

# 2022 APEx Conference Presentations

Siemens

# Energy Market Management Systems

Siemens Grid Software US

SIEMENS

# Our Mission

## Accelerating and Securing the Energy Transition







**762,925**

tons of CO<sub>2</sub> savings since 2015 (Equivalent to 160,402 cars driven for a year)

**>\$2.39 bn**

Value in gross benefits since 2014

**30M**

People served by CAISO in the US

## Transmission & Energy Market Management for California ISO

### Transmission Management

Situational awareness and operational flexibility supporting market enhancements and renewable energy integration.

### Energy Market Management

Managing complexity and simplifying end-customer interactions with day-ahead and real-time market operations (>30,000 transactions/day).

# Energy Market Management System Components: Based on Market Segments

## Market Segments

- ISO/RTO Market Segment
- Vertical System Operators
- Microgrid Management Systems
- Market Participants



## EMM Capabilities

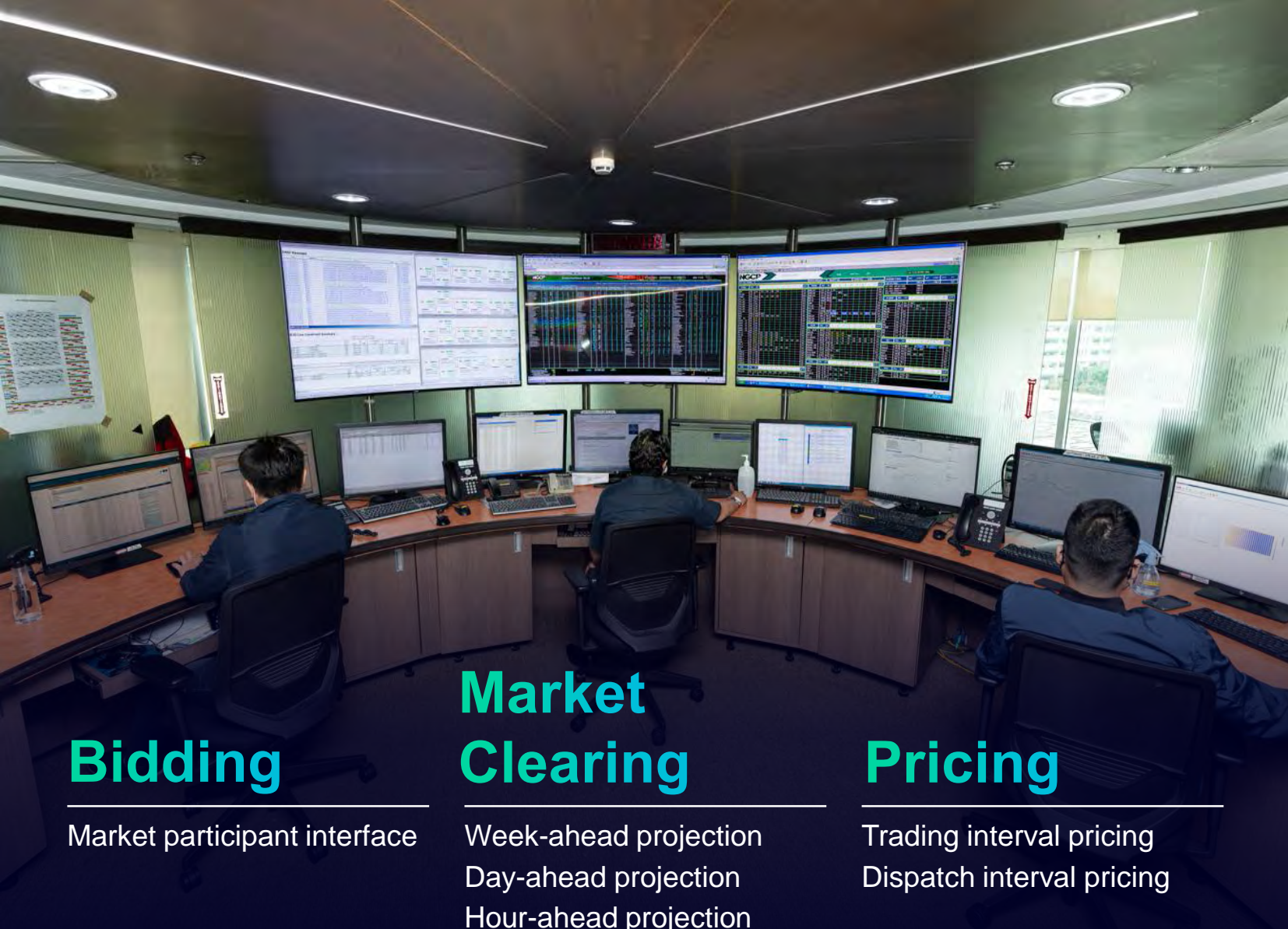
- + **ISO/RTO Liberalized Markets**
- + Market Participant Business Solutions
- + Microgrids of Communities
- + Hybrid (PV & Battery) Optimization
- + Vertical Utilities Fleet Optimization
- + **Imbalance Market for Renewables**



## Market Trends

- Utilize flexibility
- Empower hybrid energy resources
- Enable the best ROI for flexibility and renewables
- Time for big climate change initiatives
- Net-zero initiatives





## Bidding

Market participant interface

## Market Clearing

Week-ahead projection  
Day-ahead projection  
Hour-ahead projection  
Real-time dispatch

## Pricing

Trading interval pricing  
Dispatch interval pricing

# IEMO of the Philippines Operates the Wholesale Electricity Spot Market

June 2021

Since the new market is in commercial operation.

3 Main Islands  
Market footprint.

5-min Based

Electric spot market along with long-term projections.



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# Smart Grid Engineering Manager: Model Management for Midcontinent ISO

## Cloud Access

For graphical model editing or model upload provided for MISO members.

## Coordinates MISO Model Management

For submission, validation, approval, and activation of models.

## Common Model

For use by EMS, Market Management System, Congestion Revenue Rights & Outage Management System.



## Model Consistency

- Planning vs. Operations
- Multiple systems



## Model Exchange

- Multiple vendors
- Multiple organizations



## Model Formats

- Multiple versions

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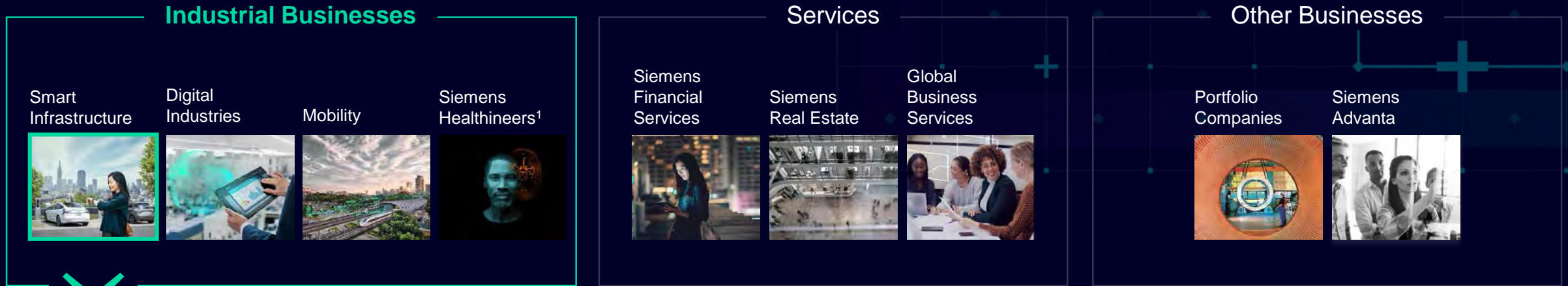


## Market Trends

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# Siemens Grid Software is Part of Siemens AG



## Siemens Grid Software

Grid Operators (plan, operate, maintain)  
Infrastructure & Industry (Grid Edge)



**2,550**  
Team members  
around the world

## Installed Base

**200+**  
EnergyIP®  
installations

**>100 m**  
Meters contracted

**1,300**  
Control  
centers

**70%**  
of the world's electricity consumption  
flows through infrastructure planned  
or analyzed by Siemens Grid Software

<sup>1</sup> Publicly listed subsidiary of Siemens; Siemens' share in Siemens Healthineers: 75%

# Bright Sparks Program





# Overview of Indian Power Sector: Energy Transition & Role of Power Exchange

By:

Vishu Vishal  
Manager – Strategy, IEX



## India's leading Platform for Electricity

- ❑ Nation wide, Automated & Transparent Platform for physical delivery of Electricity, RECs.
- ❑ Commenced operations in 2008; CERC regulated
- ❑ Publicly listed company – 2017 (NSE and BSE)
- ❑ ISO 9001:2015, ISO 27001:2013, ISO 14001:2015
- ❑ **DAM & RTM Market Share : 99.9%**
- ❑ **Overall Market Share incl DAM, TAM, RTM, Green Market FY22: 94.2%**
- ❑ Electricity volume CAGR 33% since 2008
- ❑ FY 22 Total trade: 102 BU (Electricity – 96 BU)

## Robust Ecosystem

<b>7000+</b> Registered participants	<b>4400+</b> Commercial & Industries	<b>1500+</b> RE Generators & Obligated Entities
<b>600+</b> Generators	<b>55+</b> Discoms (all)	<b>100+</b> ESCert Entities
<b>33%</b> Volume Growth CAGR since 2008	<b>99%</b> Market Share in DAM	<b>100%</b> Market Share in RTM

# Products at Indian Energy Exchange



## Integrated Day Ahead Market

DAM since Jun'08

- Delivery for next day
- Price discovery: Closed, Double-sided Auction
- 15 min. contracts, Daily trade.

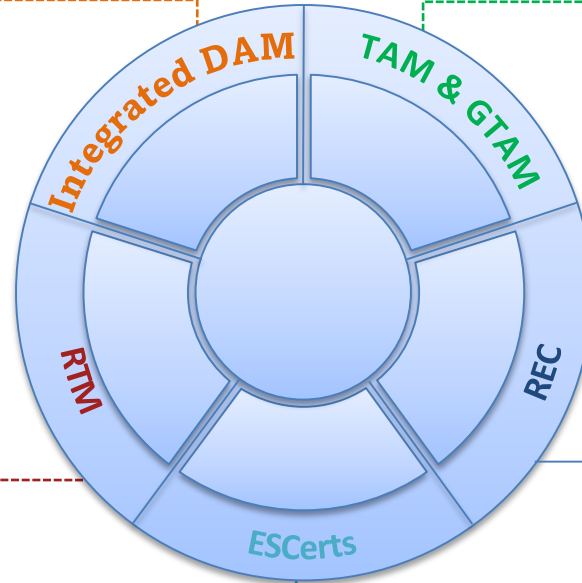
G-DAM since since oct 21

- Same as DAM, but priority for GDAM in price & volume discovery
- Option to carry forward uncleared bids in GDAM to conventional DAM
- Single price for different RE -solar, non-solar..

