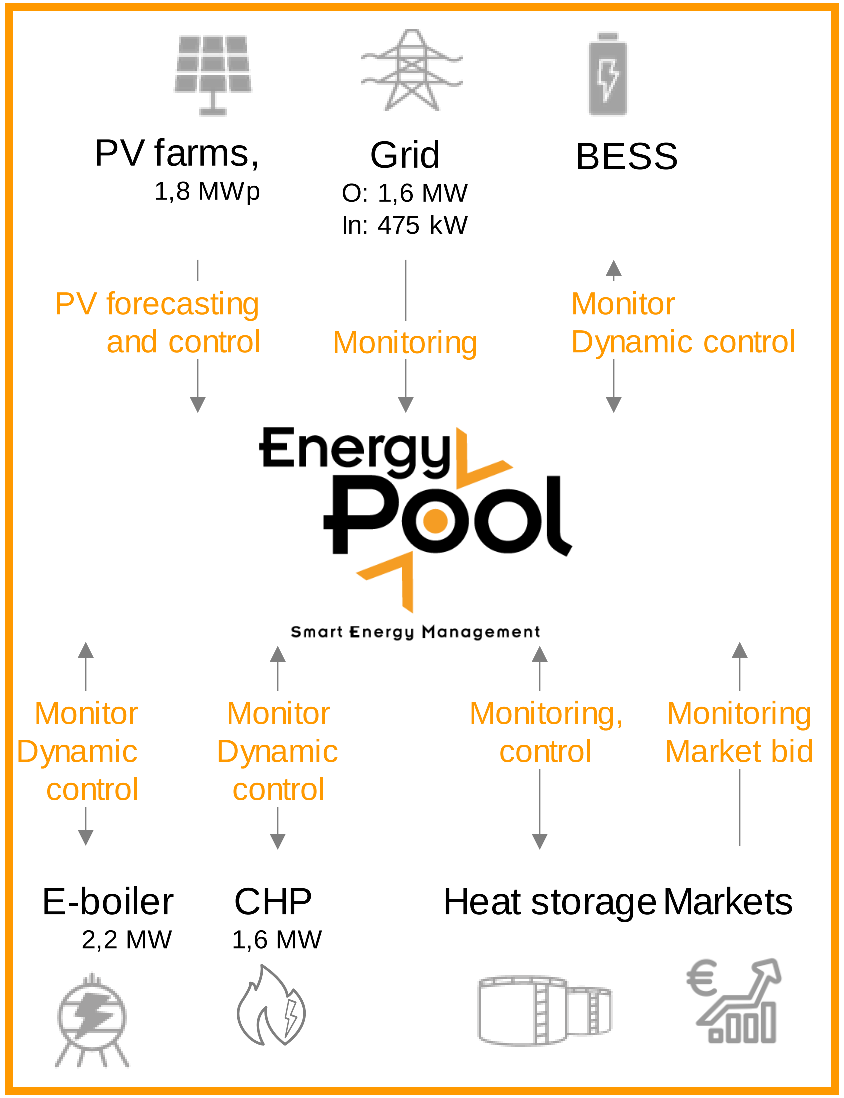
Software solution to manage a grid-constrained Prosumer system

- **Dutch agro-horticulture company**

Mopabloem

- **Control the whole installation in order to comply with grid constraints,** maximize self-consumption and respect business requirements

- **Minimize the overall cost of energy and CO2 emissions**



Solutions implemented

The first operations started in March 2023 and several stages will follow.

Energy Pool is deploying its EMS & PMS solution, which will optimize the connected microgrid by monitoring and controlling production, consumption and storage assets.

Energy Pool EMS solutions would provide:

- Multi-energy market arbitration
- Electrical and Heat Storage assets optimization
- Flexibility markets access and valorisation
- Grid cost and constraints optimization

#IIW2023

Michael Villa
CEO
SmartEn

IRENA INNOVATION WEEK 2023

Demand-side flexibility in Europe: unlocking its potential

Michael Villa, Executive Director, smartEn

#IIW2023

smartEn members

The European business association of market players unleashing the flexibility of all consumers

ade · AFRY · ampx · AMPECO · ANEO · APPLiA Home Appliance Europe · aug·e · bamboo energy

BECHAINED · bne · CHAMELEON · chargepoin+ · cleanwatts · CUCULUS · CyberGrid · dcbel

DEFTPOWER · DNV · EATON Powering Business Worldwide · EDF · ELECTRON · Elli · ENEIDA.IO

enel x · Energy Market of Things · Energy Pool · CATAPULT Energy Systems · EnergyTag · energy web · Entelios

entra · EoT · epexspot · epq · ev.energy · EVBOX · Fermata Energy

FEVER · FLEXCITY · FLEXIBLEPOWER ALLIANCE NETWORK · FLOWER. · FRACTAL ENERGY · Fronius · Fusebox.energy

Gridio · gridX · HIVE POWER · Honeywell · HSLU Lucerne University of Applied Sciences and Arts · HUAWEI · i-EM

IKEA/INGKA · JOULE ASSETS · KNAUF ENERGY solutions · LCPDelta · lunar energy · Microsoft

THE MOBILITY HOUSE · nano energies · NET2GRID · next · NODES · NORD POOL · NUVVE

OAKTREE POWER · octopus energy · openADR ALLIANCE · piclo · Plexigrid · Powerledger · REGALGRID sharing your power

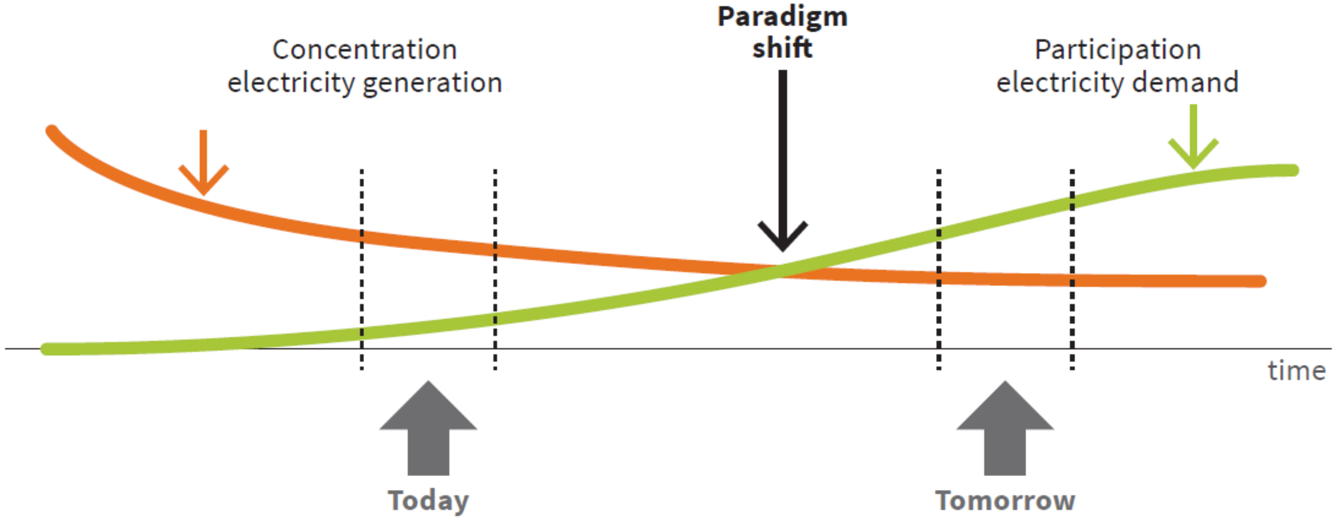
Schneider Electric · sense · SIEMENS Ingenuity for life · SMPnet · sonnen · sympower · TESLA

THERMOVAULT · tibber · tiko · THE TRAXIS GROUP · vaasaETT · Vestas · VIESSMANN

VIOTAS · Voltalis · Voltaware · voltus · Wirepas

Demand-side Flexibility: a distributed, reliable, climate-friendly, efficient resource…

Paradigm shift in electricity supply and demand

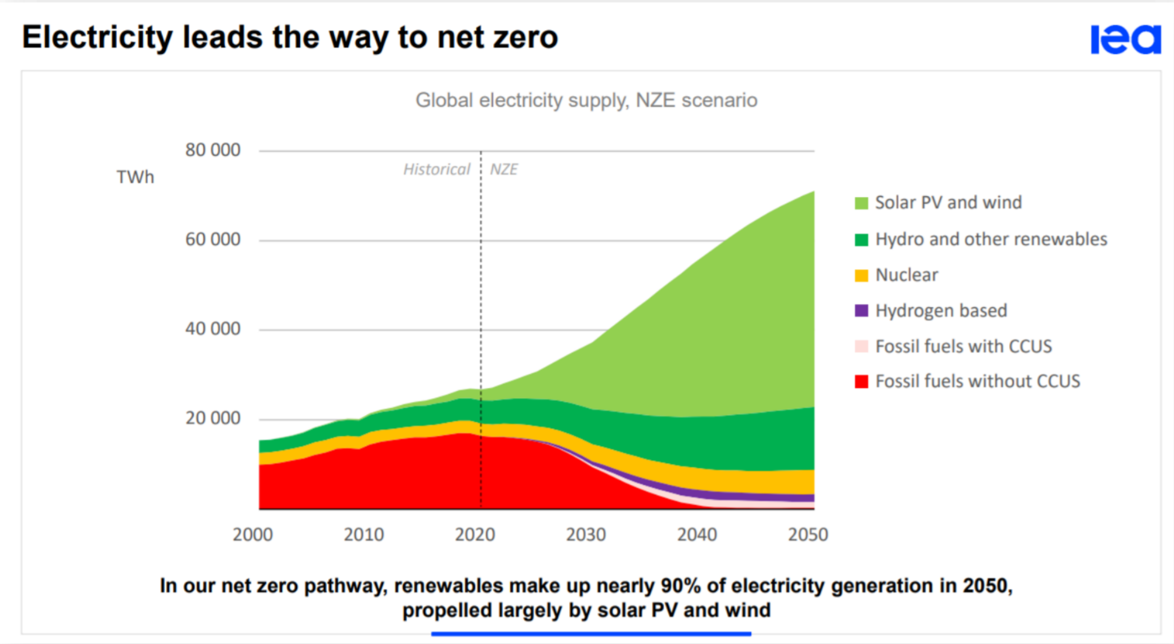


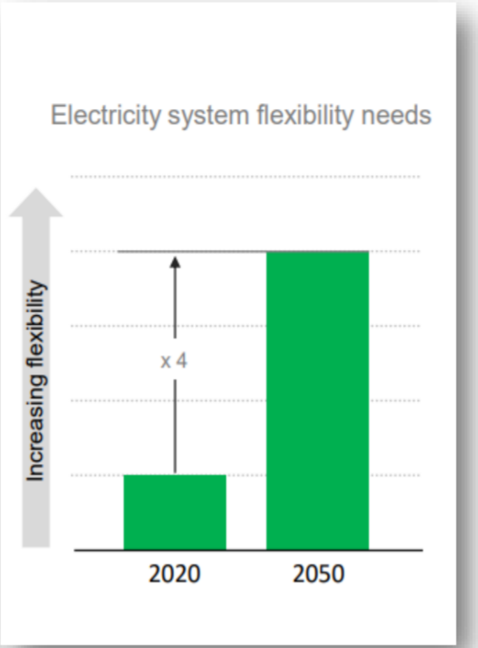
Jorge Vasconcelos, EU Electricity Reform, May 2022

"**Demand-side flexibility** means the capability of any active customer to react to external signals and adjust their energy generation and consumption in a dynamic, time-dependent way, individually as well as through aggregation. Demand-side flexibility can be provided by smart **decentralised energy resources**, including demand management, energy storage, and distributed renewable generation to support a more reliable, sustainable and efficient energy system"

#IIW2023

…crucial in a highly variable energy system…





Volatility is here to stay. The 'new business model'.

Source: IEA's 'Net Zero By 2050' report of 18 May 2021

Daily flexibility needs

+133% across EU Member States between 2021 and 2030

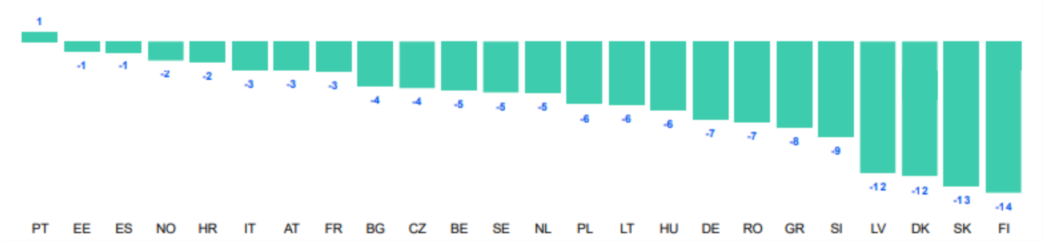
+250% across EU Member States between 2030 and 2050

Source: European Commission, March 2023

…whose volatility was evident in the past months…

Extreme high

Figure 4: Electricity – Comparison of observed load against forecasted load – EU-27/EEA (Norway)[1], June – December 2022 (%)



Source: ACER's assessment of 400+ energy emergency measures seeks to inform policy makers going forward, 14/7/2023

Extreme low

Day-Ahead Price, North West Europe (EUR/MWh)

Source: Nordpool website, Day-ahead prices 02/07/2023 14.00-15.00h

Hai ritwittato

Lion Hirth
@LionHirth

German day ahead prices drop to -500 €/MWh at 2 pm. Yes, minus 500.

That's the lowest price in several years, if I recall correctly.

If you have a dynamic pricing retail contract, charging your EV will earn you smth like €50.

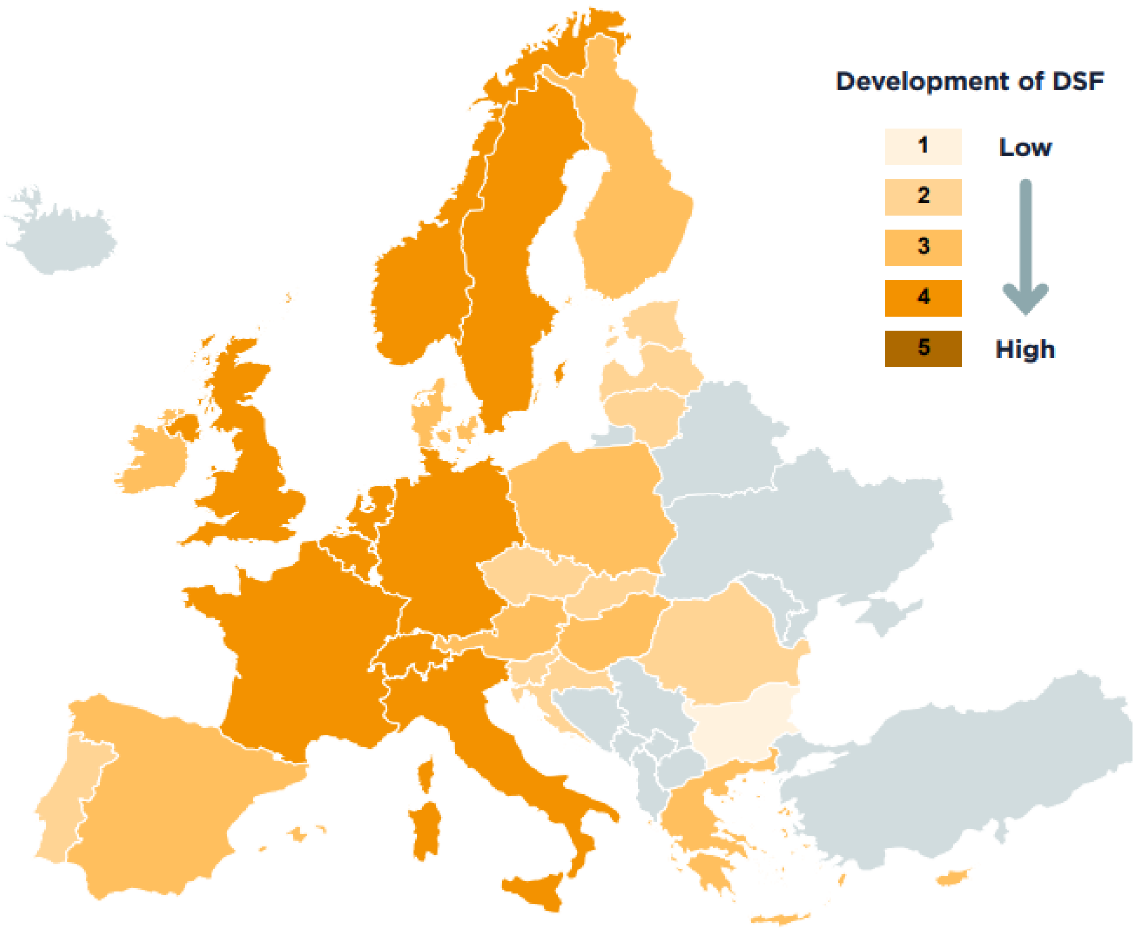
epexspot.com/en/market-data

Traduci il Tweet

10:02 AM · 2 lug 2023 · **251.266** visualizzazioni

136 Retweet **30** citazioni **692** Mi piace **45** segnalibri

...but DSF potential is still untapped...