## Real Time Market

Since 01 Jun'20

- Half Hourly market (48 times per day)
- Delivery for 30 minutes in two-time blocks of 15 minutes each
- Double sided closed auction with uniform price



## Energy Saving Certificates

Since Sep., 17

- 1 ESCert = 1 Mtoe (Metric Tonne Oil Equivalent)

## Intraday Market & Contingency Market Segment

Since Jul15

- Intraday Market : hourly and or 15 minute contracts on same day on rolling basis
- Day-Ahead Contingency- 24-hourly and or 15-minute contracts on day-ahead basis for 00:00 hours to 24:00 hours of next day
- Continuous Trade

## Term-Ahead Contracts

Since June'22 (up to 3 months)

- Weekly Contracts
- Daily, Monthly
- Any day (s) single side Reverse Auction

## Green Term-Ahead Contracts

Since 21 Aug' 20

- 15-minute quotation of MW and Rs/ MWh
- 'Continuous Trade' basis
- Revision in schedule not allowed
- Solar, Non Solar and Hydro

## Renewable Energy Certificates

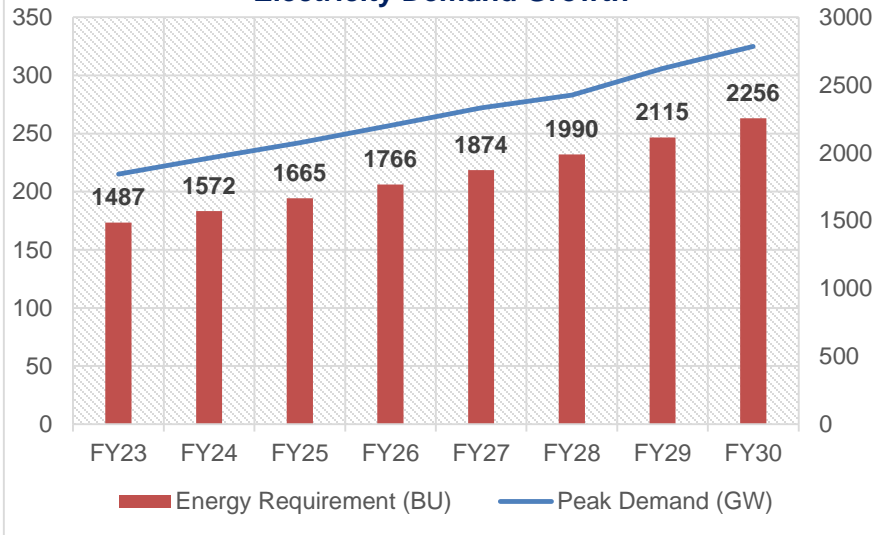
Since Feb., 11

- Green Attributes as Certificates
- **Sellers:** RE generators not under feed in tariffs
- **Buyers:** Obligated entities; 1MWh equivalent to 1 REC

# Energy Demand Trends & Shift in Energy Mix

## Projected Demand Trends

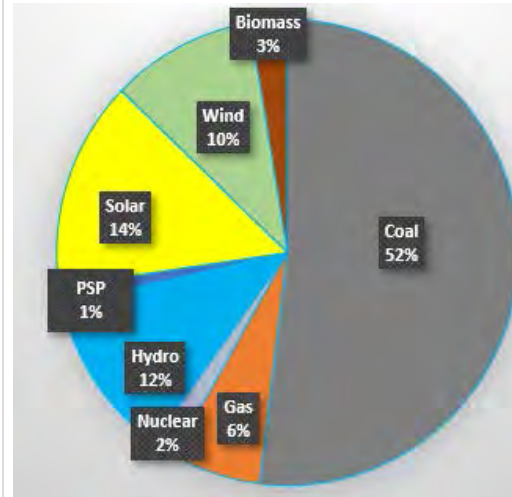
### Electricity Demand Growth



**Peak demand and Energy demand is Projected to grow at CAGR of 6.1% during FY23 to FY30**

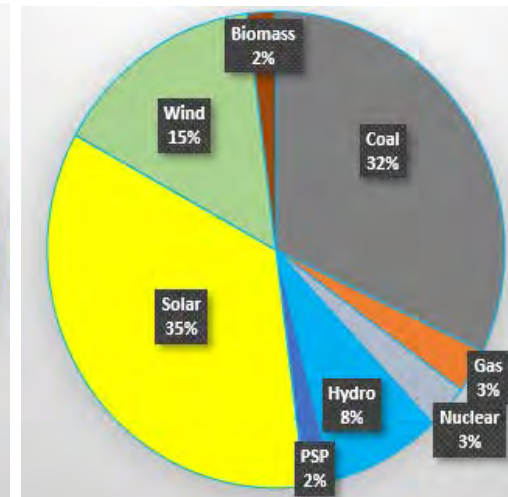
## Change in Supply Mix

### Supply Mix 2022



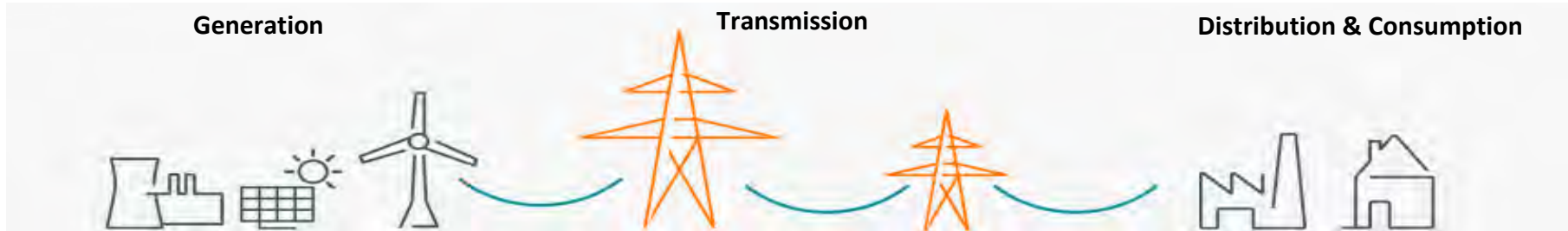
**Total IC: 403 GW**

### Supply Mix 2030



**Total IC: 817 GW**

*Ratified NDC 2022: Reduce Emission intensity to GDP by 45% by 2030 (V/s 2005 level) and 50% of IC from Non-fossil*



## Energy Transition

Installed Capacity	FY22	FY 30
Total GW	403	817
Coal Cap GW	211	266
<b>Coal (%)</b>	<b>51.5</b>	<b>32.6</b>
RE & Hydro GW	160	506
RE & Hydro %	40	62

## Integrated national Grid

- Inter-reg. trans. Cap.: 113 GW
- 460K cKM in 2022 to 600K cKM in 2030 of trans. Lines (1.3X)
- Green Corridor: RE rich states; projects for evacuation of RE into National grid
- 99.9% times no congestion

## Reforms Underway

- Peak Demand: 211 GW (Highest)
- Distribution network upgradation & smart meter installation: 250 Million
- Regional Power Market
- Prosumers/ Roof top Solar
- Choice to consumers
- Electrification as decarbonization lever: EV, Cooking, Traction

50% Non-fossil fuel based Capacity

One Nation One Price

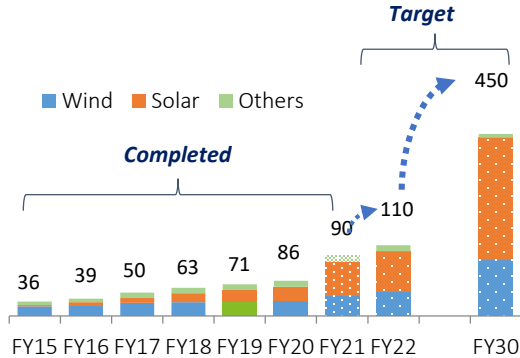
Modernisation of Discoms

# Focus on Greening the Indian Power System



Policy push towards achieving sustainable development goals

## RE Capacity (Excl Hydro)



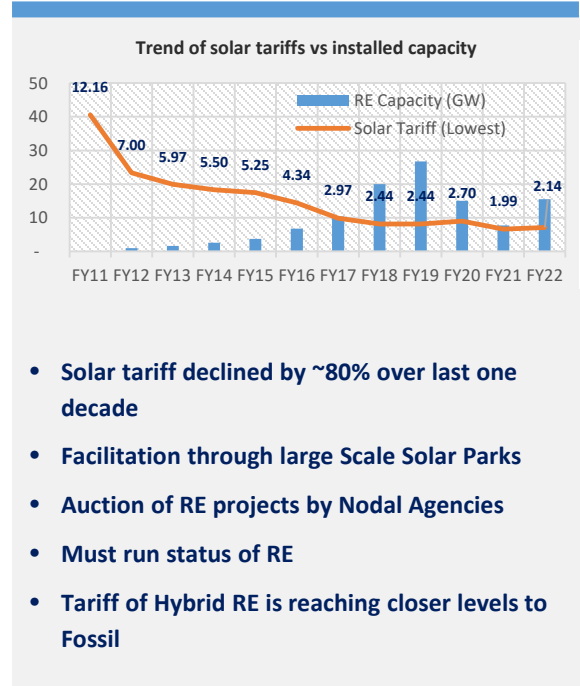
- India now at 4th global position for overall installed RE capacity
- 3X growth in Installed RE (Exl Hydro): 36 GW in 2014 to 116 GW in 2022
- 2X growth in Installed RE (Inc Hydro): 76 GW in 2014 to 163 GW in 2022
- RPO target for FY30 has been fixed at 43.33%
- Strong focus on Hybrid RE Tenders & BESS

## Investments

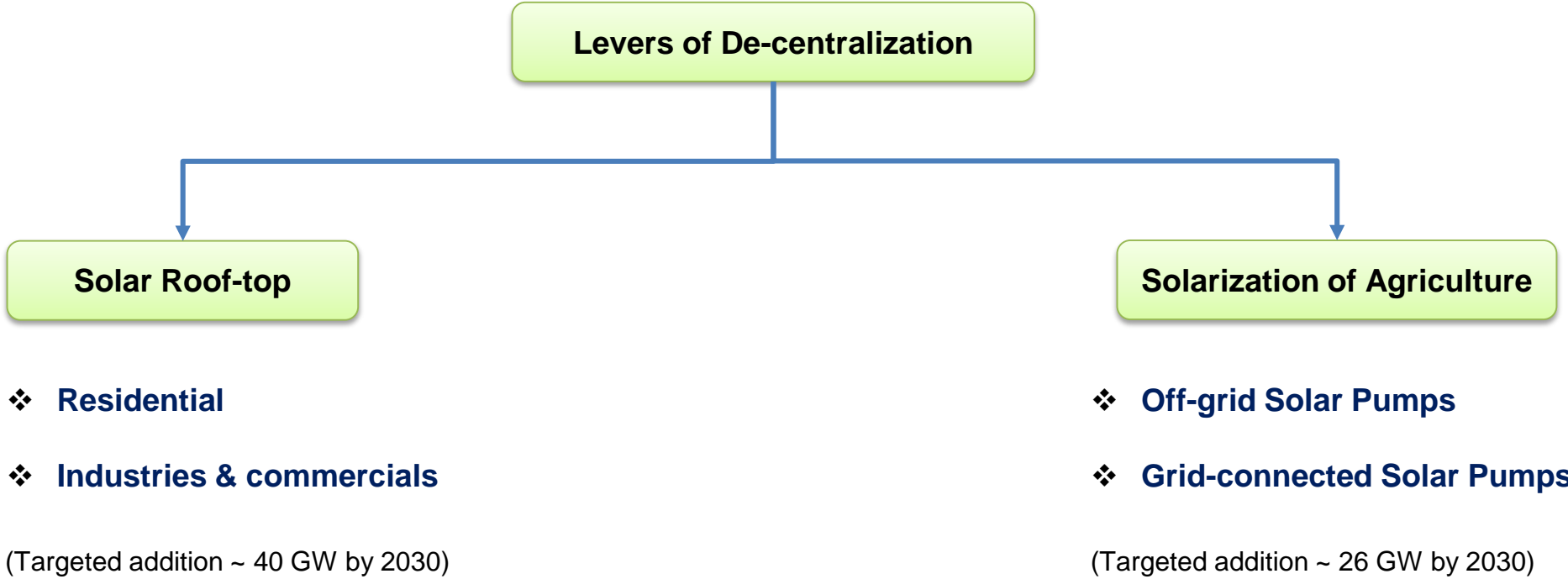


- Investment of around 20 Billion USD/ annum will be required in next 10 years
- PLI scheme to attract investment ~ \$ 5-6 Bn
- India to have 100 GW of Solar & Wind Manufacturing capacity by 2030
- Sector attracted FDI of USD 10 Bn between 2000 and 2020 (Ref: WEF)

## RE Tariffs



- Solar tariff declined by ~80% over last one decade
- Facilitation through large Scale Solar Parks
- Auction of RE projects by Nodal Agencies
- Must run status of RE
- Tariff of Hybrid RE is reaching closer levels to Fossil



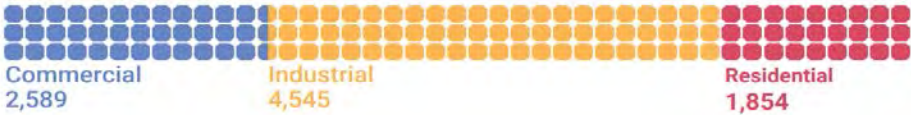


# De-centralisation of Generation capacity: Trends of Roof-top Solar

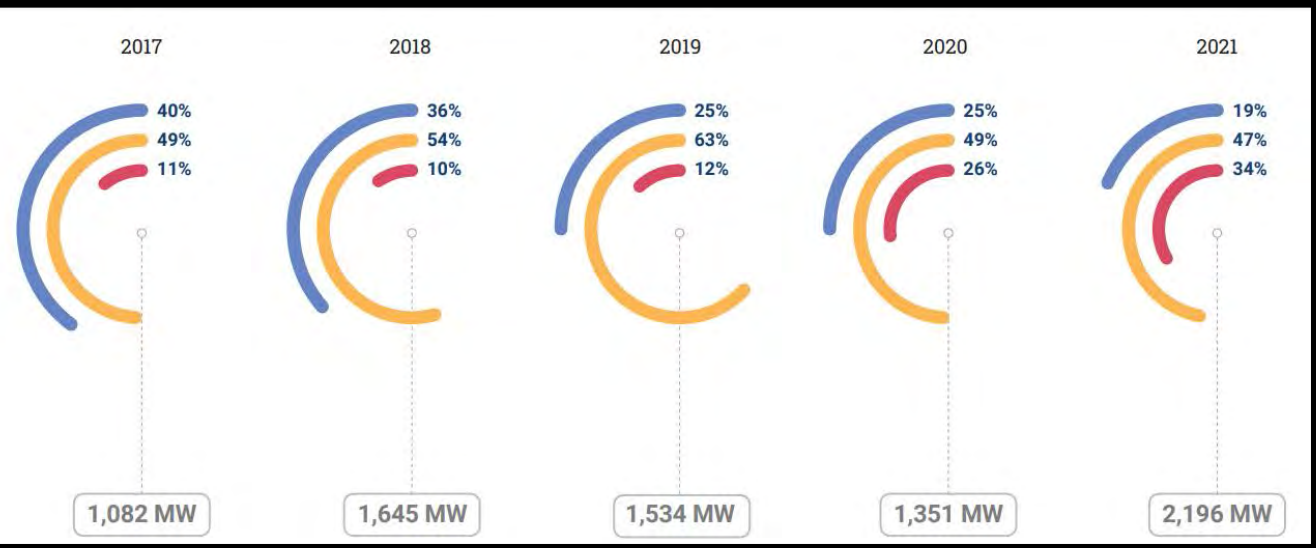


**Total installed capacity: 8,988 MW<sup>1,2,3</sup>**

as on 31 December 2021



*Steady rise in share of Roof-top addition by Residential segment over last 4 Yrs*



**Commercial**  
**Industrial**  
**Residential**

Total capacity

Fig: Trends of Addition of Year-wise addition of RTS



## De-centralisation of Generation capacity: Policy & Regulatory support in Roof-top

### ✓ **Net Metering / Gross Metering / Virtual Net Metering**

- Net Metering is allowed up to 500 KW of contract demand
- In many cases the savings are to the tune to 15-25%

### ✓ **National Portal for Roof-top solar installation requests**

### ✓ **Single Window Clearance for Green Open Access (Centralised processing within 15 days)**

### ✓ **Green Energy Open Access Rules 2022**

- Reduced eligibility requirements from 1 MW to 100 KW & allowing banking of energy with Discoms

### ✓ **Nominating Discoms as Nodal Agency & incentives to Discoms for higher RTS addition**

### ✓ **Central Finance assistance for RTS installations**



## Solar City Programme

- ✓ 60 Cities in India to be developed as Solar Cities
- ✓ Aims to meet at least 10% reduction in demand from fossil based sources over next 5 Yrs



<https://suryagujarat.guvnl.com/>

## Local Energy Markets

### Peer to Peer Power Trading

- ✓ 3 Pilot P2P Trading have been conducted in different Discoms in India
- ✓ IEX has partnered with leading players to conduct more P2P trading Pilots across India
- ✓ The Findings of the Pilot projects shall help framing required Policy & Regulatory framework

## Solarization of Agriculture: De-centralised Model

### About PM KUSUM Scheme:

- ❑ Aims to add **26 GW of Solar Capacity** with Central Finance Assistance of Rs 34,422 Crs (~ 7 Billion USD)
- ❑ Central & State grants 30% each & 40% is funded by Farmers with Equity & Debt
- ❑ Regulatory mechanism to support purchase of excess generation from Farmers
- ❑ Segregation of Agri-feeder is also being done



#### Component A

- ✓ Setting of 500 KW to 2 MW of Solar Plants by Farmers connected to Discom Network
- ✓ PPA shall be executed between Farmer & Discoms for 25 Yrs. (SERC determined)

(~ 10 GW of Capacity)

#### Component B

- ✓ Installation of New Solar Water Pumps ~ 2 Million
- ✓ Pump capacity up to 7.5 HP has been allowed for CFA

(~ 8 GW of Capacity)

#### Component C

- ✓ Solarization of existing Agri-pumps ~ 1.5 Million
- ✓ Excess Power generated shall be purchased by Discoms

(~ 8 GW of Capacity)

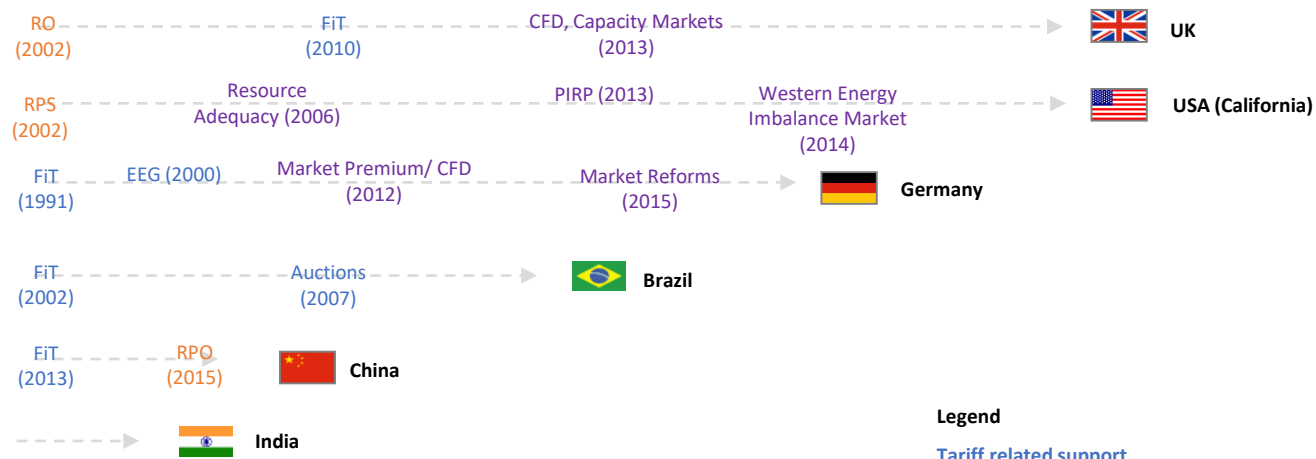


**Some new initiatives supported by IEX**

# New Initiatives to Promote decarbonization: Using Global experiences to design market based RE capacity auction model in India



- ❖ Countries such as UK, US, Germany have 30-50% of electricity traded through Market.
- ❖ This has been a key driver of RE capacity in these countries & RE power is participating in the market in competition with all other forms of power