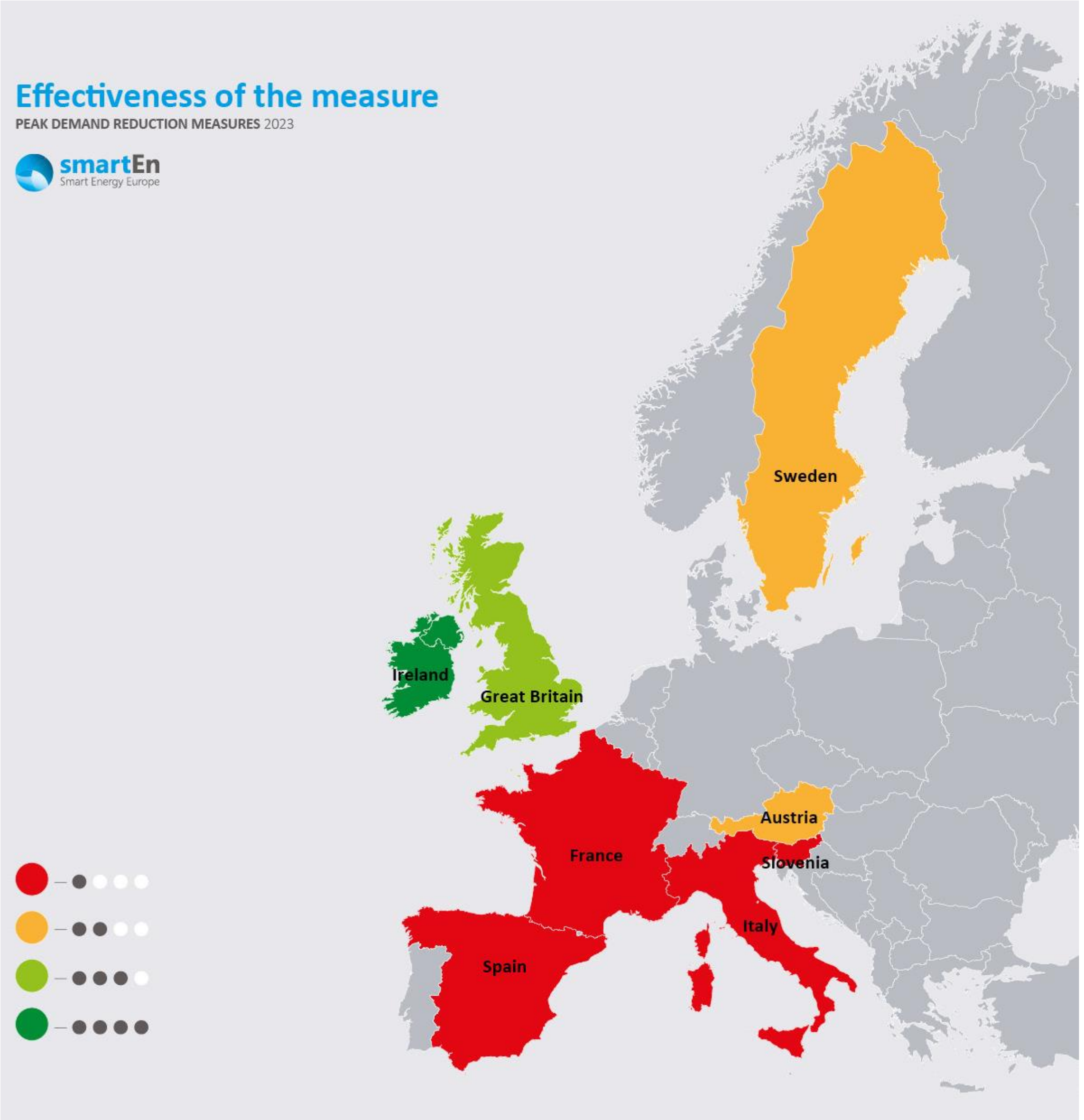
2022 Market Monitor for Demand Side Flexibility
smartEn/LCP-Delta, February 2023

Nota bene

smartEn/LCP-Delta 2022 Market Monitor for DSF only looks into TSOs and local markets.

Wholesales markets and implicit price offers are not analysed, as insignificant in volumes.

…even during emergency situations…



smartEn Map on Peak shaving products introduced in winter 2022/2023, September 2023

…although it can provide immediate benefits in the current crisis…

EU potential already in **2023**:

€16 billion saved in total gas costs

(doubling in 2025)

DNV, 5 October 2022

…and impressive benefits in 2030 to support the cost-effective clean energy transition

Energy System	Consumers
• **Renewable energy curtailment** reduces by **15.5 TWh** (61%) • **37.5 million tonnes** (8%) saved in GHG emission/year • Avoidance of at least **60 GW** of peak generation capacity, saving **€2.7 billion/year** • **€11.1–29.1 billion/year** saved in grid CAPEX investments	• Consumers with flexible assets benefit directly, more than **€71 billion/year** • All consumers benefit from lower wholesale prices and system costs, over **€300 billion/year**

smartEn/DNV study, "2030 Demand-side Flexibility: Quantification of benefits in the EU", September 2022

Why is Demand-side Flexibility still unlocked?

Existing barriers across Europe:

Lack of non-fossil flexible DERs	Blurred retail prices and limits to local innovations	No markets or limits for DERs to access	Limits to data access and sharing
• Deployed DERs not smart-ready • Lack of (long-term) flex remuneration to reduce ROI	• No ToU/dynamic price offers • No/limiting frameworks for energy communities	• Product design and procurement methods not fit for DERs • No/limiting aggregation frameworks • Unclear definition of baseline methodologies • No LFM by DSOs • Barriers in TSOs' ancillary services • No TSO-DSO cooperation	• Limited to smart meters • Property approaches prevailing and inconsistent spectrum of standards/protocols for different data flows • No transparent access to grid data

Most of these barriers are addressed in EU laws…

Lack of non-fossil flexible DERs	Blurred retail prices and limits to local innovations	No markets or limits for DERs to access	Limits to data access and sharing
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• Fit for 55 • 2019 EMD/EMD revision	• 2019 EMD/EMD revision	• 2019 EMD/EMD revision • New NC DR	• EMD revision • REDIII • Next IA on DR data

→ ***COMMISSION 2024-2029: European Green Deal Implementation Plan***

…but not implemented at national level by EU27 Member States

smartEn Implementation report on key DSF provisions in the 2019 EU Electricity Market Design, March 2022

Towards a clean energy transition

Needs

- Accelerate and increase resilience
- Ensure affordability
- Investments in smart electrification

Risks

- Supply-only focus
- Keep centralised energy system
- Costly stranded assets
- Consumer protection vs empowerment

Opportunities

- Activate demand
- System efficiency

Thank you!

IRENA INNOVATION WEEK 2023

Q&A Session

Emanuele Taibi
General Manager – Italy Field

Sylvie Tarnai
Chief strategy Officer Energy Pool

Michael Villa
CEO, SmartEn

IRENA INNOVATION WEEK 2023

Demand side management and storage: Case studies from Asia

#IIW2023

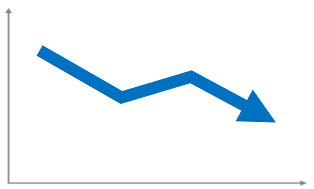
Hideyuki Umeda
Director for International Policy on Carbon Neutrality
Agency for Natural Resources and Energy
Japan (METI)

The effort of demand side management in Japan

Agency for Natural Resources and Energy, METI

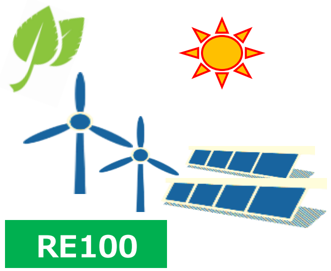
Structural changes in the energy system.

Depopulation



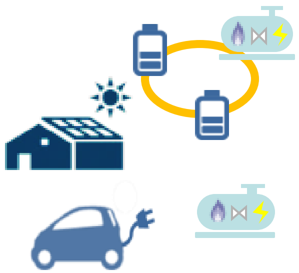
- ✓ Declining energy demand
- ✓ Aging infrastructure and growing deficits

De-carbonization



- ✓ Growing momentum for climate control
- ✓ Renewable energies becoming the main source of power

De-centralization



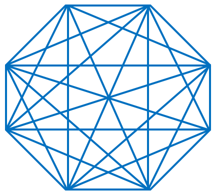
- ✓ Distributed Energy Resource price reduction
- ✓ Enhanced resilience

Deregulation

- Power sector
- Transmission/ Distribution
- Retail sector

- ✓ The full liberalization of electricity retailing
- ✓ Unbundling
- ✓ Decreased investment predictability

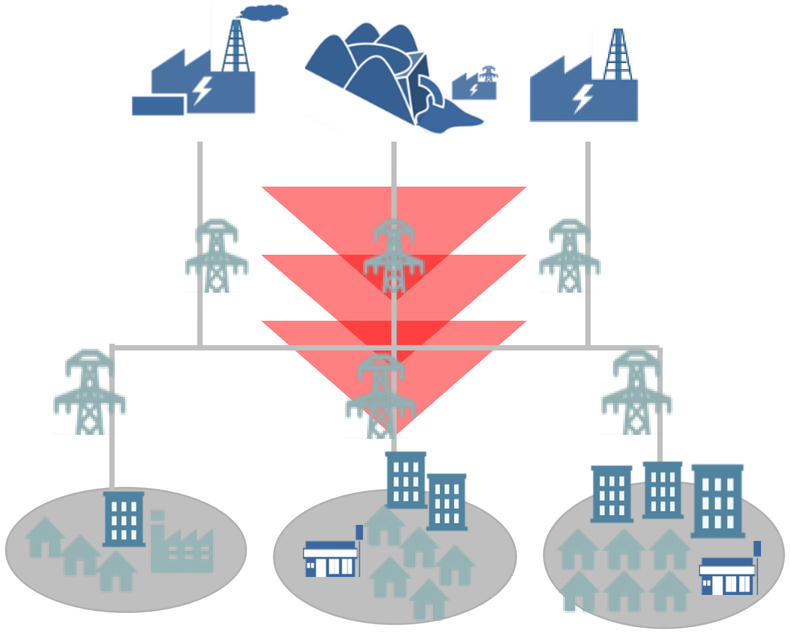
Digitalization

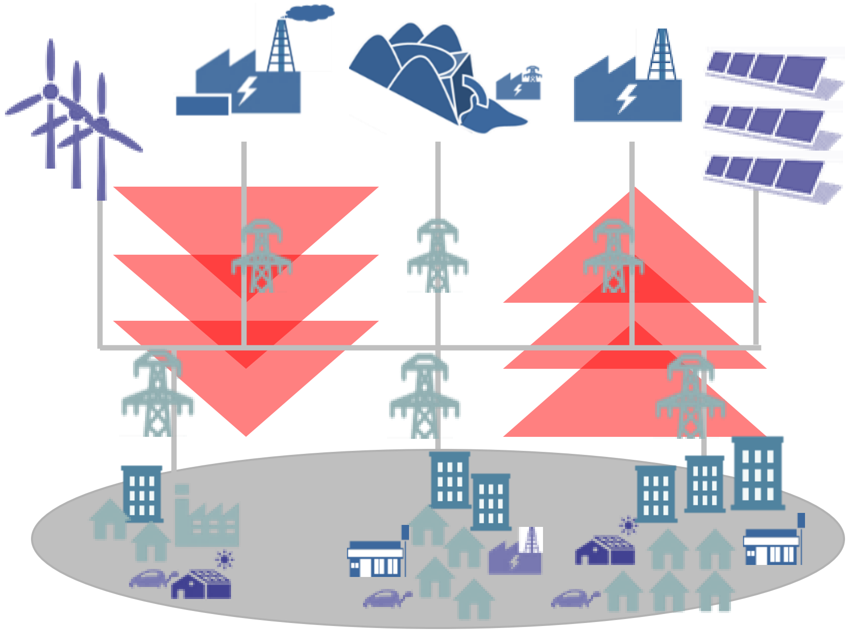


IoT,AI,5G,etc

- ✓ Application of digital tech to the energy sector

How do we respond to this structural change?





- large-scale
- centralized
- consumer

- small-scale
- distributed
- "pro-sumer"
  (producer x consumer)

Basic Policy for Realization of Green Transformation (GX) (Adopted at GX Implementation Council on Feb. 10)

To rebuild a stable energy supply, various measures (including maximum use of clean power sources) are to be taken.

- Renewable Energy: To expand the introduction of renewable energy, a grid development plan has been set.
  Investment in the next 10 years will be 8 times as much as that in the past 10 years.
- Nuclear power : Replacement of to-be decommissioned reactors with next generation innovative reactors.
  Review of operating period (40 years + 20-year extension + shutdown period such as inspection)

～2023(Spring) ～2025 2030 2050

【Construction of next-generation grid networks】
- ●HVDC undersea cable from Hokkaido to Honshu(~2030)
- ●Grid development based on the master plan (2023~)
- ●Improvement of financing environment to grid investment (6~7 trillion-yen scale)

【Securing balancing power】
- ●Accelerating introduction of stationary storage batteries
- ●Long-Term Decarbonized Energy Auction scheme to start
- ●Utilization of hydrogen and ammonia

【Accelerating innovation】
- ●Next-generation solar cells (perovskite solar cells)
- ●Floating offshore wind power generation

① Construction of grid networks and securing balancing power toward the maximum introduction of renewable energy

H_2 / NH_3
2030: 3 mil. tons/3 mil. tons
2050: 20 mil. tons/30 mil. tons

Solar cells
2030: 104-118GW

Offshore Wind
2030: 10GW
2040: 30-45GW

②Maximum introduction of renewable energy
Realization of 36-38% introduction in 2030
(Cabinet approval in October 2021)

【Maximum introduction of domestic renewable energy】
- ●Expansion of renewable energy with understanding from local communities
  (Rule to reinforce business discipline to comply with regulations on safety, land development etc.)
- ●Transformation from Feed-in-Tariff to Feed-in-Premium scheme (FY2022~)
- ●Maximum use of existing renewables（PV ~60GW）
- ●R&D on recycling technology of solar power panels

Targets for DR

- Targets for Demand Response(or DR) have been set in the Action Plan to expand the introduction of renewable energies* based on the Basic Policy for the Realization of GX.

  * Formulated on April 4, 2023, by the Ministerial conference on renewable energy and hydrogen.

(Items to be addressed in the future)

With regard to DR, currently approximately 2.3GW, that contributes to supply-demand constraints and the effective use of renewable energy, the Act on the rational use of energy have been revised to make periodic reporting on DR efforts by large-scale consumers mandatory starting in FY 2023.

Aiming to expand by approximately 500MW per year while promoting the use of IoT in facilities so that they can respond DR. A framework for evaluating DR performance will be used to encourage factories and other facilities to take DR. In addition, a more advanced reporting and evaluation method for DR performance will be discussed and materialized in FY 2023.

Aggregators

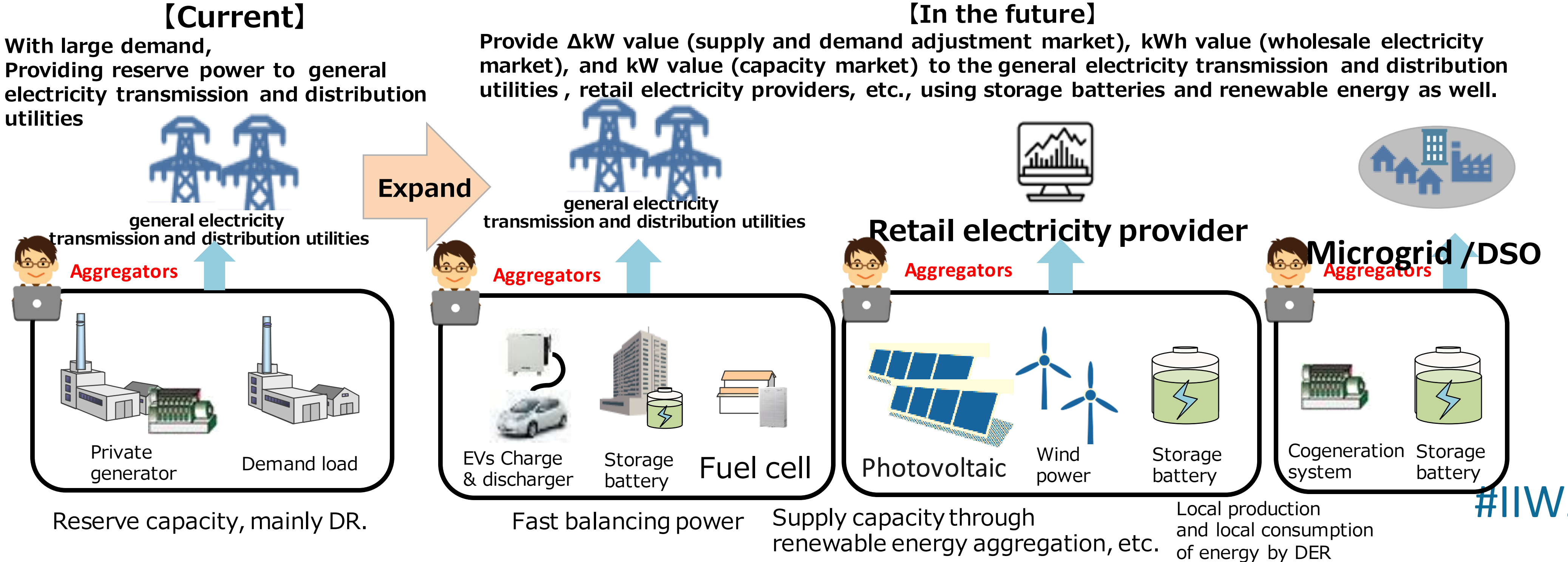
- Under the Electric Business Act, notification of specified wholesale suppliers that came into effect in April 2022.
- As of August 7, 2023, **57 companies** were registered as **Specified Wholesale Suppliers (or aggregators).**
- The number of aggregators active in Japan is steadily increasing, but further development is also important.