**Legend**  
 Tariff related support  
 RPO/ REC support  
 Power market reforms

\*Excluding hydropower

## RE journey of India vs other countries

PIRP – Participating Interim Resource Program  
 CFD – Contracts for Difference

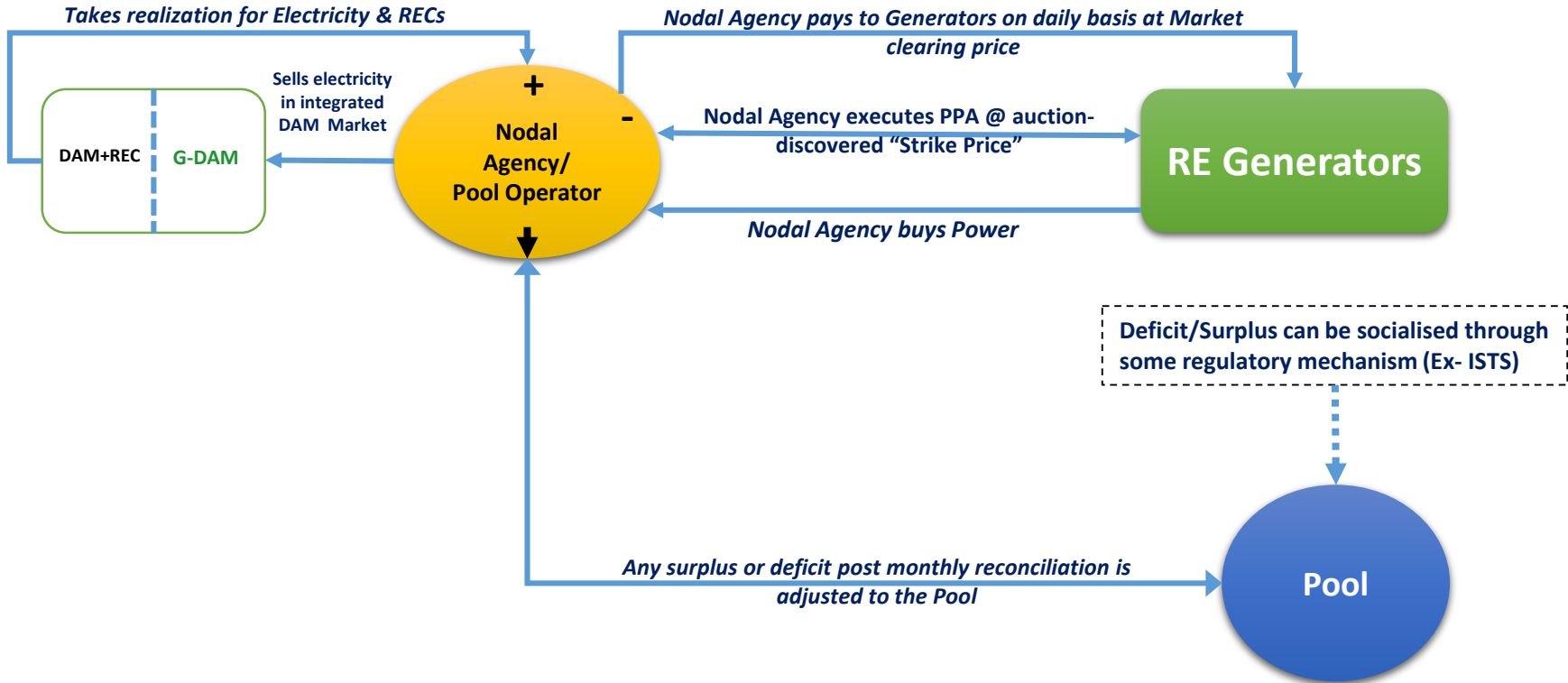
FIT – Feed in Tariffs  
 RPS – Renewable Portfolio Standards

EEG – Renewable Energy Act

# Proposed model: Bilateral contract settlement (BCS) based market model

- ❖ Nodal Agency (NA) executes PPA with Generators.
- ❖ NA buys Power from REG & sells in market.

- ❖ NA gets RECs & Sells in Market.
- ❖ NA owns the responsibility to pay REG & socialisation of surplus/deficit of the Pool



# New initiatives to support faster decarbonisation of Industries: Development of National Carbon Markets in India to accelerate decarbonization



## Decarbonisation of Industries: PAT Scheme

- Covers energy Intensive sector (~ 13 sectors) which represents ~ 50% of primary energy consumption
- Covered entities are given targets to reduce their SEC
- Trading of Energy saving certificates Power Exchanges (weekly)
- PAT scheme has led to saving of about 17 MTOE or 87 MTCO2 per year by 2020

## National Carbon Market

### Phase 1

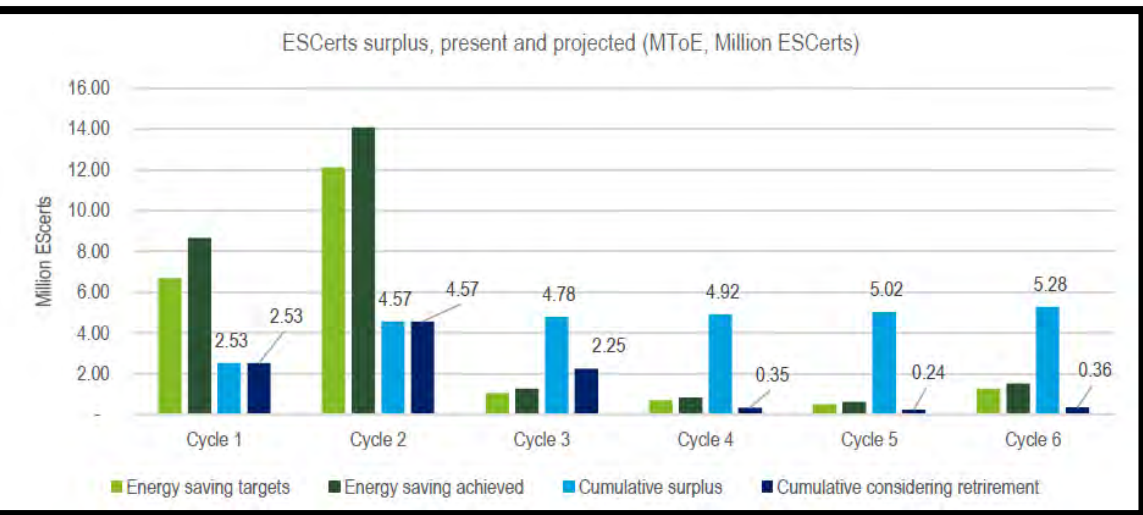
- Fungibility of attributes
- Allowing Voluntary Buyers

### Phase 2

- Increase sell liquidity
- SDM based project approval

### Phase 3

- Launch of ETS
- Gradual tightening of cap in line with climate goals







# Thank you



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# Bright Sparks Spotlight

Melissa Piong  
Lead Analyst  
PJM Interconnection

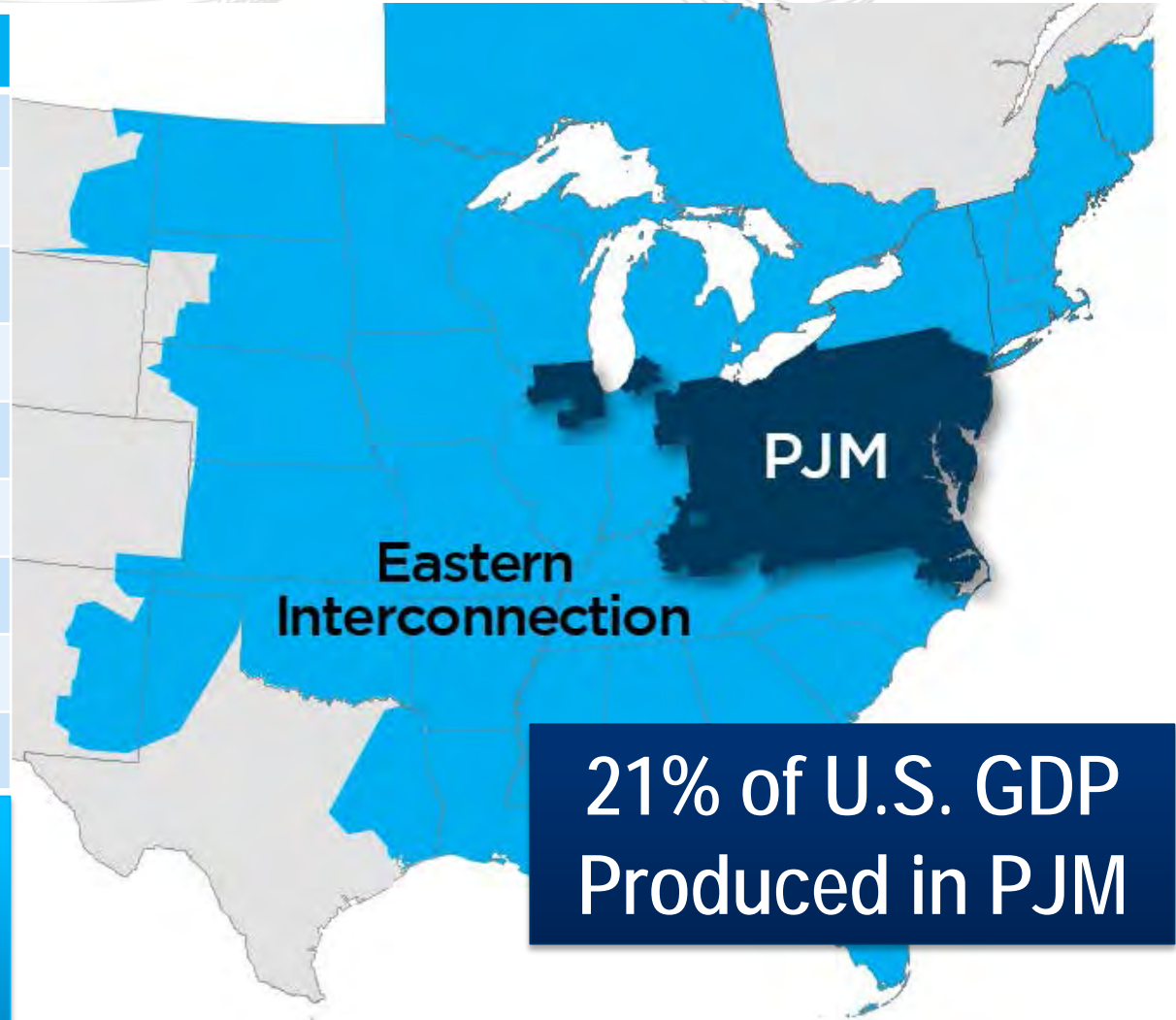
APEX Conference  
October 20, 2022

- 14 years of industry related experience
  - Finance (power plant outage budgeting)
  - Power, gas, & environmental trading compliance
  - Generation dispatch (including dispatch training & compliance)
  - Energy market compliance
- Education
  - Bachelor of Science in Finance, Rutgers University School of Business
  - Master of Business Administration, Villanova University