※ Specified Wholesale Supply Notified Entities as of August 7, 2023

Expanding business opportunities for aggregators

- Aggregators have so far focused on the business of **suppressing the demand of large-volume consumers (Demand Response (DR)) when electricity supply and demand are tight.**
- Now that aggregators have been positioned under the Electric Business Act, **it is expected that the scope of aggregators will be expanded to include control of a variety of small- and medium-scale resources**, such as **storage batteries and renewable energy sources such as solar power**.
- In particular, the company is expected to expand its business opportunities by (1) **providing balancing power** for electricity supply and demand **during normal times**, (2) bundling renewable energies under the FIP system **to supply electricity to the market and avoid imbalances**, and (3) also working to **support supply and demand coordination in microgrid and power distribution projects**.

Potential aggregator business model



Aggregator Training

- A demonstration project to improve aggregation technology has been underway since FY2021. In FY2023, **the final year of the project, the demonstration is underway from the perspective of improving profitability**.
- In addition, a training program for aggregators to improve cyber security is underway in cooperation with the Information-technology Promotion Agency, Japan (IPA).

Distributed Energy Resources aggregation demonstration

【Purposes】

Technical demonstration of the ability to bundle various resources based on the requirements of various products in the supply and demand adjustment market and control them at high speeds on an hourly, minutely, or secondly basis.

【Results】

・Control accuracy has been improved to the level of social implementation.

・In FY2023, the final year of the project, we will confirm whether control can be achieved with profitability.

Renewable energy aggregation demonstration

【Purposes】

(1) Minimize changes in power generation due to sudden weather changes, etc. (avoidance of imbalance)

(2) Improve profitability

(3) Improvement of power generation forecasting and wholesale market price forecasting technology

【Results】

・(1) and (3) have been improved to a level where they can be implemented in society.

・In FY2023, the final year of the project, we aim to further improve profitability.

Act on the Rational Use of Energy

- In order to promote a shift in demand for electricity to the time of renewable energy output control and a decrease in demand for electricity when the supply-demand balance of electricity is tight, **specified business operators, etc. will report the results of "Turn-up DR" and "Turn-down DR" ***in accordance with the supply-demand situation of electricity.
- In addition**, assessments (intensity, industry deviation, etc.) of the amount of DR implemented will be conducted** from FY2024 to improve the quality and quantity of DR.
- Furthermore, we plan to make **DR-compatible requirements for water heaters, air conditioners, and other equipment** in the future.

*the number of DR days (times) since FY2023, and the amount of DR implemented since FY2024

<Create DR response requirements>

Water heaters

Air conditioners

Quick chargers

DR tends in a public offering for the balancing power and the capacity market

- In a public offering for the balancing power (Power Source I' *) of general electricity transmission and distribution utilities, **successful bids by DR of the aggregators increases to 2.5GW in FY2023**.

*The general electricity transmission and distribution utilities procure reserve capacity for responding to extreme heat or severe cold that happens roughly once every 10 years, through public offering.

- The amount of successful bid for **the activation order power source including DR** in the main auction for FY2026 **is 6.36GW**, and **utilization of DR tends to increase**.
- Power Source I' and activation order power source are relatively easy for aggregators to participate in. Therefore, we expect for aggregators to participate in this market as a training place for balancing markets, which requires more sophisticated control.

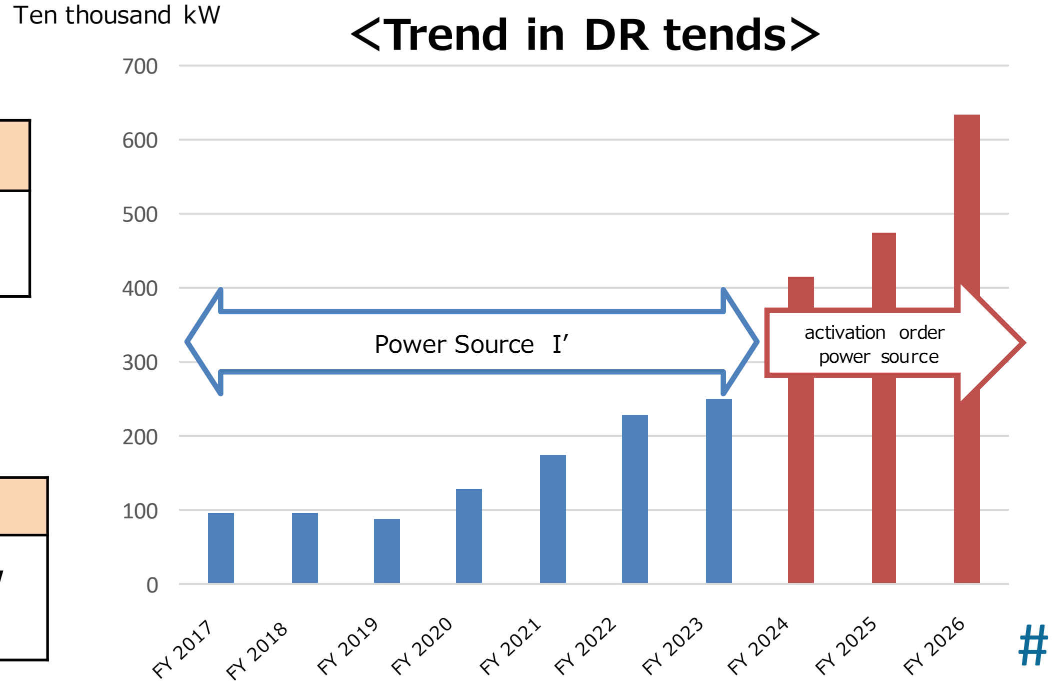
<result of a public offering for the balancing power Power Source I' in FY2023>

	In FY2023
DR bids amount (total bids amount)	**2.5GW** (3.8GW)

<capacity market/ result of activation order power sources>

	FY2024	FY2025	FY2026
result ofthe activation order power sources (total amount)	**4.15GW** (16GW)	**4.75GW** (16GW)	**6.36GW** (16GW)

<Trend in DR tends>



Regional microgrid

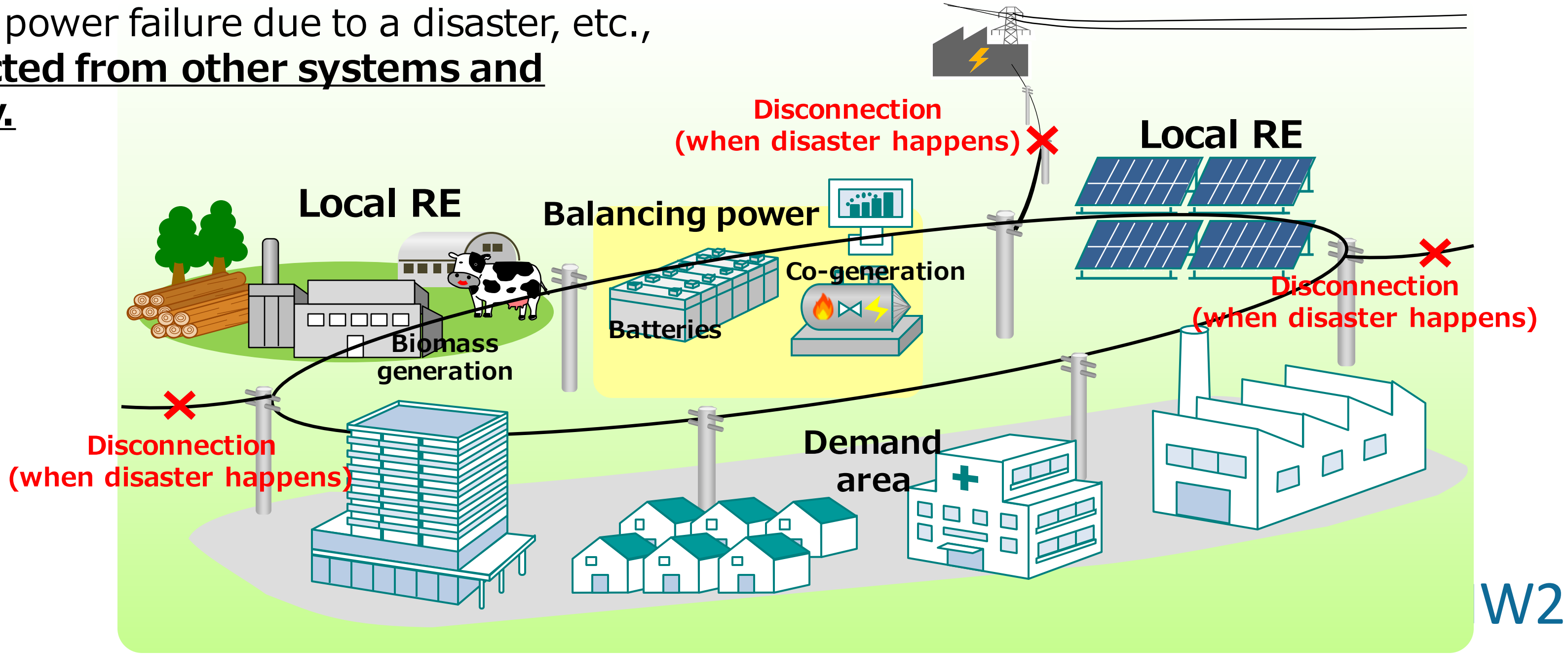
- **Regional microgrid promote local production and local consumption of electricity and heat** within a region, enabling efficient regional energy use and **contributing to resilience strengthening and regional revitalization**.
- **Efficient coordination of energy supply and demand within the microgrid avoids the costs and time** associated with the build-up of electricity network facilities **if the amount of electricity flowing to the transmission level, where congestion is a concern, is reduced**.

  Furthermore, in rural and other areas where long-distance transmission and distribution lines are laid, such as in the countryside, this can lead to more efficient grid operation.

< A model of local micro-grid construction>

◆ In normal times, each facility is effectively utilized and the tidal currents in the microgrid area are monitored.

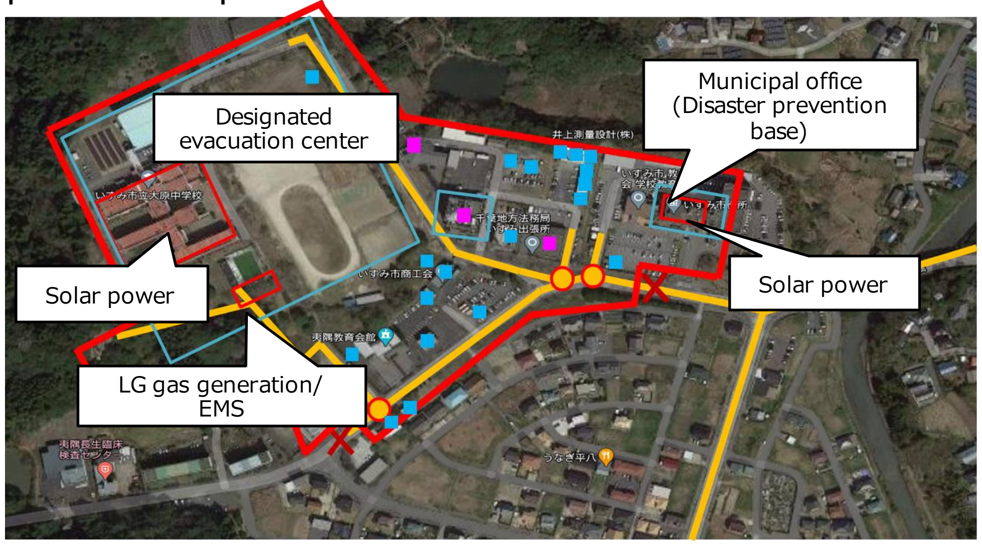
◆ In the event of a major power failure due to a disaster, etc., **the system is disconnected from other systems and operated independently.**



(Ref.) Examples

Isumi City, Chiba

Isumi city, Chiba Prefecture, experienced a prolonged power outage in 2019 due to typhoon. Therefore, as part of its disaster prevention efforts, **Isumi City has established a power supply system using solar power, storage batteries and LP gas generation.** This enables the city to supply power for up to 96 hours in the event of a blackout.



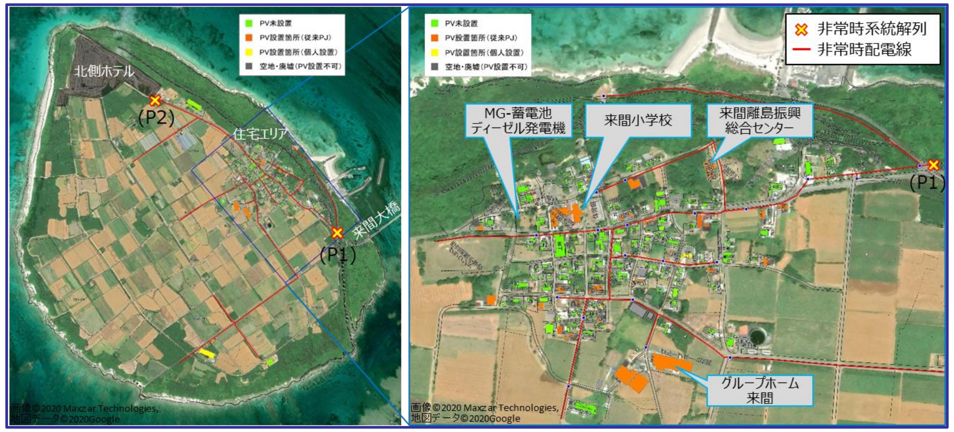
Equipment name	Specifications, etc.
Solar power generation equipment	258kW
energy storage system	238kWh
Liquefied petroleum gas engine generator	100kW
Energy Management System Equipment	Data acquisition and supply/demand adjustment

Kurima Island, Miyako Island, Okinawa

Kurima Island is at the end of the Miyakojima system and receives power supply via bridge-attached cables, and power restoration tends to be delayed more than in other areas during typhoon power outages.

Therefore, residential photovoltaic power generation + storage batteries + Eco-Cute and energy management system equipment are installed in residential buildings, etc. and controlled by the demand-side energy management system, while microgrid storage batteries and diesel generators for supplementary power are installed on the island and controlled by the microgrid energy management system.

By integrating and controlling them, a regional microgrid is being built that can utilise power sources independently in times of emergency, such as typhoon blackouts.



Equipment name	Specifications, etc.
Solar power generation + storage batteries	5.5kW-5.6kWh × 34units 5.5kW-13.5kWh × 10units
Eco cute	1.5kW × 11units 1.5kW × 8units
microgrid storage battery	400kW-800kWh
diesel generator	100kw
solar power generation	Total 380 kW

Thank you!

Sylvie Tarnai
Chief Strategy Officer
Energy Pool

IRENA INNOVATION WEEK 2023

Demand-side management in Japan

Sylvie Tarnai, Energy Pool

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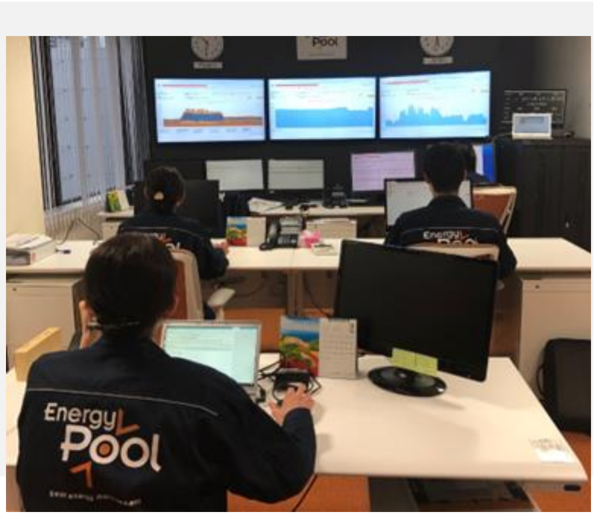
#IIW2023

Energy Pool Japan: key figures

Demand-Side Flexibility Management for TEPCO & EPCOs



FIGURES - 2023

3094 sites

with 755 MW of flexible capacity

+280 sites

IoT ready with 540 MW of flexible capacity

Implicit ACTIVATIONS 2022

+7.5 GWh	Activations of demand curtailment
+124 GWh	Activations of demand stimulation

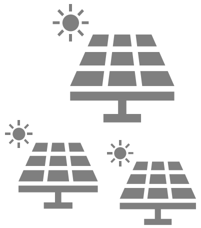
Establishment of EP Japan in 2015

EPJ's CEO has committed himself to DR institutional design as a member of several METI councils.