## Key Statistics

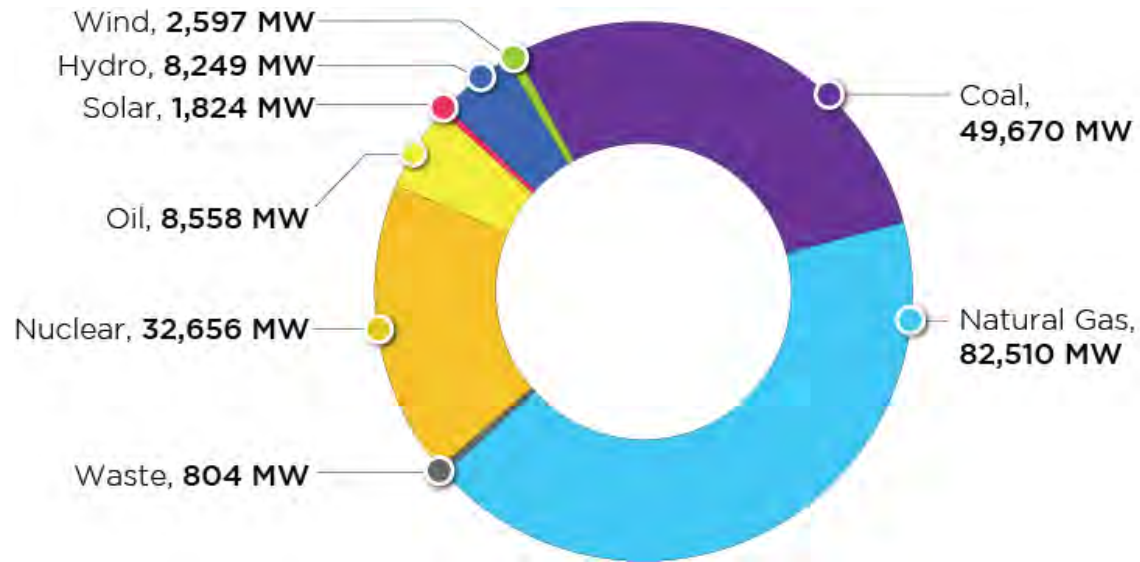
Member companies	1,060+
Millions of people served	65
Peak load in megawatts	165,563
Megawatts of generating capacity	185,442
Miles of transmission lines	85,103
2020 gigawatt hours of annual energy	782,683
Generation sources	1,436
Square miles of territory	368,906
States served	13 + DC

- 26% of generation in Eastern Interconnection
- 25% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection

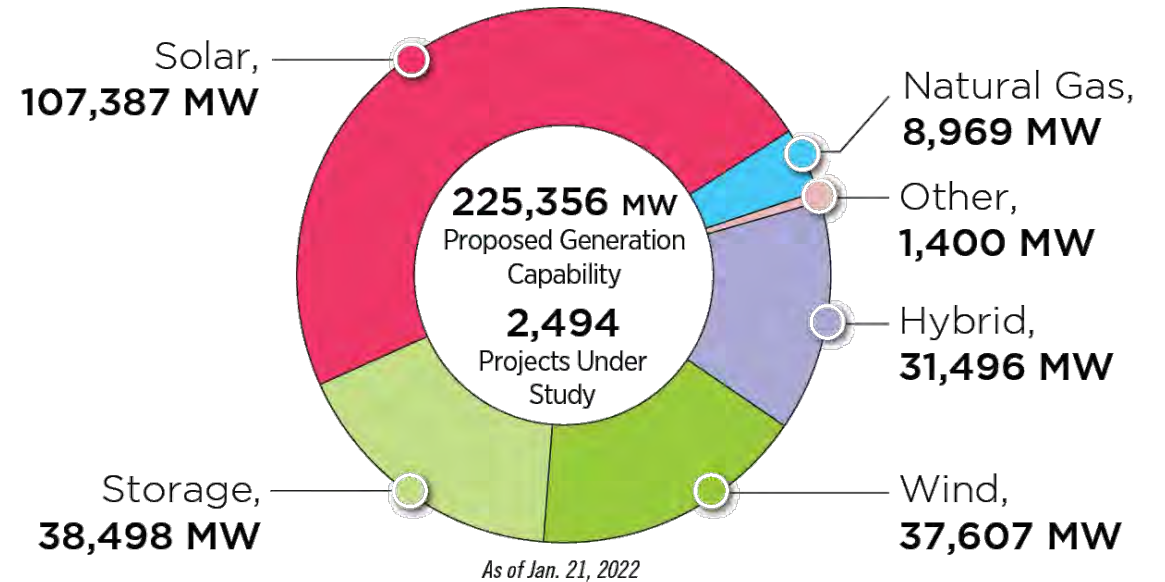


As of 2/2022

## PJM Existing RPM-Eligible Installed Capacity Mix



## Current Interconnection Queue





Changing market participant profiles



Changing fuel mix



Regulatory uncertainty



Energy efficiency



Renewable and distributed energy resource integration



Cybersecurity and system resiliency



Customer behavior and choice



# Ensuring Reliability at Least Cost

Prepare for Energy  
Transition through  
Analysis

Facilitate Policy-  
Maker & Consumer  
Objectives through  
Stakeholder Process

I would like to thank APEX for this wonderful opportunity and CROPEX for their generous hospitality!

## Contact Information

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هيئة الربط الكهربائي لدول مجلس التعاون لدول الخليج العربية  
Gulf Cooperation Council Interconnection Authority

# Bright Spark Program Yousef O. Al-Marwan APEX 2022 Croatia

21 October 2022



السوق الخليجية لتداول الطاقة الكهربائية  
GCC Power Exchange



# Self-Introduction

## Work Experience

- 18 Years of total work experience
- Joined Market Operation in 2017 and went through extensive Career Development Program.

## Education

- Holds MBA degree from King Fahad University of Petroleum and Minerals.

## Current Position and Duties Highlights

- Carry out the duties of Market Operator:
  - a. Marketing of Electricity Trading Opportunities.
  - b. Scheduling and compensation of the traded electricity.
  - c. Operation of Market Systems (Capacity Auctioning System, Trading Platform, and Settlement System).
  - d. Trading parties' support and engagement.
  - e. Billing and Accounting of the Traded Energy.
  - f. Continuous upgrade of the market technologies.
  - g. Development and review of market processes and procedures.



# Agenda

1. About - GCCIA
2. GCC Electricity Sector - Overview
3. GCC Electricity Market - Overview
4. Power Trading – Stats
5. Power Trading Enablers & Challenges
6. Ongoing projects, currently involved in.





## About - GCCIA



السوق الخليجية لتداول الطاقة الكهربائية  
**GCC Power Exchange**

# GCCIA – Objectives

- A joint stock company owned by the six GCC States with a share capital of US\$ 1.4 billion
- The primary objectives of the interconnection:
  - Sharing of installed capacity resources
  - Supporting each other in case of emergencies
  - Entering into contracts for operating reserves
  - Trading electrical energy through scheduled energy transfers



GCCIA has been providing support to Member States in case of emergencies. Over the past few years, the focus is on utilization of the interconnector for economic benefits through power trade.

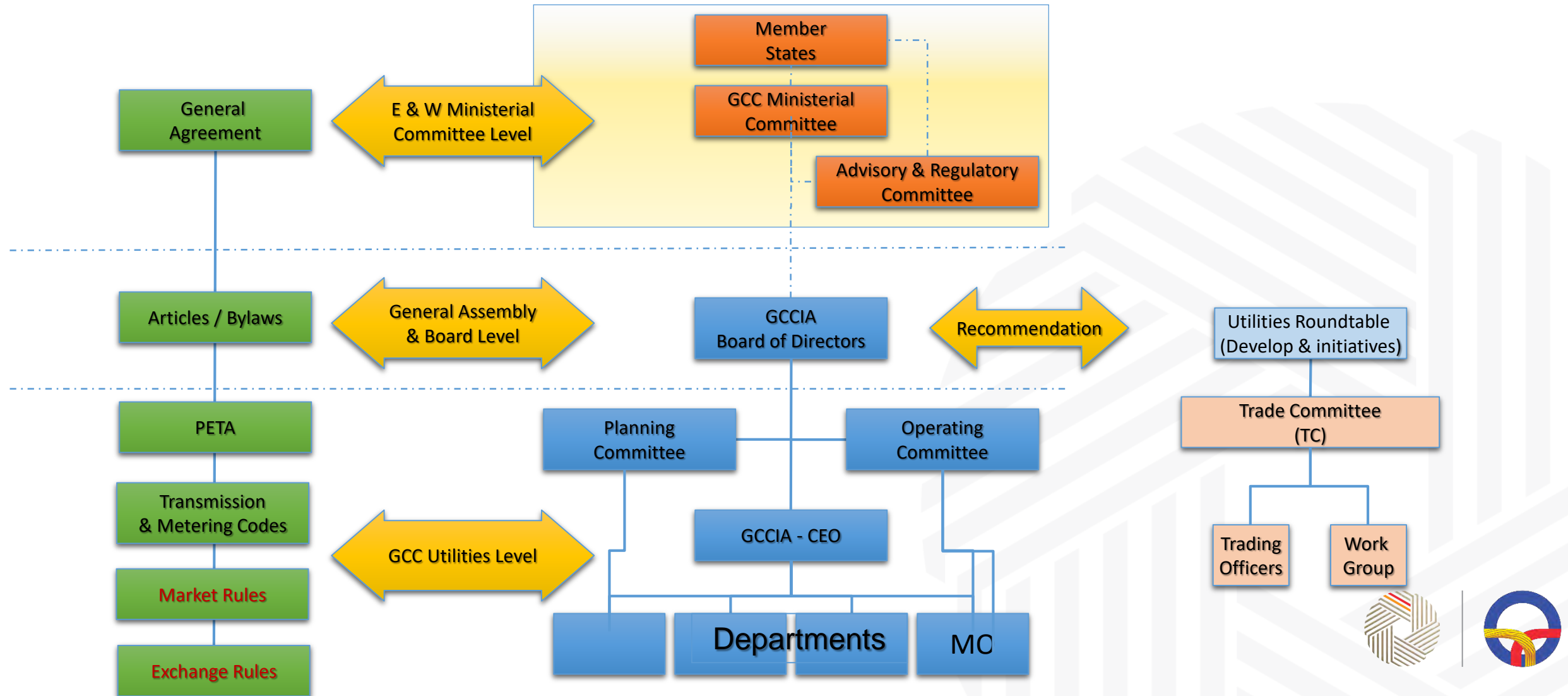


# Legal Framework of GCCIA

## Legal Framework

## Organizational Framework

## Market Framework





## GCC Electricity Sector - Overview



السوق الخليجية لتداول الطاقة الكهربائية  
**GCC Power Exchange**



# Unbundling Progress of Electricity Sector in the GCC Countries

Companies	QAT 	KSA 	OMN 	BAH 	KUW 	UAE 
Vertical Integration with IPPs		✓	✓			✓
Generation	✓	✓	✓	✓	✓	✓
Single Buyer Model			✓			✓
Procurement		✓	✓			✓
Spot Market			✓			
Regulator		✓	✓			✓

- Reforming the power sector is an ongoing task for all Member States.
- In some countries, government's electricity ministries still carry out all the functions related to the electricity, while others have established a government owned companies.





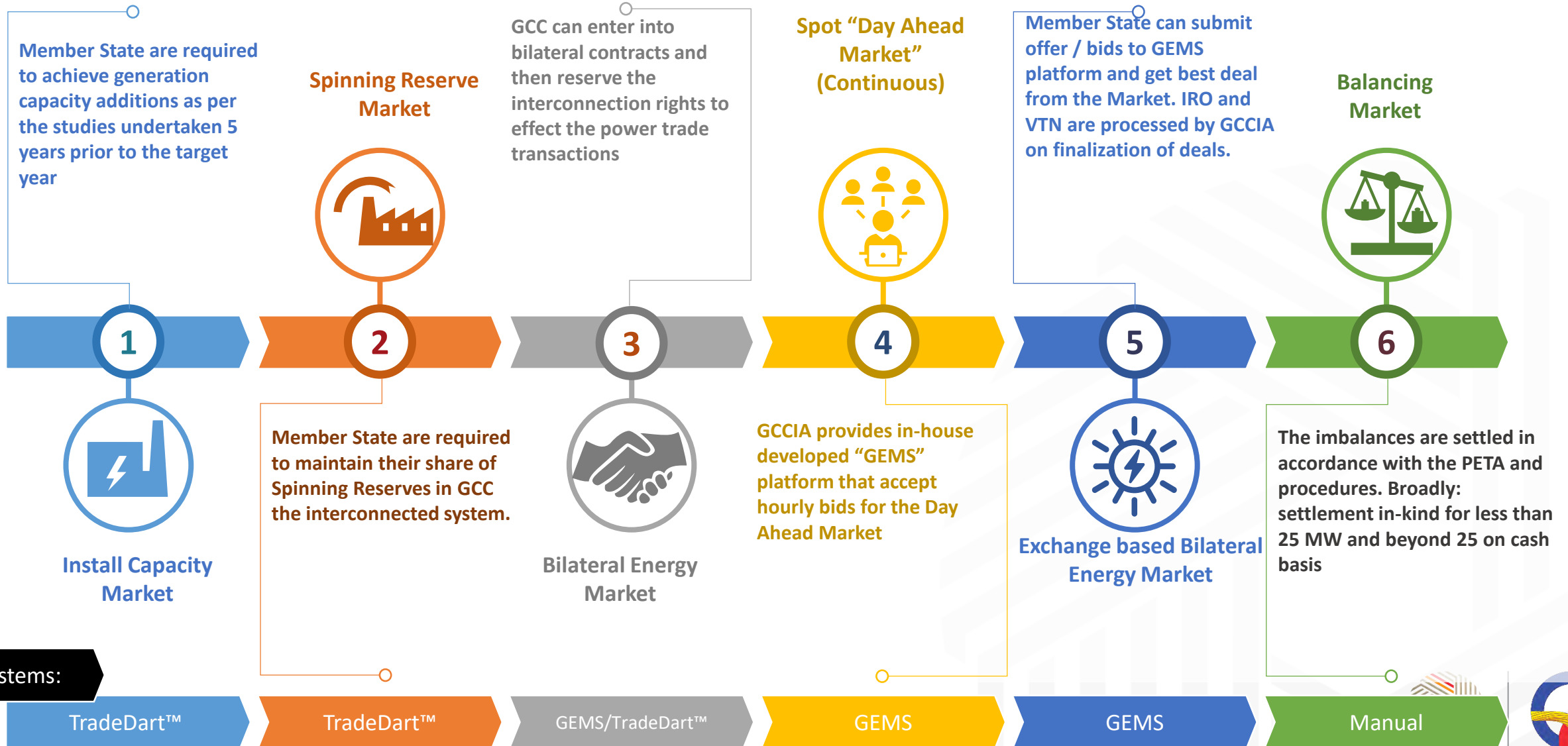


## GCC Electricity Market - Overview



السوق الخليجية لتداول الطاقة الكهربائية  
**GCC Power Exchange**

# Currently functioning markets



# Roadmap for GCC Market Development

## Transition Market Phase **CONSOLIDATION**

- Unbundling in GCC countries implemented (single buyer model in first phase)
- Price subsidies to be transferred from generation to supply side
- GCCIA wholesale market opening for third parties
- Regional Target Model designed and approved
- Incentive regulatory measures to additionally enhance regional market liquidity put in place
- Transmission losses and renewables feed-in present on regional day ahead market
- Design of the Regional balancing and ancillary services market

## Final Market Phase **REGIONAL TARGET MODEL**

- Regional Target Market Model in place
- Retail Market opening in GCC countries (staged approach)
- Market based model for renewables' investment developed and put in place
- New markets and products to be developed (flexibility market, capacity market, demand response, etc.)

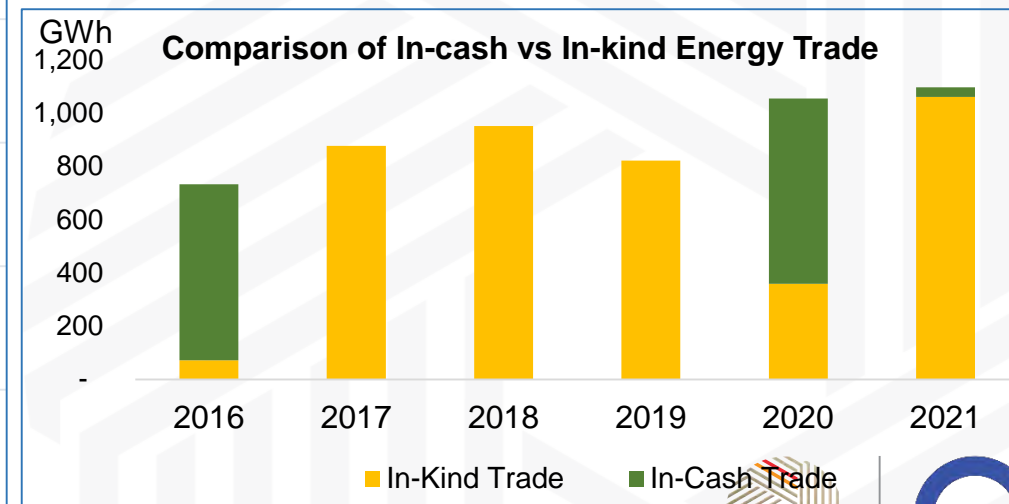
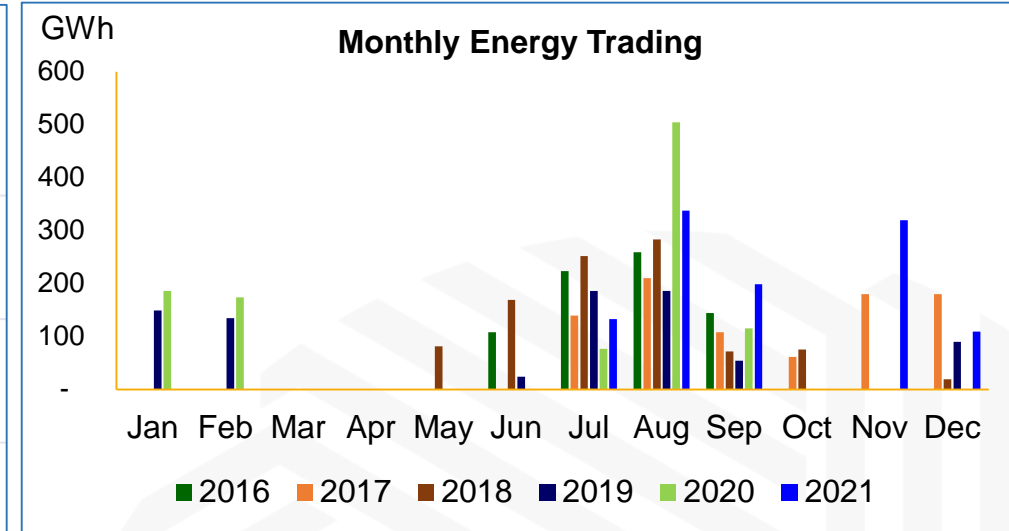
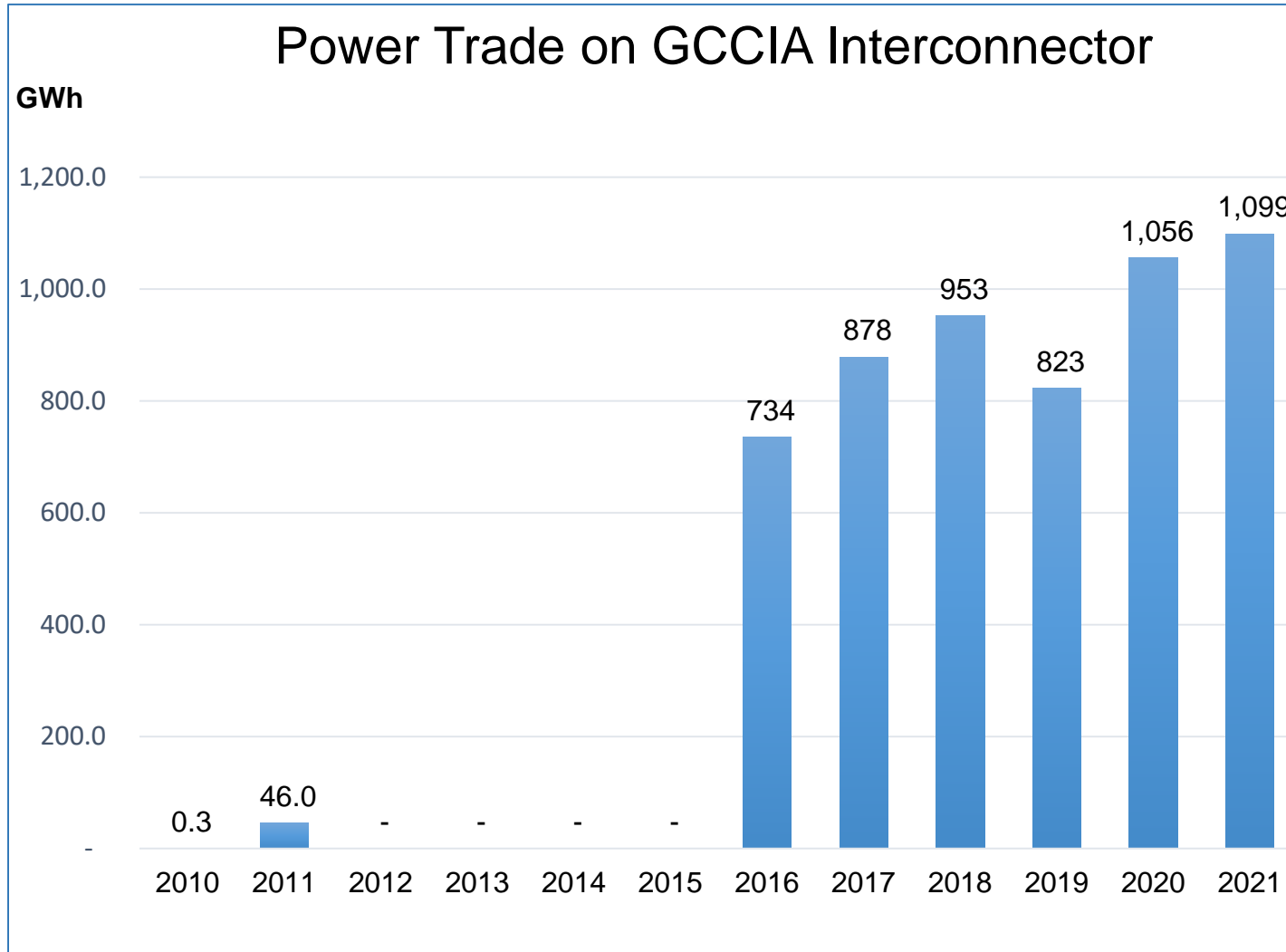
## Initial Market Phase **SET-UP & PRICING**

- Bilateral market among PETA parties enhanced (in-kind and cash)
- Regional reference price provided (Day ahead auctions in place)
- Regulatory support measures to ensure liquidity

The timing of each phase will strongly depend on the commitment on Member States



# Power Trading Stats





## Power Trading Enablers and Challenges



السوق الخليجية لتداول الطاقة الكهربائية  
**GCC Power Exchange**

# Power Trading Enablers



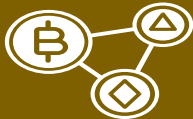
## Communication:

GCCIA formed committees at the working level, mid-management level and at the Management level to discuss, facilitate and execute power trading transactions



## Reduction in Transmission Charges:

As an incentive to trade, the prevailing transmission charges of \$5.0/MWh were reduced to \$0.0 for the period 2016 to 2018 and then marginally increased to \$0.5/MWh in 2019



## Power Trading on in-kind basis:

Due to the absence of a price signals, the relative value of energy was calculated for different seasons and accordingly power trading was executed on in-kind basis.