Thanks to the partnership with TEPCO

Case-study: Load-modulation in Japan

An innovative service to TEPCO enabling to integrated more VRE

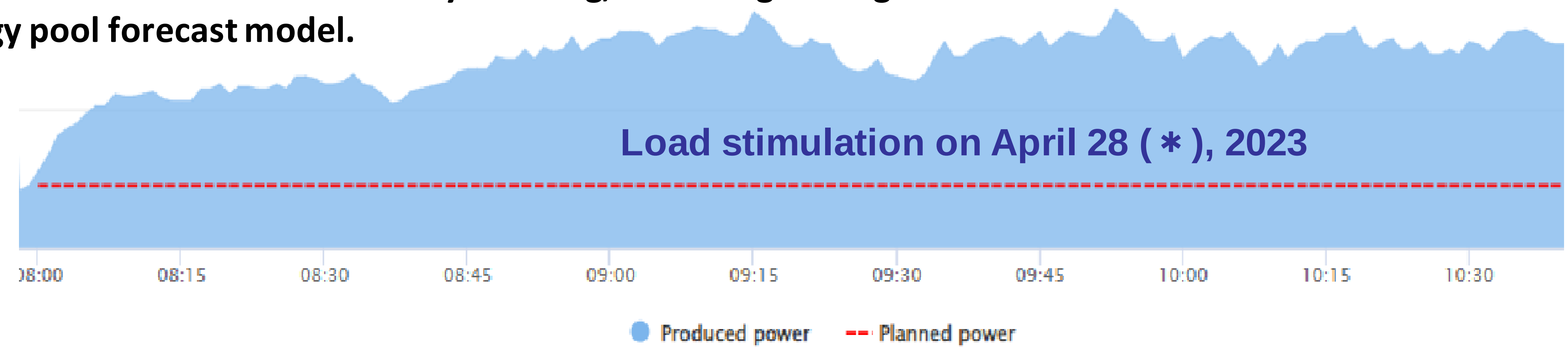


Context: Japan has by far the world's largest solar power installation per square meter of flat land area. Frequent curtailment of PV farms in Japan on days with high PV output creating surpluses which cannot be absorbed by consumption, interconnectors, or storage.

Stake: Maximize solar output utilization

➔ TEPCO as front-runner utility incentivizing variation of loads within its consumers' portfolio.

Consumer demand stimulation from early morning, according to PV generation status based on the Energy pool forecast model.



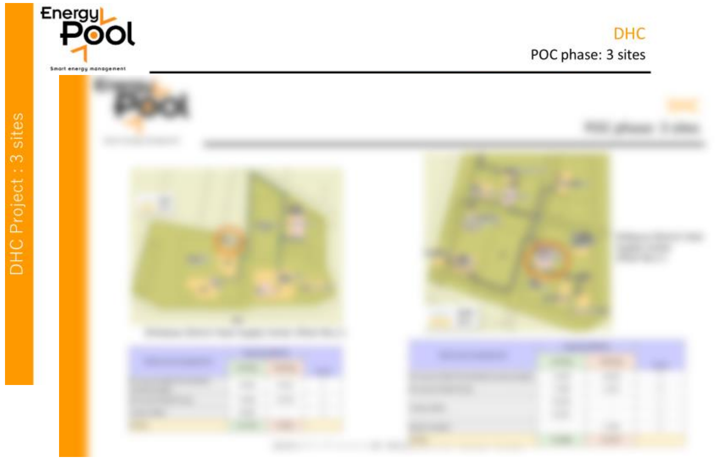
(＊) Since April 28 was the first day of Golden Week (a week of consecutive holidays), there was a possibility of oversupply even in the Tokyo metropolitan area.

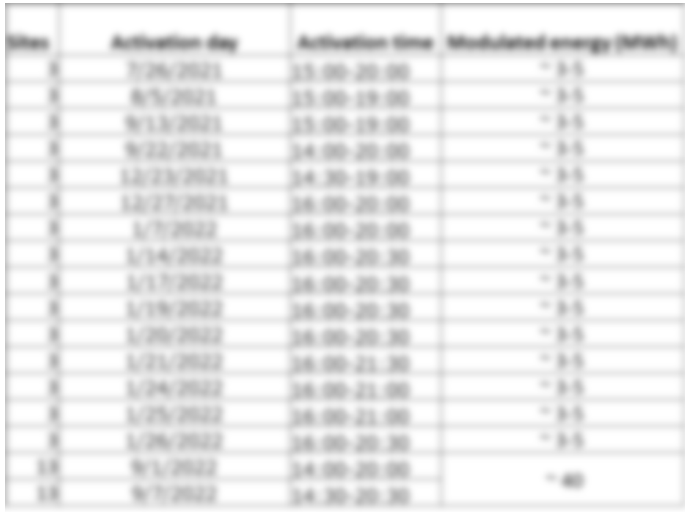
Case-study: participation of DHC systems

Our mission: valuing flexibility potential of District Heating and Cooling (DHC) systems

Context at TEPCO

- **Leverage on highly flexible assets (water tanks) to better balance supply & demand**
- **Forecast demand to enable optimized use of flexibility potential whenever needed for balancing**





Solution implemented

2021 : muti-site implementation and development of a DHC site consumption forecast model (3 sites and 15 activations).

2022: 10 additional DHC sites equipped with Flexbox. One site has a thermal storage tank capacity approximately equivalent to eight 50m swimming pools.

TEPCO and Energy Pool Japan expanding operations further in 2023 to similar sites in the Tokyo area.

IRENA INNOVATION WEEK 2023

Songsong Chen
CEPRI

#IIW2023

Practices of State Grid Corporation of China in DSM

China Electric Power Research Institute

September 27 ,2023

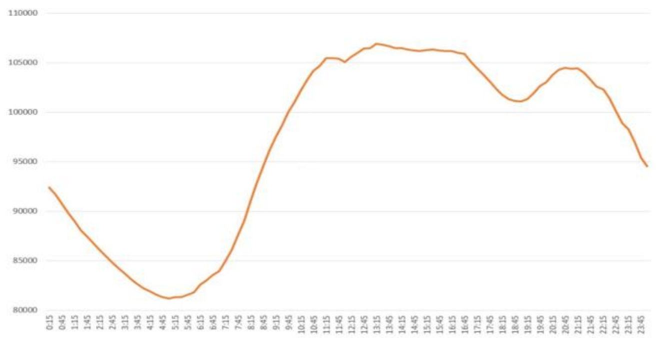
国家电网有限公司
STATE GRID
CORPORATION OF CHINA

Content

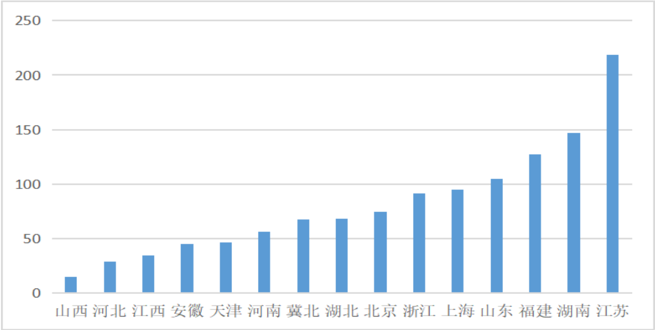
1. Background

Frequent short-term power supply and demand conflicts due to seasonal extreme weather

- In 2022, the maximum cooling load within the State Grid operating zone reached **350GW** and the maximum load of the entire grid reached **1069GW.**
- In 2022, in mid-eastern China, the duration reaching more than 95% of the maximum value, is between 15 hours and 218hours.



Load curve of the State Grid in 5 August, 2022

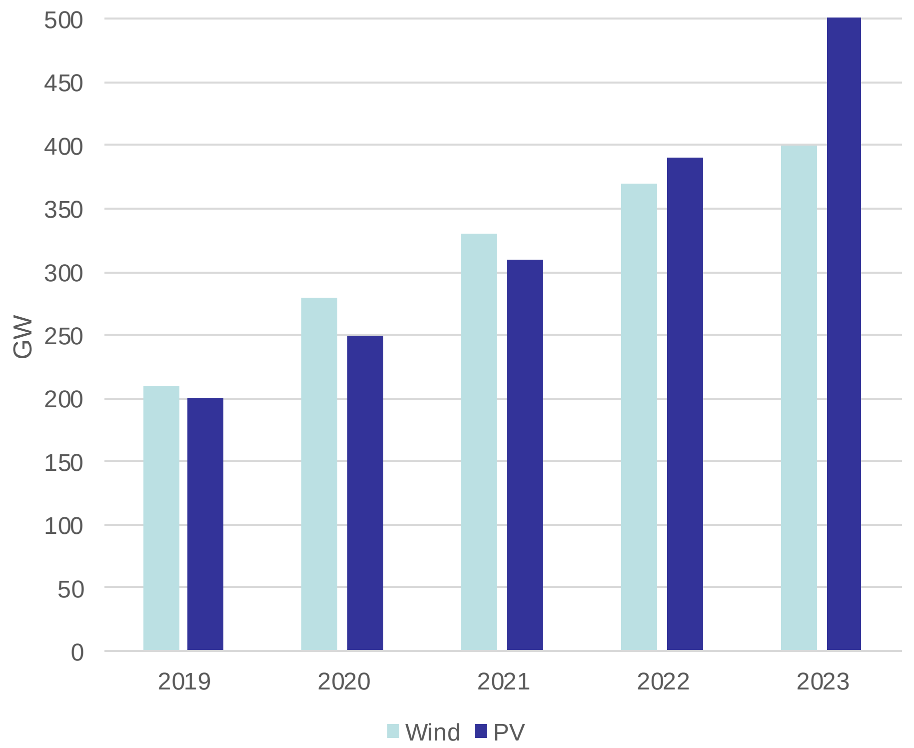


Duration reaching more than 95% of the maximum value in the 96-point load curve throughout the year

Data source: State Grid Headline *SGCC Party Group Special Research Meeting on Meeting Peak and Summer Power Supply Guarantee Work*

Shortage of flexibility resource capacity in the new type of power system

- Till the end of August, the on-grid wind and PV in China has reached **910GW**, with an estimated annual increase of around **160GW**.
- The high penetration of volatile renewable energy challenges the traditional way of power system operation.



Accumulated installation of renewable energy sources[1]

1 Data Source: *Guiding Opinions on Energy Work* over the years and *Statistical Data of the National Electric Power Industry from January to July.*

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Demand-side management balances the supply and demand

- DSM is a significant approach to balance the supply and demand in the new tendency by using demand-side flexible resources with high-economy value in power system operation.

Prediction of Resource Gap in Flexibility Regulation

Unit: GW		2020	2025	2030	2050
Volatile renewable energy		500	1000	1500	4000
Traditional regulatory measures	Flexible coal-fired	100	200	300	400
	Ggas-fired	100	150	180	230
	Pump-hydro	32	68	120	170
	Electrochemical energy storage	3	20	200	610
Gap		265	562	700	2590

Data Source: the "14th Five-Year Plan" Modern Energy System Planning issued by NEA.

STATE GRID CORPORATION OF CHINA 国家电网有限公司

Market structure and roles

- **Market operation departments**: Power system dispatch department, grid marketing department, power transaction centers
- **Market entities**: Resource owners, agencies including resource aggregators, VPP operators, comprehensive energy service providers, etc. In future, it will involve renewable generations and other types of generation entities with auxiliary service obligations.
- **Regulatory authorities**: The National Development and Reform Commission (NDRC), National Energy Administration (NEA) and State Administration for Market Regulation(SAMR).

Transaction types involving demand-side resources

Market	Time Scale	Range	Modes
Demand Response	Day-ahead	Local	Invitation with fixed subsidies or marginal price for unilateral volume clearance
	Intraday		
Auxiliary services (peak and frequency modulation)	Medium and long-term	Local, regional	Fixed subsidies or marginal price for unilateral volume clearance
	Short-term		
Wholesale market	Medium and long-term	Local, regional	Bilateral negotiation, listing, centralized bidding
	Short-term	Local, regional	Centralized bilateral bidding

Encouragement to tap the potential of demand-side resources

1. **In February 2022,** the NDRC and NEA issued ***Opinions on Improving the Mechanism and Policy Measures for Green and Low Carbon Energy Transformation***, proposing to promote the integration of demand side adjustable resources into the power system balance.

2. **In March 2022,** the NDRC and the NEA released ***14th Five Year Plan for a Modern Energy System***, requesting to improve the power load elasticity, aiming to achieve a demand-side response capacity of 3%-5% by 2025.

3. **In June 2022,** the NDRC issued ***The Notice on Promoting the Construction of The New Power Load Management System***, requiring a over 20% load control capacity and a over 70% load monitoring capacity of the maximum local load by 2025.

4. **In 2023,** the NDRC and the NEA Release ***Power Demand Side Management Measures (Draft for Soliciting Opinions)*** which make specific provisions for energy-saving, environmentally friendly, green, intelligent, and orderly electricity use.

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Promoting demand-side resources participate into market

1. **In 2015,** the State Council released ***Several Opinions on Further Deepening the Reform of Electric Power System***. It stresses further construction of power marketization and to guarantee the balance between supply and demand mainly based on DSM.

2. **In 2023,** the NDRC and the NEA issued ***Power Load Management Measures (Draft for Soliciting Opinions)***, proposing to gradually adopt DR as a normalized regulation measure for the economic operation of the power grid and to promote the normalization of DR resources participation in the electricity and auxiliary service market.

3. **In 2023,** the NDRC and the NEA updated ***The Basic Rules of the Electricity Spot Market (Trial)***, which has proposed to promote the market participation of new entities such as distributed generation, load aggregators, power storage and virtual power plants.

4. **Till now, 25** provinces and regions have issued DR policies and provided relevant subsidy standards and funding sources; **All** provinces and regions support demand-side resources to participate in peak-shaving, and **17** provinces and regions support participation in frequency modulation auxiliary services.

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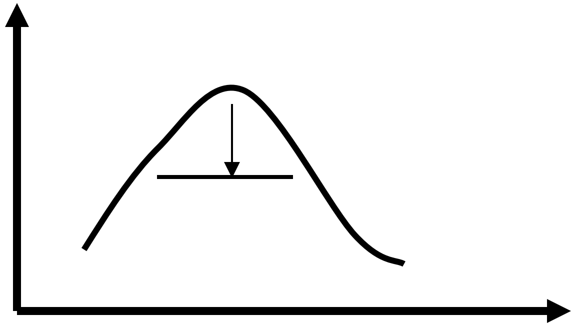
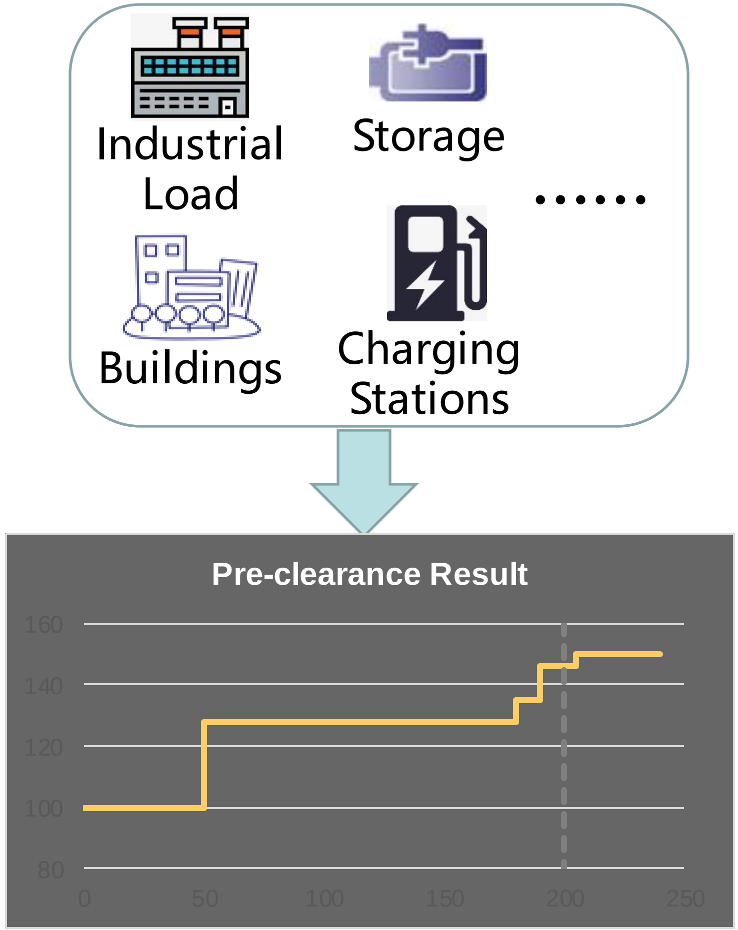
Peak load reduction

- During the peak load period of summer and winter, when the reserve capacity of the power grid is insufficient, peak shaving demand response is initiated.
- Users, load aggregators and other entities execute demand response instructions to **reduce** or **transfer** their electricity loads based on the demand of the grid.



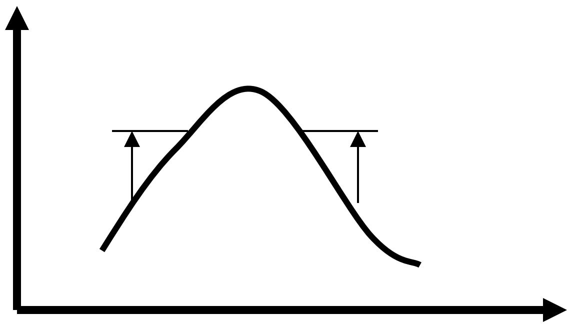
Peak-shaving



Zhejiang Third Party Auxiliary Service Market

Facilitating VRE integration

- During low demand periods such as holidays and nights, the renewable energy consumption capacity and negative reserve capacity of local power grids are insufficient, leading to the initiation of valley filling demand response.
- Users **increase** their electricity load base on grid demand and promote the consumption of renewable energy.