## Difference in Fuel and Seasonal differences:

The difference in the generation mix as well as the seasonal differences create power trading opportunities in the GCC region.



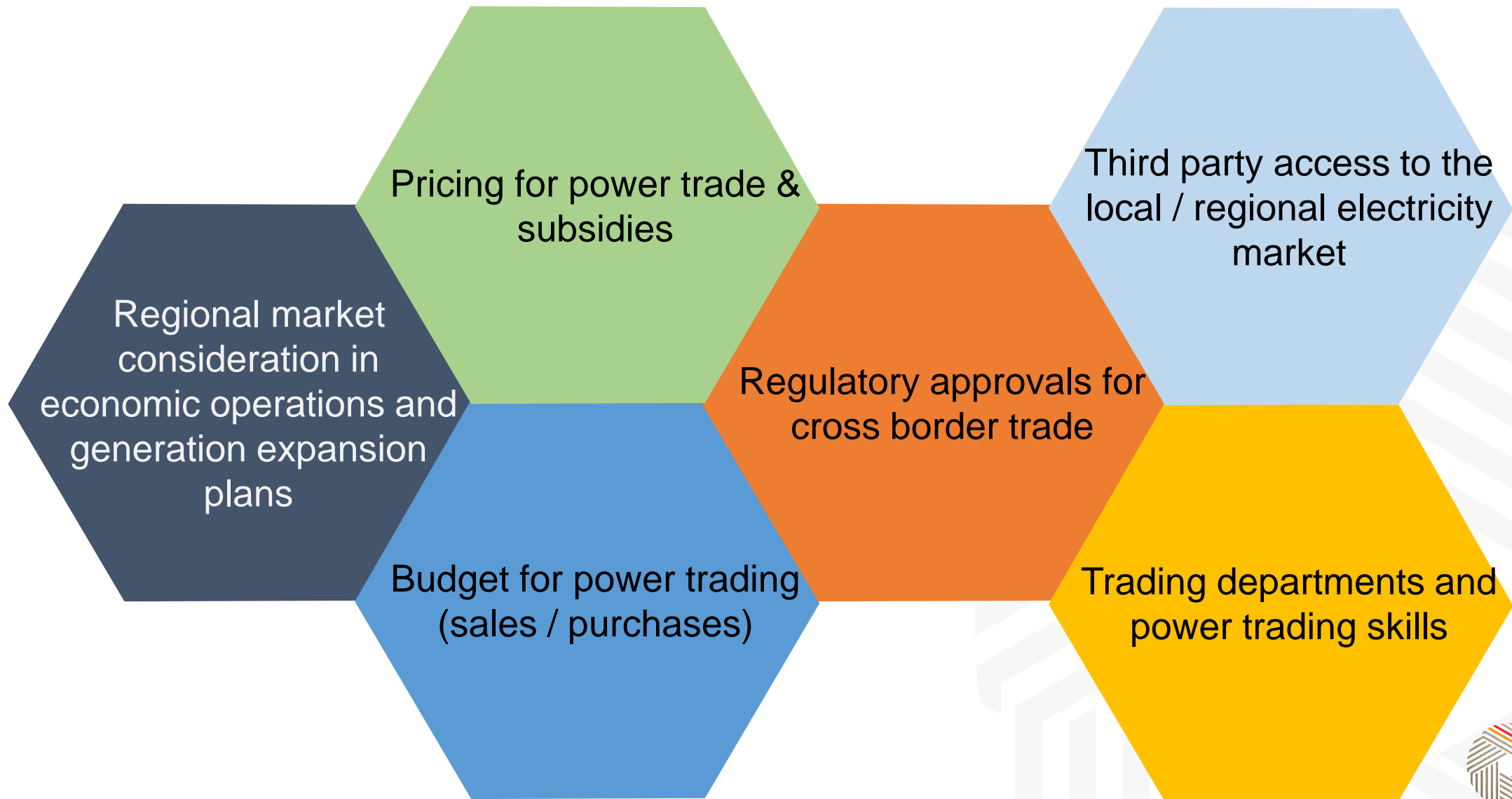
## Facilitation by GCCIA:

GCCIA facilitates undertakes studies for power trade opportunities, conducting regular meeting between prospective trading parties, provides simple trading tools, etc.





# Challenges for Power Trade





Projects currently involved in



السوق الخليجية لتداول الطاقة الكهربائية  
**GCC Power Exchange**

# Current Projects

Sq.	Project	Objectives
1.	Studies for Power Trading Opportunities	<ul style="list-style-type: none"><li>- Finding Opportunities for economical exchange of power between GCC Member States.</li><li>- Promoting these opportunities to both parties for actual implementation.</li></ul>
2	Development of Power Trading System (Continuous – DAM and Bilateral Market)	<ul style="list-style-type: none"><li>- Reducing the time for executing trade transactions.</li><li>- To provide necessary technology for trading parties.</li><li>- To streamline the trading process between parties.</li><li>- To facilitate the interactions and payments between Member States</li></ul>
3	Pilot Pricing Project	<ul style="list-style-type: none"><li>- Enabling MSs of calculating their energy prices for short periods i.e. week ahead.</li><li>- Participate actively in power trade with more accurate prices and measurable savings.</li></ul>



# Current Projects

Sq.	Project	Objectives
4	Development of Auctioning System for Interconnection Capacities	<ul style="list-style-type: none"><li>- Mandated by legal agreements, GCCIA to provide a secure auctioning system for the transmission capacities among the shareholders.</li></ul>
5	Pilot Project for DAM	<ul style="list-style-type: none"><li>- Enable the Member States of simulating the operation of Day Ahead Market.</li><li>- Experience the benefits and challenges of operating the DAM.</li><li>- Finding the required procedures and process for managing the operation of the DAM within each country.</li></ul>
6	Settlements between trading parties	<ul style="list-style-type: none"><li>- Clearing all the backlogs of payments between Member States.</li><li>- Streamline the process of settling the payments.</li><li>- Provide technologies required for the settlement process.</li></ul>



# Working towards the Colombian energy transition.

**XM, the Colombian system and market operator.**

**APEX 2022**

Carlos Mario Correa, Leader of Market Operations







## ¿Who am I?

Lila and Floki's dad,  
Manu's husband  
an electrical engineer  
with Masters' degree in  
Engineering and Power  
Systems,  
and a Ph.D. in Power systems,  
who loves running marathons  
and is passionate about the  
operation of the system, the  
market and the energy  
transition.





**At XM we are committed to the energy transition and sustainability.**

**We anticipate, learn from global experiences and lead the change to continue providing the best energy.**



# South America is committed to the transition



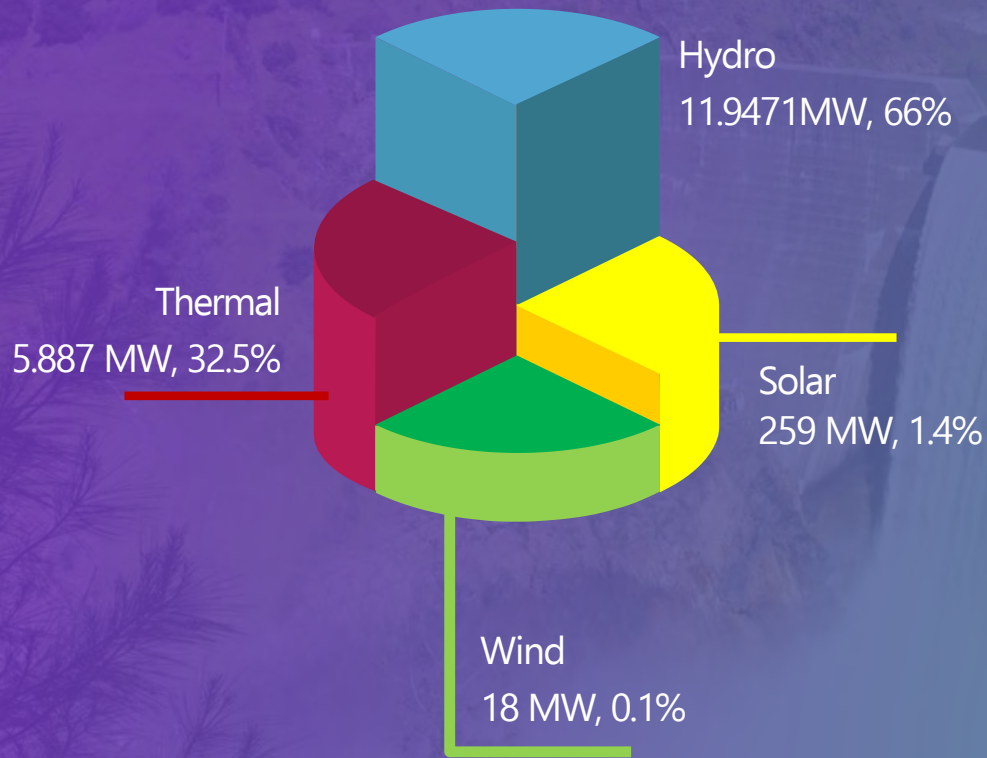
In **2030**, 70% of the electrical energy consumed in the region should be from renewable sources

In **2050**, South America will reach the **carbon neutrality**

International commitments:  
COP21, COP25, SDGs



# In Colombia we have one of the cleanest matrices in the world and we are one of the countries with the lowest per capita emissions in the region\*