Valley filling

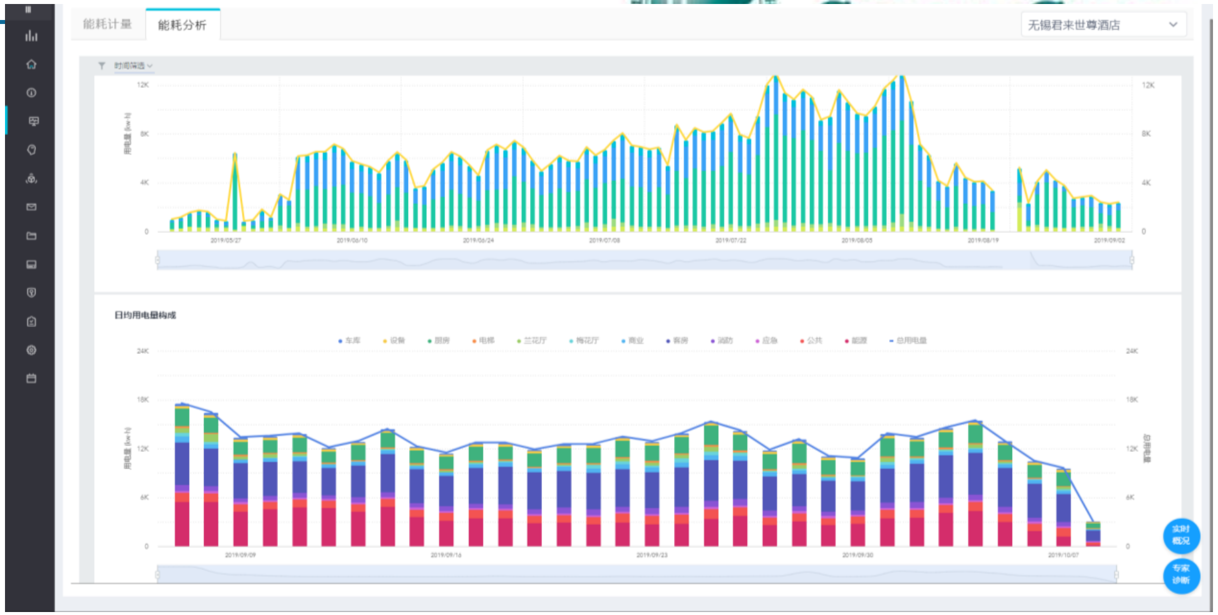
Connecting to load capacity of **1.29** million kVA

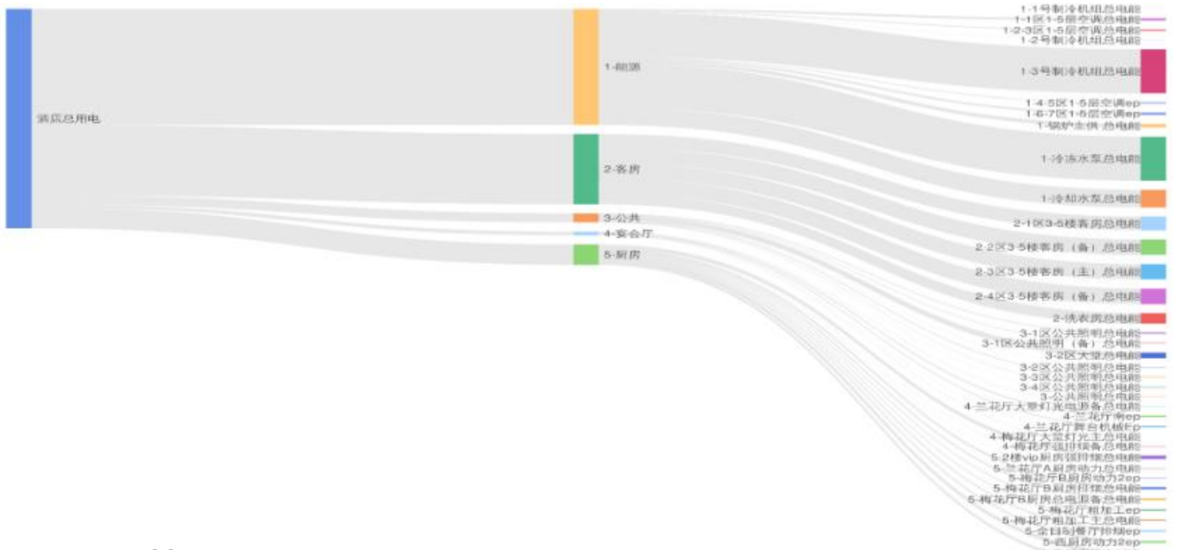
Liaoning Wind Power Consumption with Industrial Load

3. Impact of Present Policies

Upgrading energy efficiency

- During the 13th Five Year Plan period, the energy consumption per unit of GDP of China was about **3 times** that of OECD countries and **1.5 times** the world average.
- *The Outline of the 14th Five Year Plan* requires to reduce energy consumption per unit of GDP by **13% to 14%.**
- SGCC has been continuously focusing on this field for years and has implemented over **40000** energy service projects.





Energy efficiency improvement cases in Hunan Province

4. Recommendations

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- Privacy security and ununified interfaces in different types of electrical equipment
- High investment with low anticipated profits
- Absence in the voluntary carbon market

- Establish and optimize a unified standardized system for DSM privacy and security, unify interactive interface inspection and certification standards.
- Continuously improve the market transaction varieties, before a mature market is established, increase special subsidies.
- Develop CCER methodologies and include DSM projects in the scope of voluntary emission reduction transactions.

Thanks for your attention

Q&A Session

Hideyuki Umeda
Director for International Policy
on Carbon Neutrality
METI

Sylvie Tarnai
Chief strategy
Officer
Energy Pool

Songsong Chen
CEPRI

Demand side management and storage: Case studies from US

Siva Gunda
Vice Chair
of the California Energy Commission

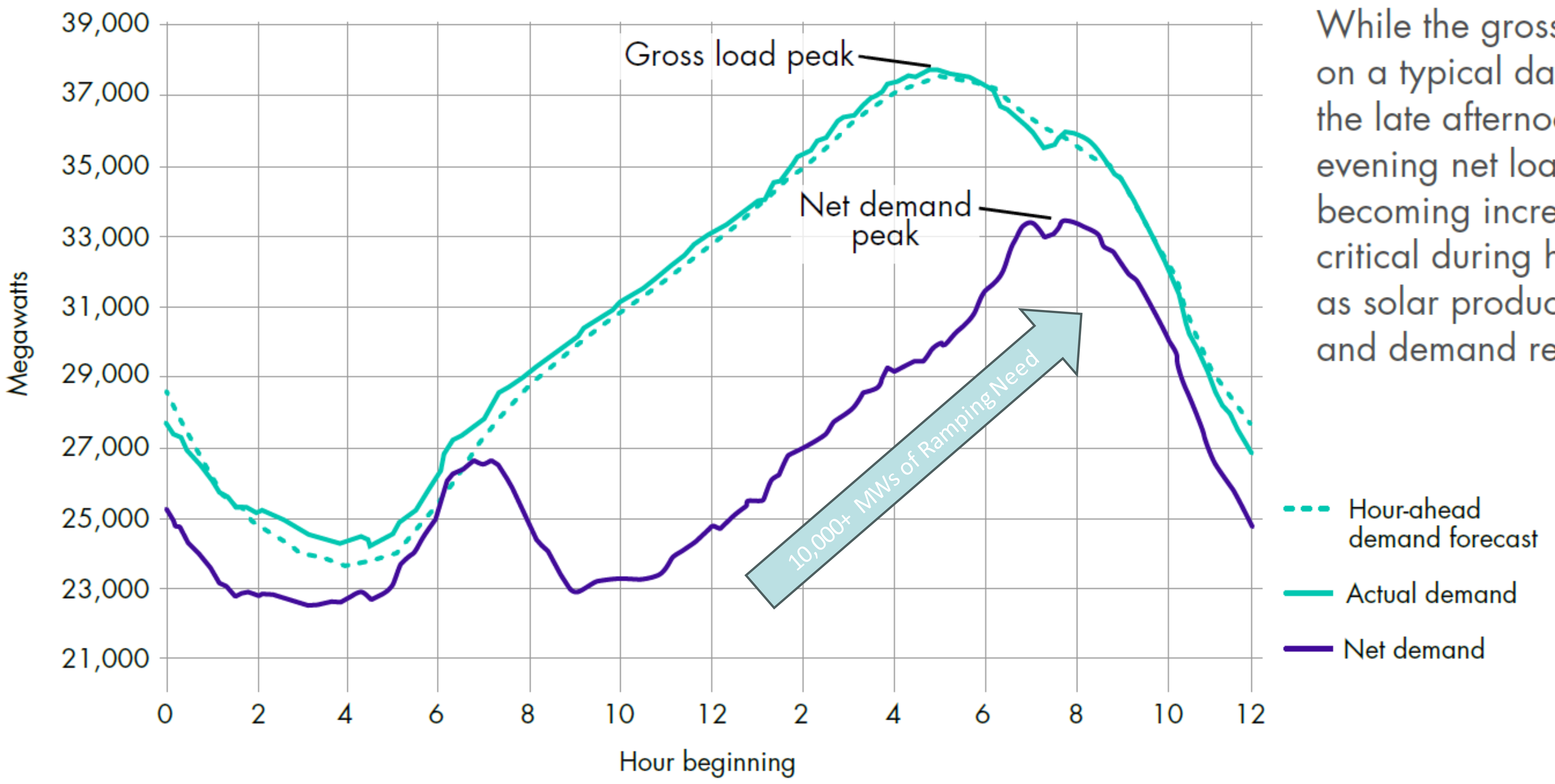
IRENA INNOVATION WEEK 2023

Enabling Load Flexibility in California

Vice Chair Siva Gunda, California Energy Commission

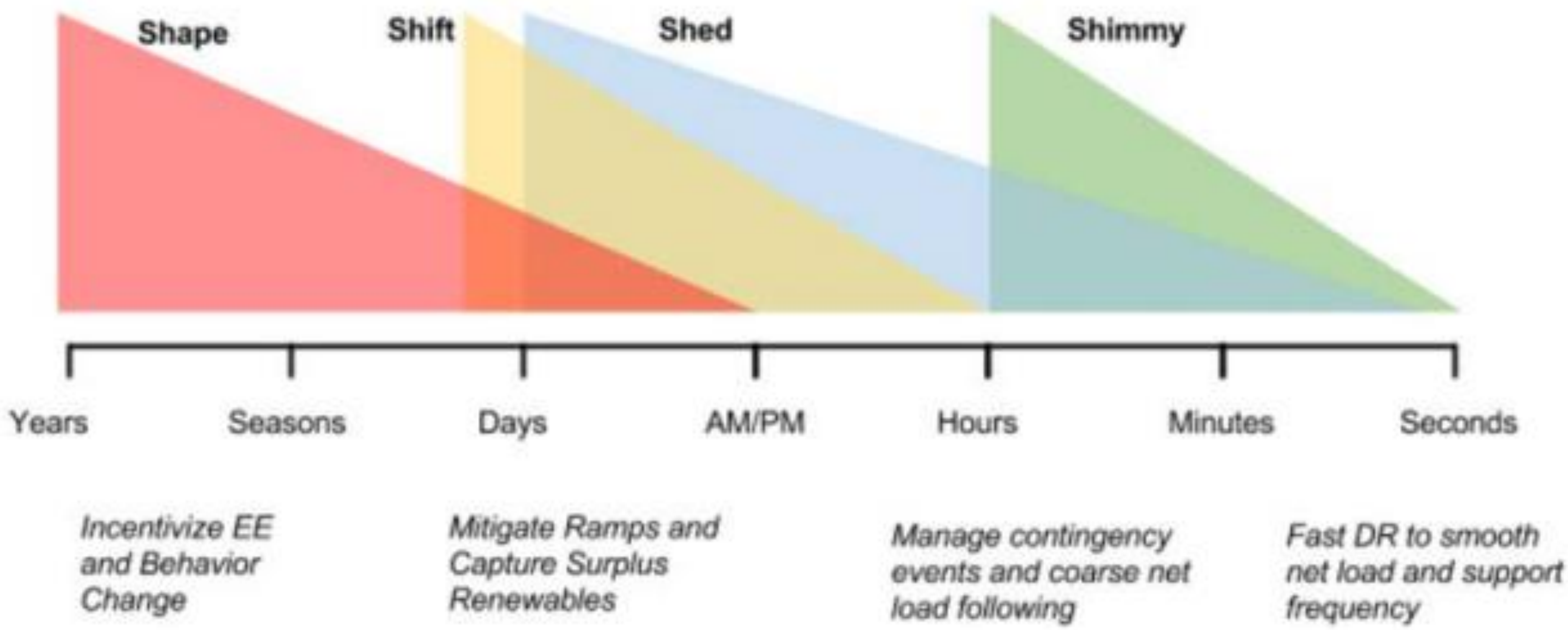
#IIW2023

Shaping Demand is Essential



While the gross load peak on a typical day occurs in the late afternoon, the early evening net load peak is becoming increasingly critical during hot weather, as solar production ends and demand remains high.

Demand Flexibility Takes Various Forms



Source: Lawrence Berkeley National Lab, 2025 California Demand Response Potential Study

Considerations in Incorporating Demand Flexibility Options

Responsiveness:
How Quickly will the measure respond?

Duration:
For how long can we sustain the measure?

Frequency:
How often can I call on the measure?

Reliability:
Will it show up when I call on it?

Cost:
How cost effective is the option compared to alternatives

Evolution In California's Planning Processes

Post 2020 Summer Started Including Emergency Event Planning

Standard Planning Pre 2020 Summer

Demand Forecast incorporates load modifying measures:

- Energy Efficiency
- **TOU**
- **Hourly Rates** and other dynamic pricing
- **BTM Storage**
- **Load-modifying programs**

Load Modifying DR

Resource Planning (IRP* and RA)**

- Bulk system additions
- Contract for Resource Adequacy
- **Economic DR** (DRAM, CBP, AC Cycling, etc.)
- **Reliability DR** (BIP, AP-I)

Economic & Reliability DR

Extreme Event Planning

- **Emergency Load Reduction Program**
- **Demand Side Grid Support**
- **Distributed Generation Backup assets**

Emergency DR

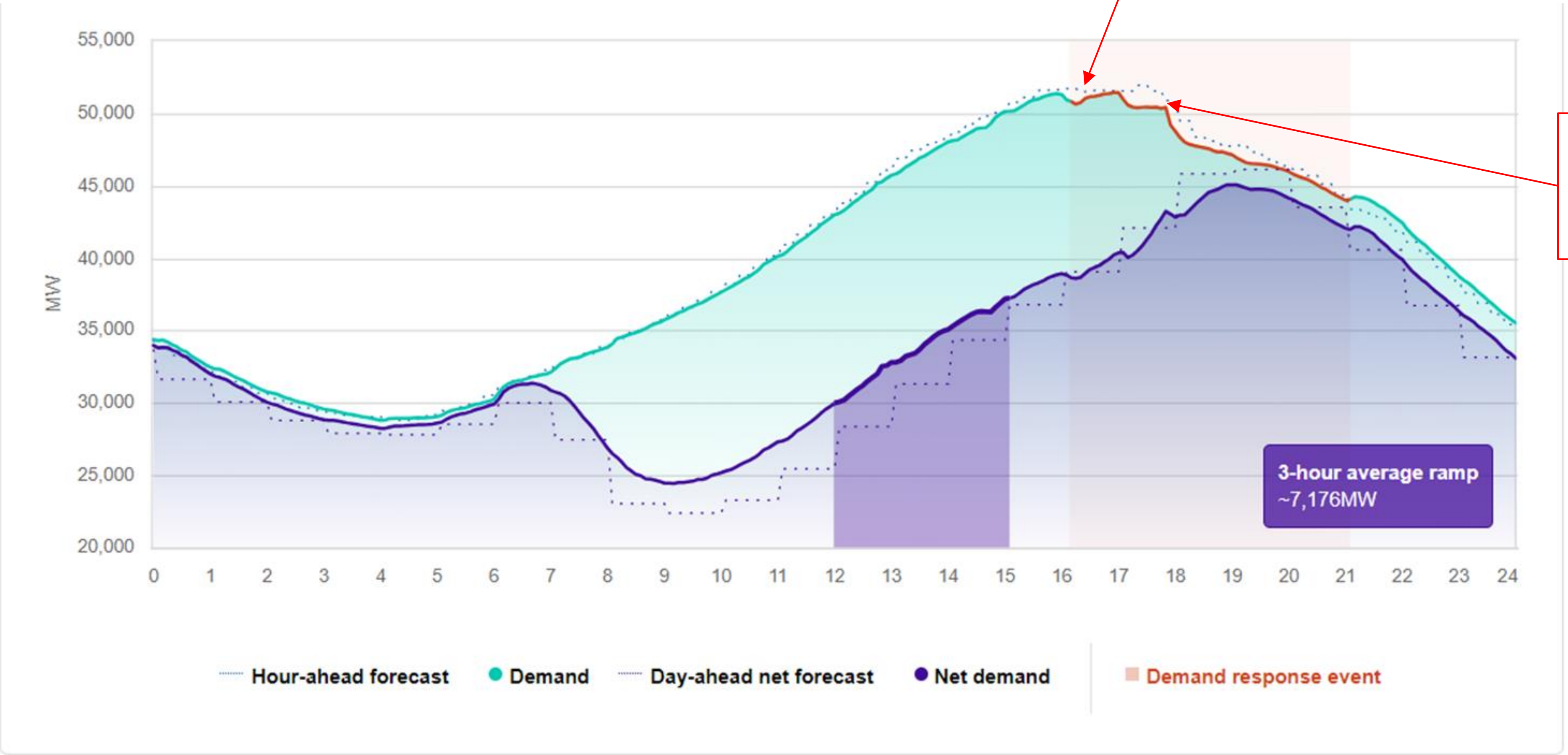
IRP – Integrated Resources Planning
RA – Resource Adequacy

Sept 6, 2023: Need and Opportunity for Demand Flexibility

Flex Alert requesting Voluntary Load Reduction in Day ahead timeframe

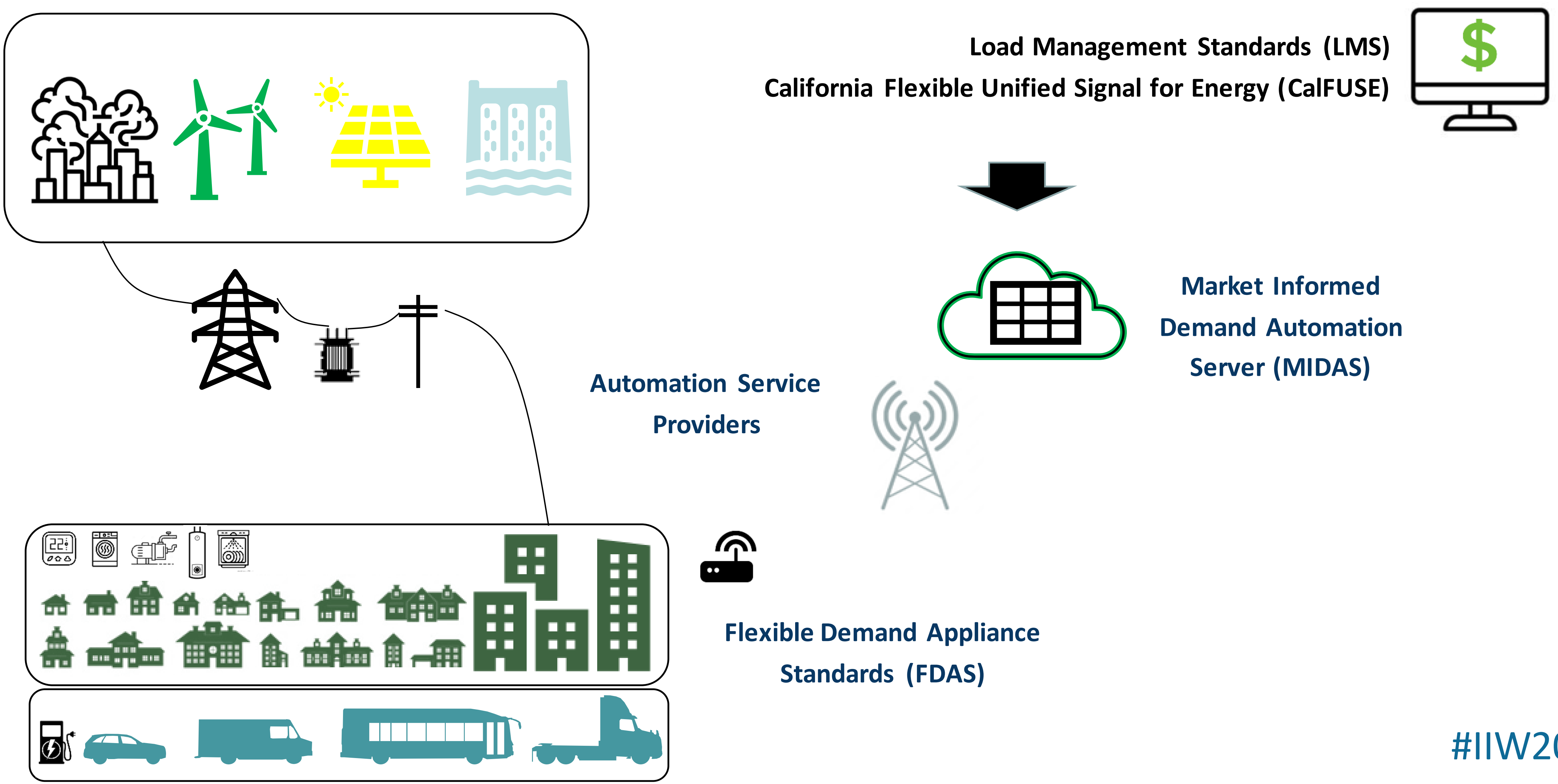
Begin Triggering Formal Demand Response Incentive Programs

Triggered Amber Alert requesting help from all Californians



Source: California Independent System Operator

California Evolving Load Flexibility Ecosystem



#IIW2023

CA Set a Load Flex Goal of 7000 MWs By 2030

Core Planning

Category	Intervention	2022 Estimate	2030 Goal
Load Modifying	TOU Rates	1,200 MW	**3,000 MW**
	Dynamic Pricing	30 MW	
	Programs Optimizing Load	7 MW	
Resource Adequacy	Economic Supply-side DR (PDR)	825 MW	**4,000 MW**
	Reliability Supply-Side DR (RDRR)	740 MW	
Emergency & Incremental	Emergency-Only Programs	800 MW	
	Back-Up Generators*	375 MW*	
Total (nearest hundred)		**3,600 MW**	**7,000 MW**

*Diesel Back-up generators are part of the current emergency framework but are not considered true load flexibility. This capacity is not included in load flexibility totals.

Load-Modifying (1)

Support hourly and other dynamic pricing

CalFUSE

Encourage alternative rate and program designs that incentivize load shifting

Provide incentives for load shifting technologies paired with dynamic rates

Load-Modifying (2)

Deploy information infrastructure to support load shifting

Market-Informed Demand Automation Server (MIDAS)

Adopt standards to enable appliance operations to be shifted, scheduled, or curtailed

Flexible Demand Appliance Standards (FDAS)

Complete deployment of advanced metering infrastructure (AMI) to support load shifting

Resource Adequacy (1)

Adopt an incentive-based capacity valuation approach for supply-side DR

Explore a centralized, competitive DR procurement process

Include an adder on wholesale market revenue for supply-side DR

Resource Adequacy (2)

Reform availability rules and resource requirements for DR resources participating in RA

Conduct an evaluation, measurement, & verification study of supply-side DR load impacts

- CEC interval meter database

Emergency & Incremental

Pilot approaches to compensate DR providers for incremental capacity delivered under extreme heat or other critical conditions

Pilot a pathway for behind-the-meter energy storage to support decarbonization and reliability of the electric grid in emergency & incremental programs

Pilot short-duration load shifting resources in emergency & incremental load flexibility programs

Periodically reassess the role of emergency resources in demand-side, RA, and emergency planning processes

Reliability Reserve Incentive Programs

	Demand Side Grid Support (DSGS)	Distributed Electricity Backup Assets (DEBA)
Funding	$314 Million (over 5 years)	$545 Million ($595 Million over 5 years)
Incentivized Activities	Use of load reduction resources during extreme events	Purchase of cleaner and more efficient distributed energy assets that would serve as on-call emergency supply or load reduction
Eligibility	Statewide	Statewide
Program Status	Launched Aug 2022; incorporating lessons learned	Under Development

Examples of Eligible Technologies

Bulk Grid Assets

Efficiency upgrades, maintenance, and capacity additions to existing power generators

- Equipment upgrades
- Clean back-up generation or storage
- Waste heat to power

Distributed Resources

New zero- or low-emission technologies, including, but not limited to, fuel cells or energy storage, at existing or new facilities

- Load flexibility controls, SCADA systems, demand-response aggregation software
- Fuel cells
- Battery storage
- Linear generators
- Microgrids
- Microturbines
- Vehicle-to-grid integration
- Pumped hydroelectric storage
- Combined heat and power systems

Ineligible

The following technologies are ineligible for DEBA Program funding:

- Diesel backup generators, including diesel, biodiesel, and renewable diesel
- Standalone variable renewable resources without paired storage (e.g. solar, wind, etc.)

Thank you!

Daniel Bowermaster
Senior Programme Manager
EPRI

ELECTRIC TRANSPORTATION

Preparing for Opportunity: V2X and Transportation Electrification

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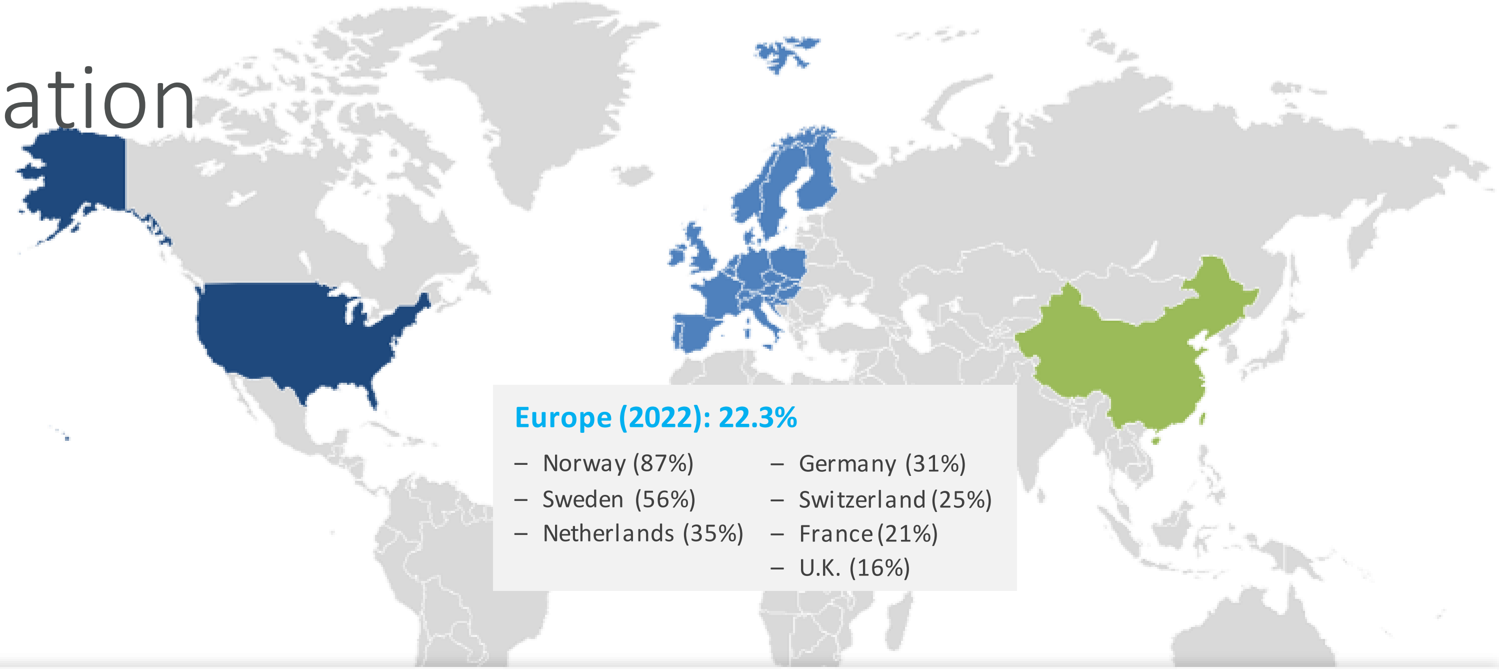
27 September 2023

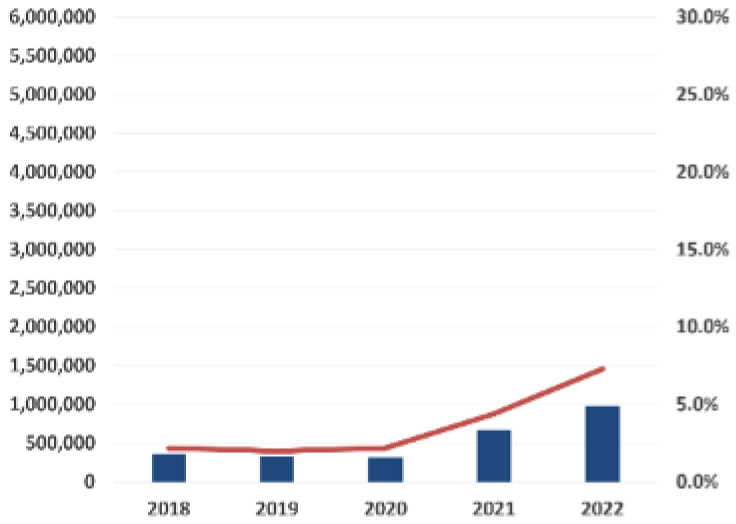
Transportation Electrification

KEY GLOBAL MARKETS

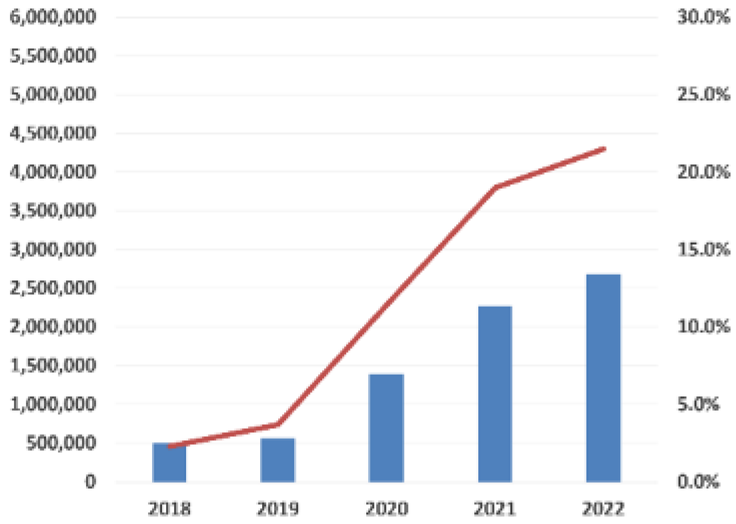
- 2022 global EV sales exceeded 10.5M (+55%, 15.9% of market) especially where supported by strong policy and EV supply



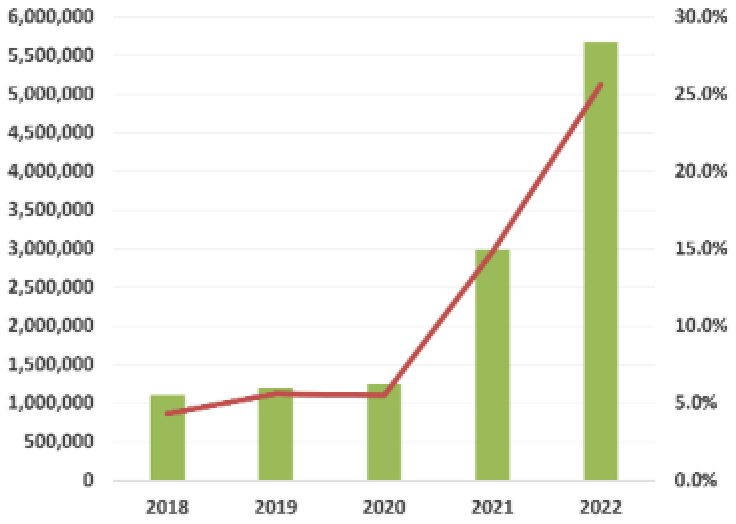
US EV Sales 2018–2022



Europe EV Sales 2018–2022

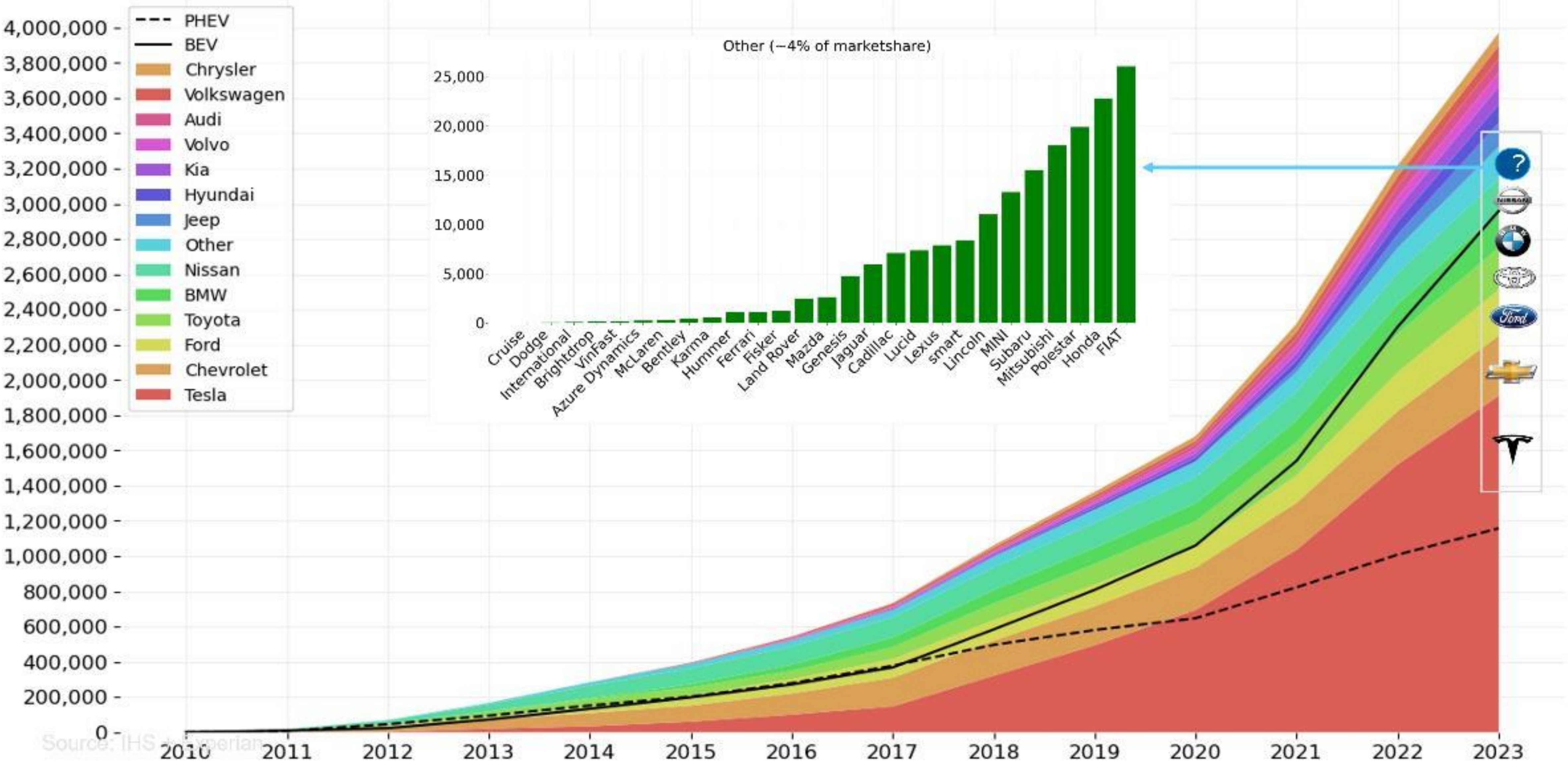


China EV Sales 2018–2022



Significant industry opportunity:

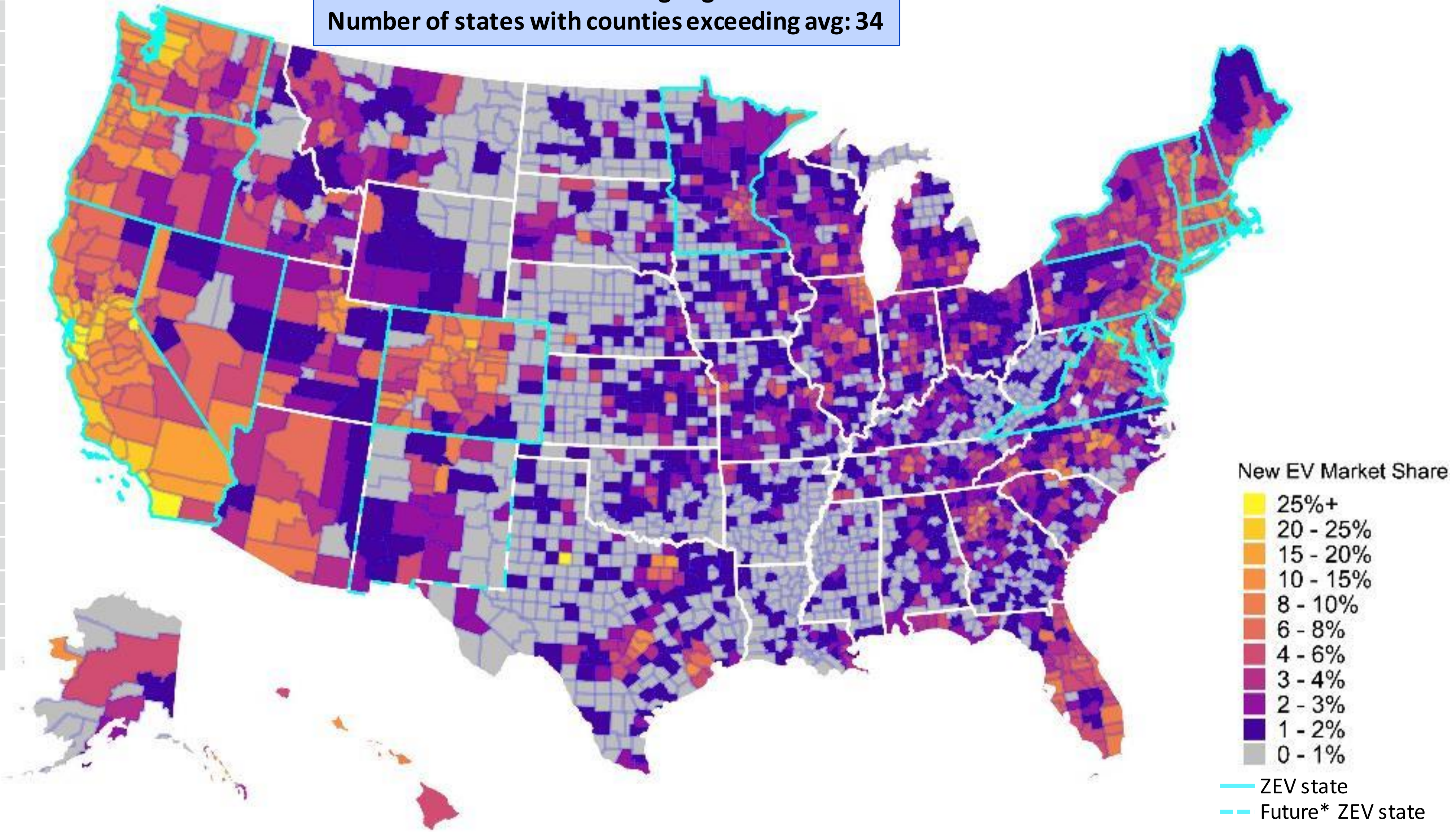
4.1M EV sales through 7/31/2023 = ~14.4 TWh in movable new load



US Nationwide New EV Market Share by County (Jan. – July 2023)

Top 5 counties in CA and Top 15 counties outside CA	
Santa Clara, California	43.8%
Alameda, California	39.3%
Marin, California	35.6%
San Francisco, California	34.5%
Contra Costa, California	31.4%
Kent, Texas	33.3%
San Juan, Washington	27.0%
King, Washington	23.8%
Boulder, Colorado	23.6%
Loudoun, Virginia	22.9%
Multnomah, Oregon	20.8%
Middlesex, New Jersey	20.8%
Snohomish, Washington	20.3%
Forsyth, Georgia	20.1%
Skagway, Alaska	20.0%
Benton, Oregon	19.8%
Howard, Maryland	19.1%
Somerset, New Jersey	19.0%
Jefferson, Washington	18.8%
Petersburg, Alaska	18.2%

Nationwide avg new EV market share: 8.8%
Number of counties exceeding avg: 194
Number of states with counties exceeding avg: 34



Transportation Electrification

U.S. FORECAST

Biden's executive order

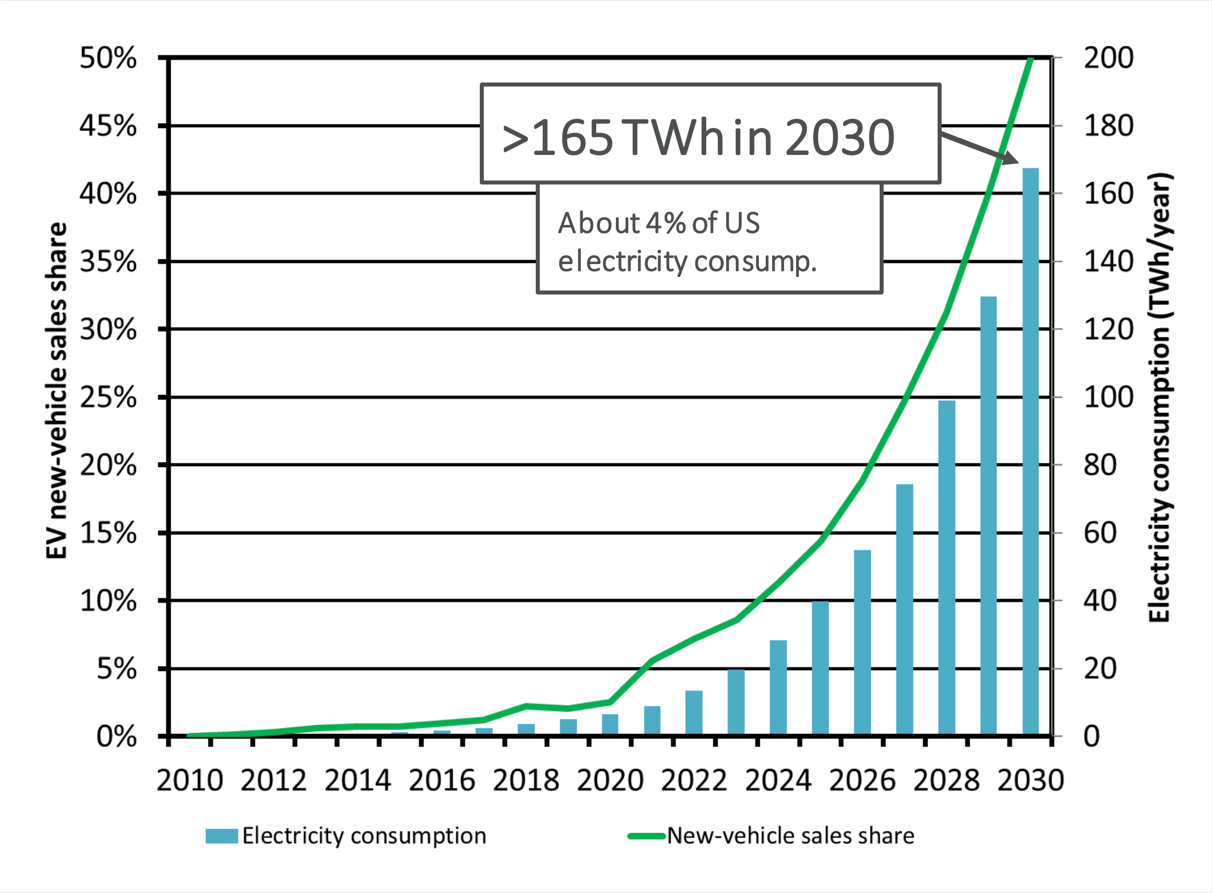
- **Goal** of 50% of new sales as ZEV by 2030
- ZEV includes BEV, PHEV, and fuel-cell EVs
- Goal applies to **passenger vehicles**
- New MD/HD fuel economy rules for MY2027+

Autos pledge 25-100% EV by 2030

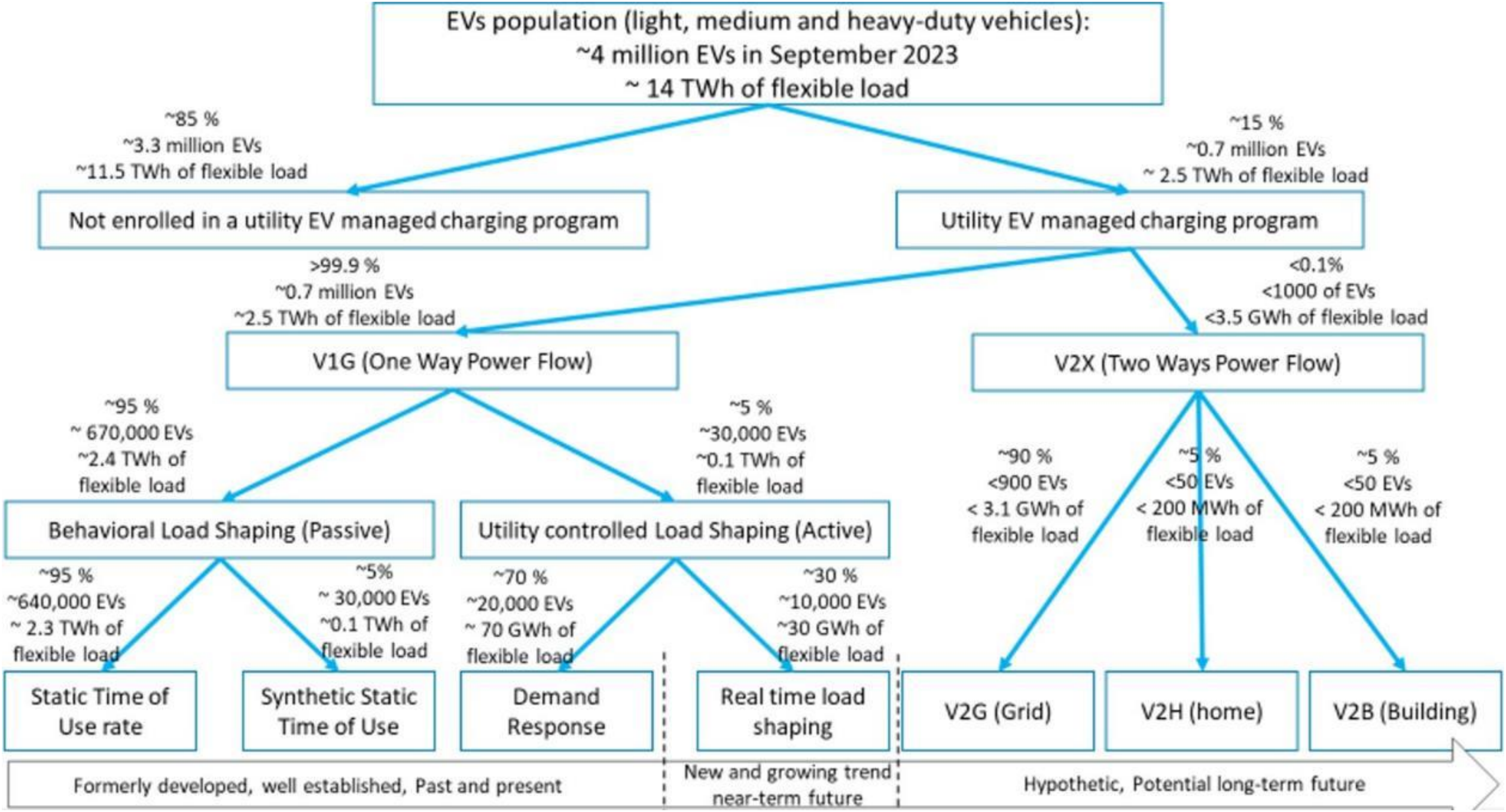
- Share of annual new U.S. sales
- U.S. autos GM, Ford, Stellantis pledged 50%
- Several other OEMs targeting 25% to 100% EV

LDV EV charging >165 TWh by 2030

- About 4% of US consumption*
- 36M EVs in operation in 2030
- About 1 in 7 (14%) LDV in operation are EV



* Total U.S. electricity consumption in 2030 is estimated to be 4,210 TWh
Annual Energy Outlook 2022, Reference Case, Table 8. https://www.eia.gov/outlooks/aeo/tables_ref.php


EVs population (light, medium and heavy-duty vehicles):
~4 million EVs in September 2023
~ 14 TWh of flexible load
~85 %
~3.3 million EVs
~11.5 TWh of flexible load
~15 %
~0.7 million EVs
~ 2.5 TWh of flexible load
Not enrolled in a utility EV managed charging program
Utility EV managed charging program
>99.9 %
~0.7 million EVs
~2.5 TWh of flexible load
<0.1%
<1000 of EVs
<3.5 GWh of flexible load
V1G (One Way Power Flow)
V2X (Two Ways Power Flow)
~95 %
~ 670,000 EVs
~2.4 TWh of flexible load
~5 %
~30,000 EVs
~0.1 TWh of flexible load
~90 %
<900 EVs
< 3.1 GWh of flexible load
~5 %
<50 EVs
< 200 MWh of flexible load
~5 %
<50 EVs
< 200 MWh of flexible load
Behavioral Load Shaping (Passive)
Utility controlled Load Shaping (Active)
~95 %
~640,000 EVs
~ 2.3 TWh of flexible load
~5%
~ 30,000 EVs
~0.1 TWh of flexible load
~70 %
~20,000 EVs
~ 70 GWh of flexible load
~30 %
~10,000 EVs
~30 GWh of flexible load
Static Time of Use rate
Synthetic Static Time of Use
Demand Response
Real time load shaping
V2G (Grid)
V2H (home)
V2B (Building)
Formerly developed, well established, Past and present
New and growing trend near-term future
Hypothetic, Potential long-term future

ELECTRIC TRANSPORTATION

Thank You!

Gregory Poilasne
Co-Founder, Director, Chairman and CEO
Nuvve

INTELLIGENTLY ELECTRIFYING THE PLANET

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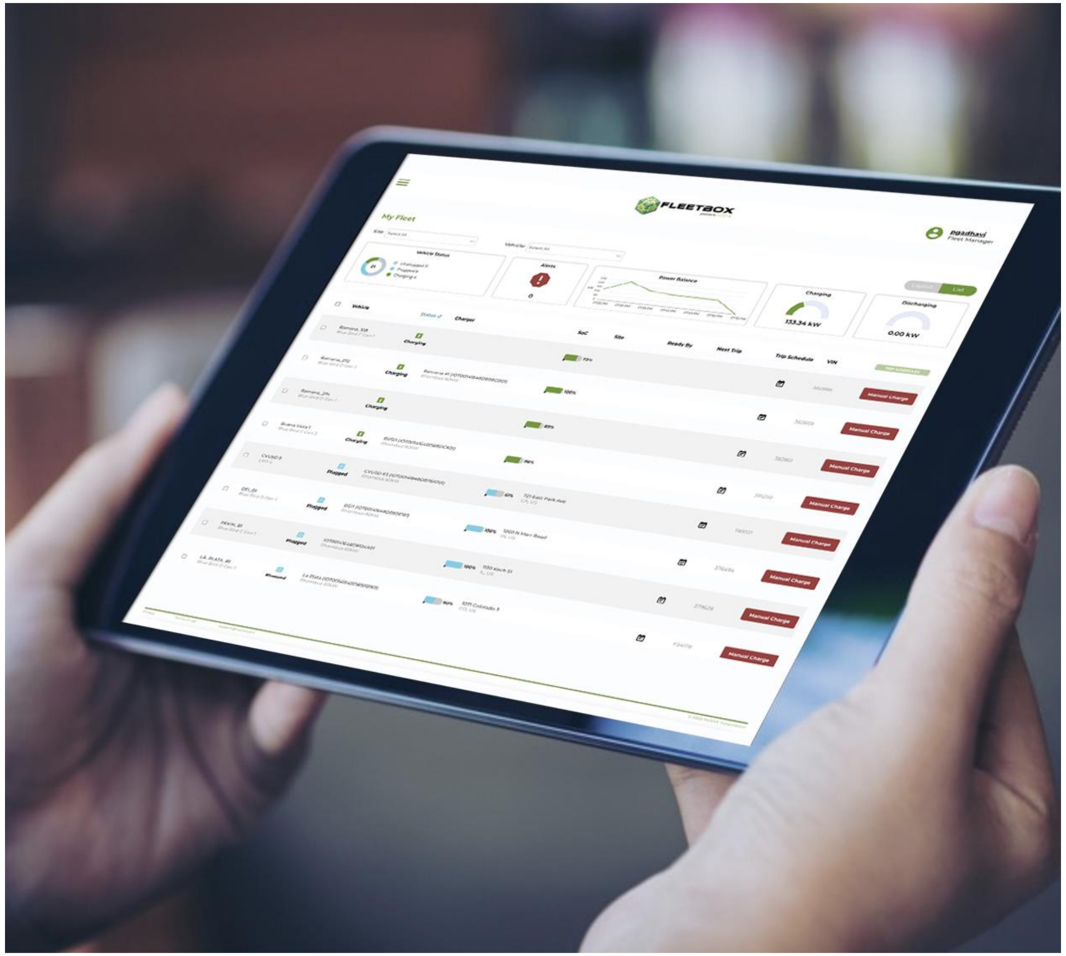
THE WORLD'S MOST ADVANCED V2G

- Enables EVs to charge *and* discharge energy from their batteries
- Precisely controls power flow between EVs and the grid
- Aggregates energy and power capacity from multiple EV batteries to form a virtual power plant (VPP)
- Performs grid services that help stabilize the grid and prevent blackouts*
- Sell energy back to the grid*
- "Energy equity" – increasing capacity for grid benefits for everyone



**In markets where this is allowed/applicable*

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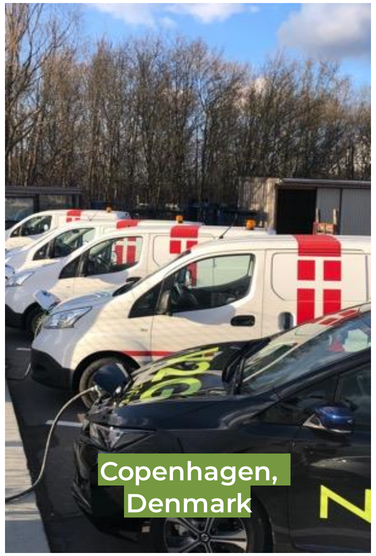
El Cajon, CA


Bornholm, Denmark

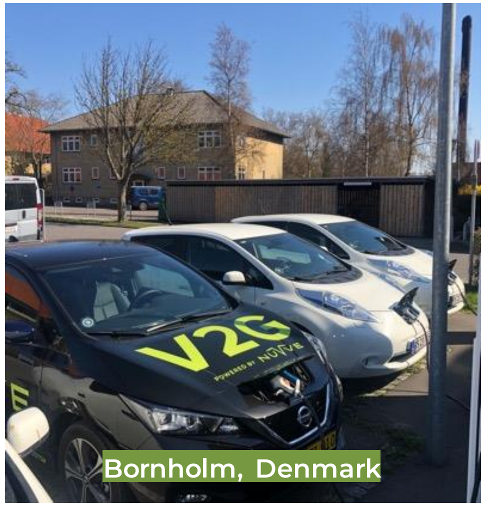

Oxford, UK


Concord, CA


Copenhagen, Denmark


Azores, Portugal


Durango, CO



Bornholm, Denmark

Pekin, IL


Frederiksberg, Denmark


San Diego, CA


White Plains, NY

V2G AROUND THE WORLD

THE BIRTHPLACE OF COMMERCIAL V2G

Denmark

- 7+ years of continuous V2G operations in Denmark
- 49+ light-duty vehicles located around the country
- Commercial fleets, municipalities, and utilities
- Grid services: frequency regulation
- Supporting Danish offshore wind renewable integration to the grid
- Gross, $3,000 to $5,000 per vehicle bid in 2022 on 10kW EVSEs

LARGE-SCALE GRID SERVICES WITH V1G

- *Nuvve's GIVe™ platform to manage 40 megawatts of electric vehicle (EV) fast charging and stationary storage capacity at 50 Circle K service stations*
- *Nuvve's cloud-based software to allow fast chargers to* ***provide a variety of grid services including frequency regulation, generating revenue*** *for Circle K by stabilizing deviations in the Norwegian and Danish electric grid*

US COMMERCIAL V2G SCHOOL BUS OFFERING

- Standard V2G School Buses are available with CCS plugs

BLUE BIRD THE LION ELECTRIC CO BYD

- Additional integrations ongoing
- Certified UL1741-SA bidirectional chargers, UL1741-SB planned
- Nuvve offers a complete V2G fleet solution
  - Buses
  - Chargers
  - Installation
  - Financing

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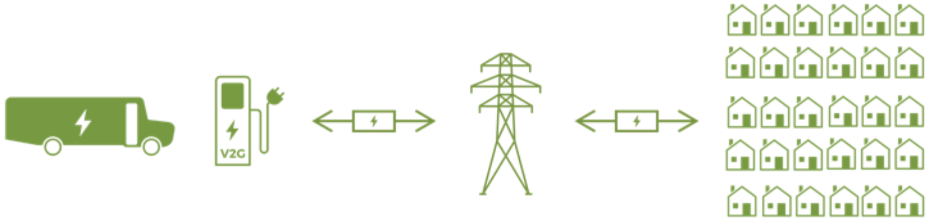
THE POWER OF V2G

- Average U.S. home uses 30kWh of energy per day
- An electric bus battery of 150kWh can store enough electricity to power 30 homes for 4 hours



"As a co-op, we have an obligation to lower costs for our ratepayers, and Nuvve's V2G solution is helping us do this. We also have aggressive decarbonization goals, and electrifying school buses in Durango helps us achieve those. It's a win for our ratepayers and students…"
– Dominic May, Energy Resource Program Architect at LPEA.

LPEA
La Plata Electric Association, Inc.
A Touchstone Energy® Cooperative

Based on avg. U.S home energy use. Source: U.S. Energy Information Administration

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NUVVE PLATFORM: HOW IT WORKS

Forecast

- **Vehicle-based**
  - Availability
  - Power capacity
  - Historical usage

Bid

- **Market-based**
  - Historical trends
  - Projected value
  - Volatility

Dispatch

- Compatible w/ all standards
- Control infrastructure directly or via APIs

Report

- Performance and financial results to stakeholders (utilities, fleet owners, drivers)

AI integration in development

Nuvve GIVe aggregator

Nuvve's platform simultaneously meets the needs of drivers, batteries, and the grid on a second-by-second basis

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THE NUVVE PROMISE

Drivers always have enough energy to drive

Cost savings and revenue generation opportunities

We work within OEM battery warranty limits

Fun Fact from Rønne Harbor, Bornholm, Denmark:
Port Security Vehicle: Nissan Leaf with 24kWh battery
Operating nearly 5 years of V2G; 93000km, 91% SoH[1]

[1] SoH = Battery state of health

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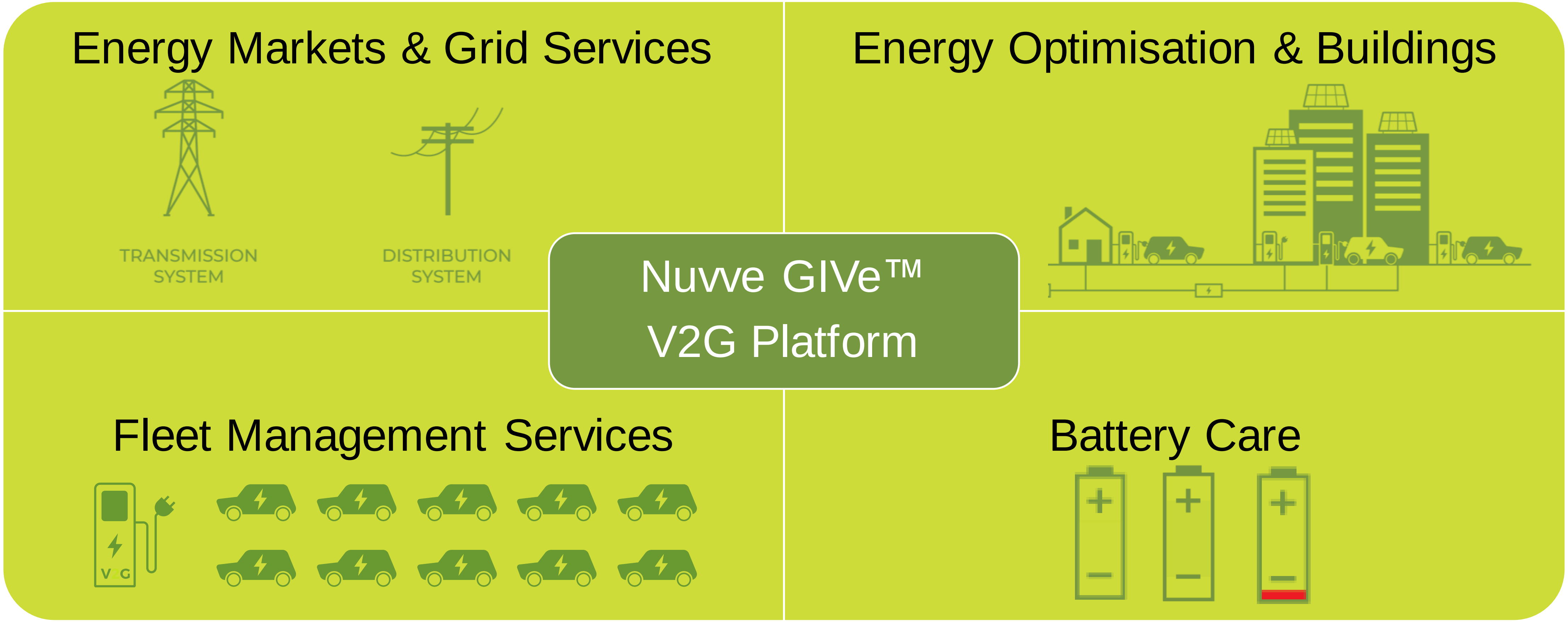
NUVVE CUSTOMER OFFERING



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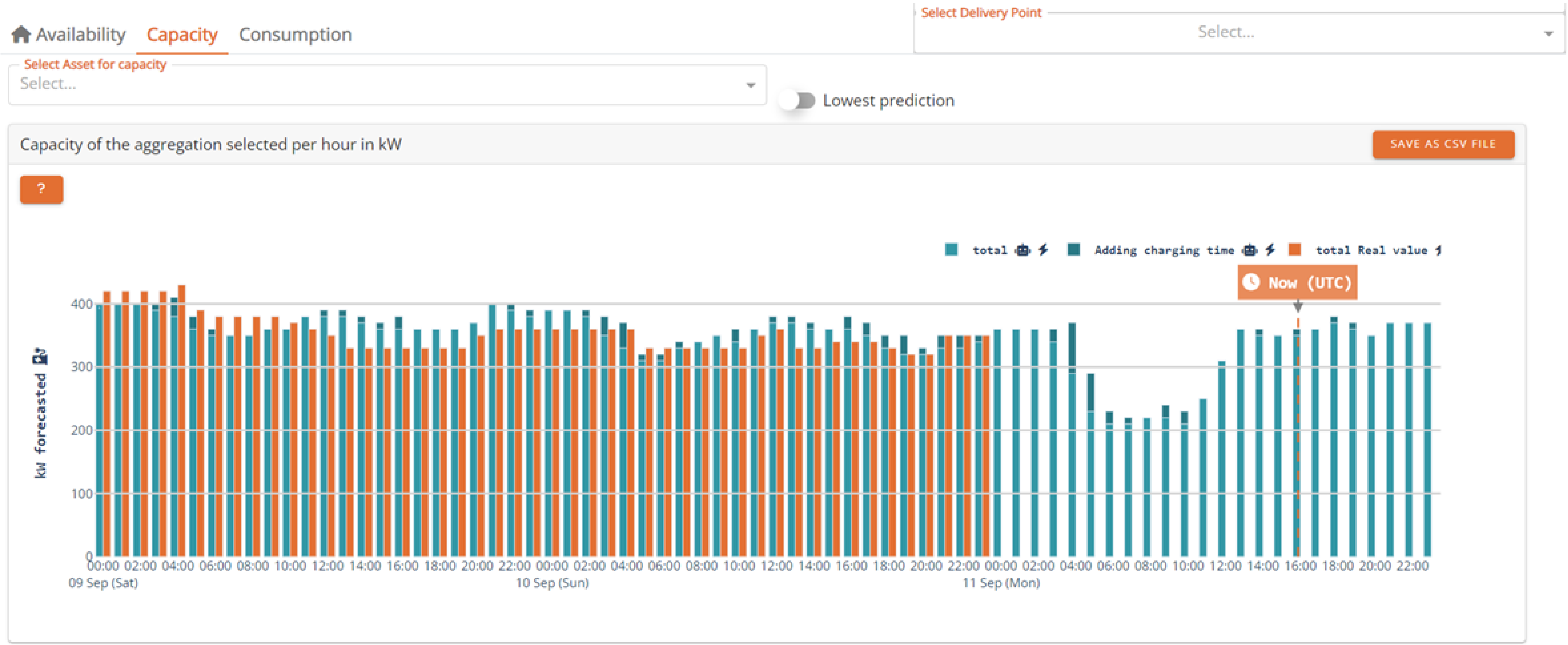
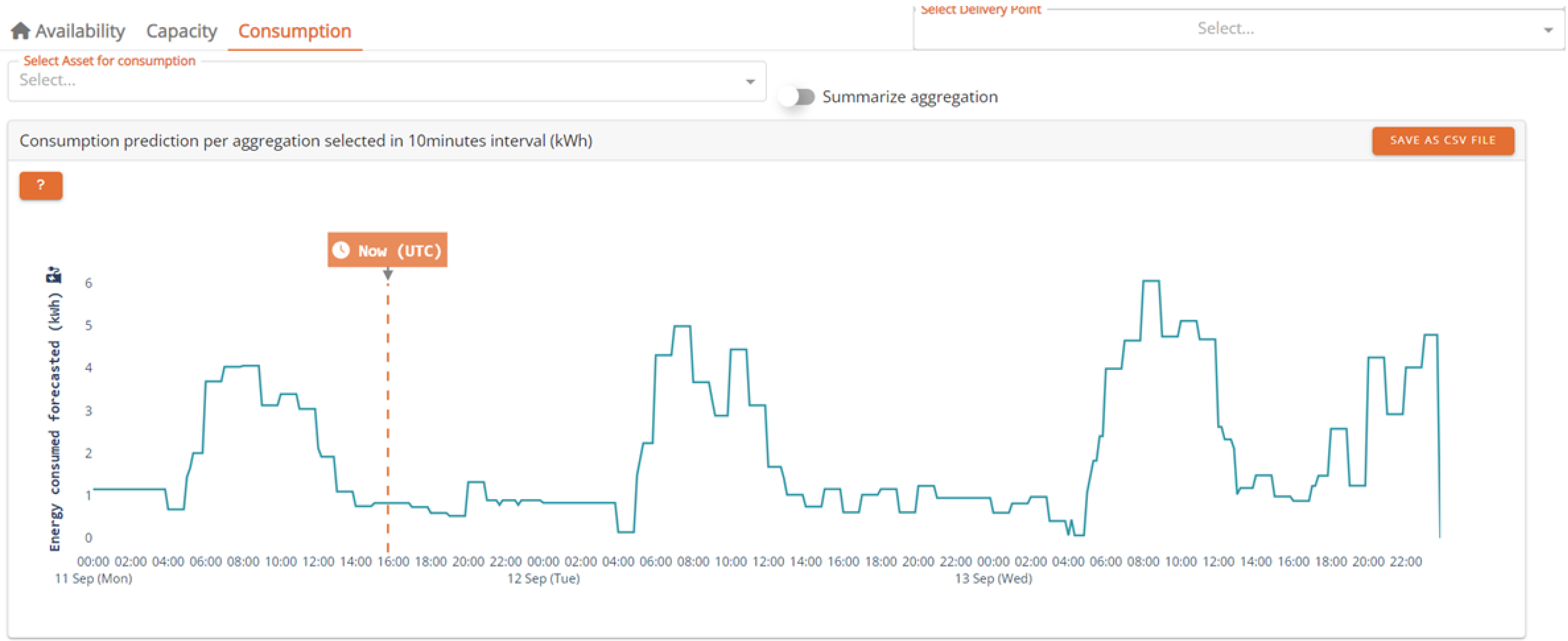
NUVVE AI ASTREA – CAPACITY FORECASTING



NUVVE AI ASTREA – ENERGY FORECASTING



THANK YOU

IRENA INNOVATION WEEK 2023

Q&A Session

Siva Gunda
Vice Chair of the California Energy Commission

Daniel Bowermaster
Senior Programme Manager
EPRI

Gregory Poilasne
Co-Founder, Director, Chairman and CEO
Nuvve

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IRENA INNOVATION WEEK 2023

Closing remarks

Francisco Boshell
Head of Innovation
IRENA

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