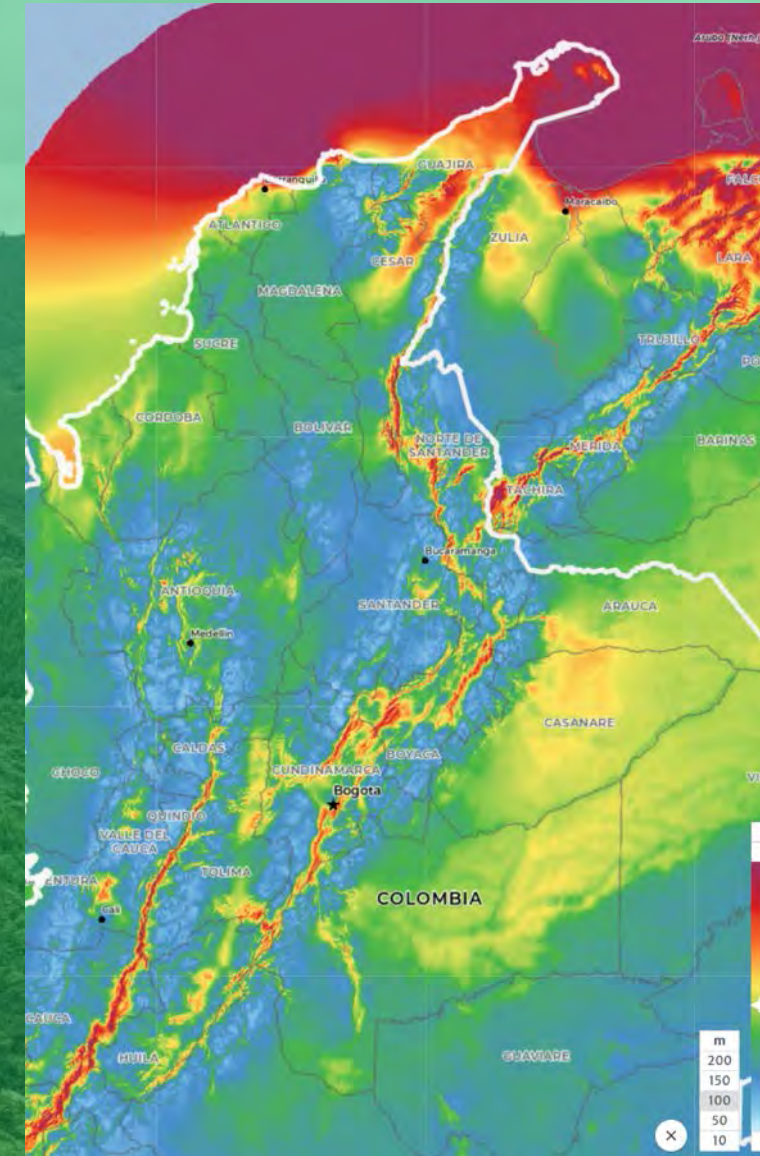
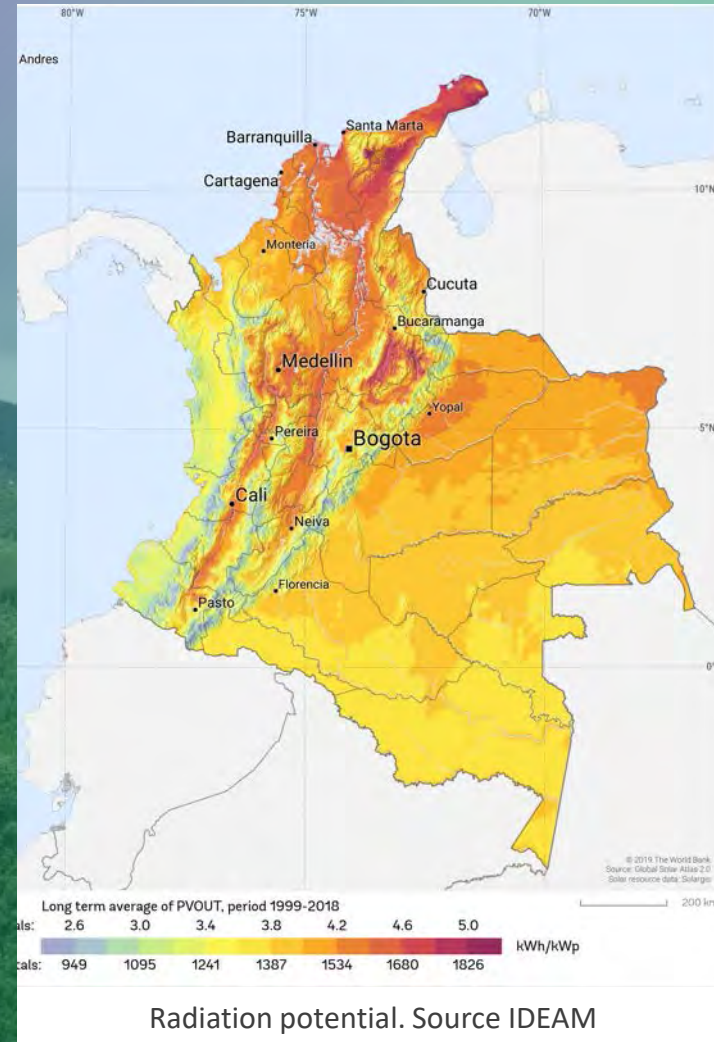


- The Colombian electricity sector emits 0.16 Mton CO<sub>2</sub> eq for each GWh generated, while on average 0.59 Mton CO<sub>2</sub> is emitted per Gwh.
- We have a **matrix** with an installed capacity of 18.1 GW to meet a peak demand of 11 GW.
- Under normal conditions, demand is met 80% with hydroelectricity and 20% with thermal generation.
- High vulnerability due to climate dependence.



# Abundance and diversity of natural resources

- High potential for solar and wind energy integration.
- Development of energy efficiency programs.
- Generation and storage of green hydrogen.





## We have an increasingly interconnected network

The National Interconnected System integrates about **98% of the Colombian population.**

Hydraulic plants are in the center of the country. The north has thermal plants.

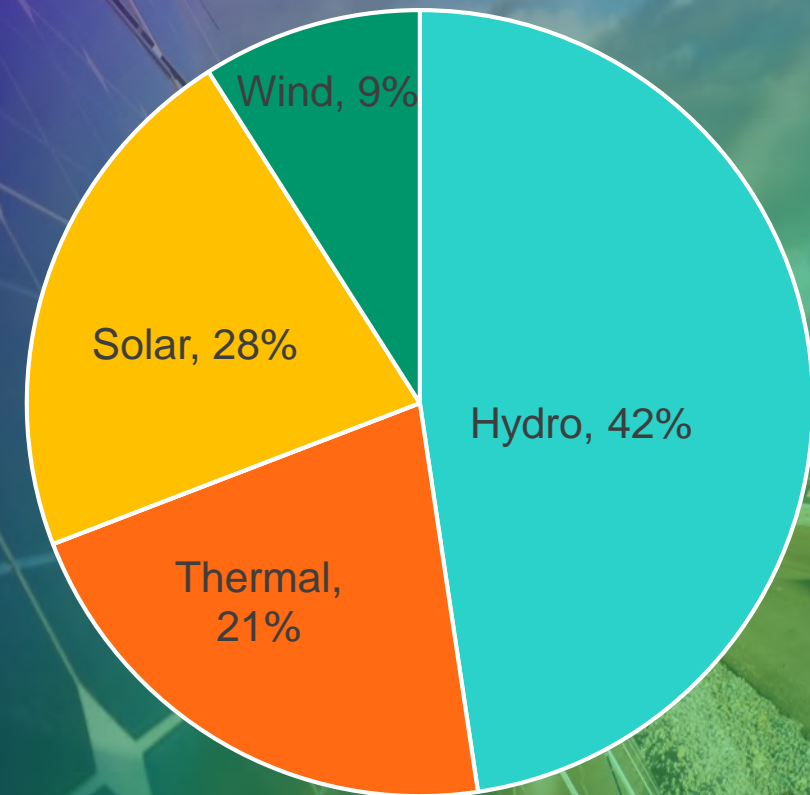
Colombia is in the process of strengthening transmission networks to **integrate the new generation.**

Progress in interconnections with neighboring countries to **strengthen regional integration.**



## And we are committed to diversify our matrix

- By 2027 about **30%** of generation will be from **wind and solar**.
- Expected installed capacity increases from 18.1 GW to **32 GW**.
- Sufficient technologies to **support critical conditions**.
- **Reinforcement** of the transmission network to integrate the new generation.



An even cleaner matrix with complementarity resources



# Relevant contributions for the transition



## Energy systems integration

Develop optimization models for the energy systems integrations.

## Flexibility and resilience

Develop methodologies for evaluate flexibility and resilience.

## Market development

Contribute to market development and operations.

# Energy systems integrations



Security constrained unit commitment.



Combined cycle modeling.



Power and natural gas co-optimization.



**Power and natural gas coordination schemes.**



Stochastic mid- and long-term energy planning.

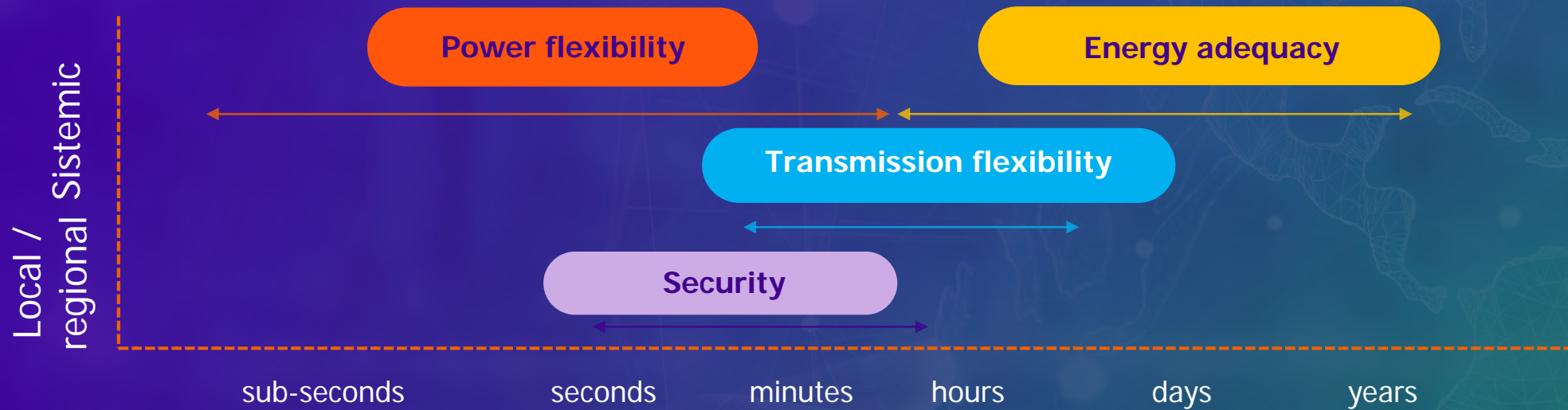


Maintenance scheduling.



Establish **alliances** to improve competitiveness and develop capacities.

# Facing flexibility challenges due to VER integration



**Energy adequacy:** energy supply in the long and mid-term.

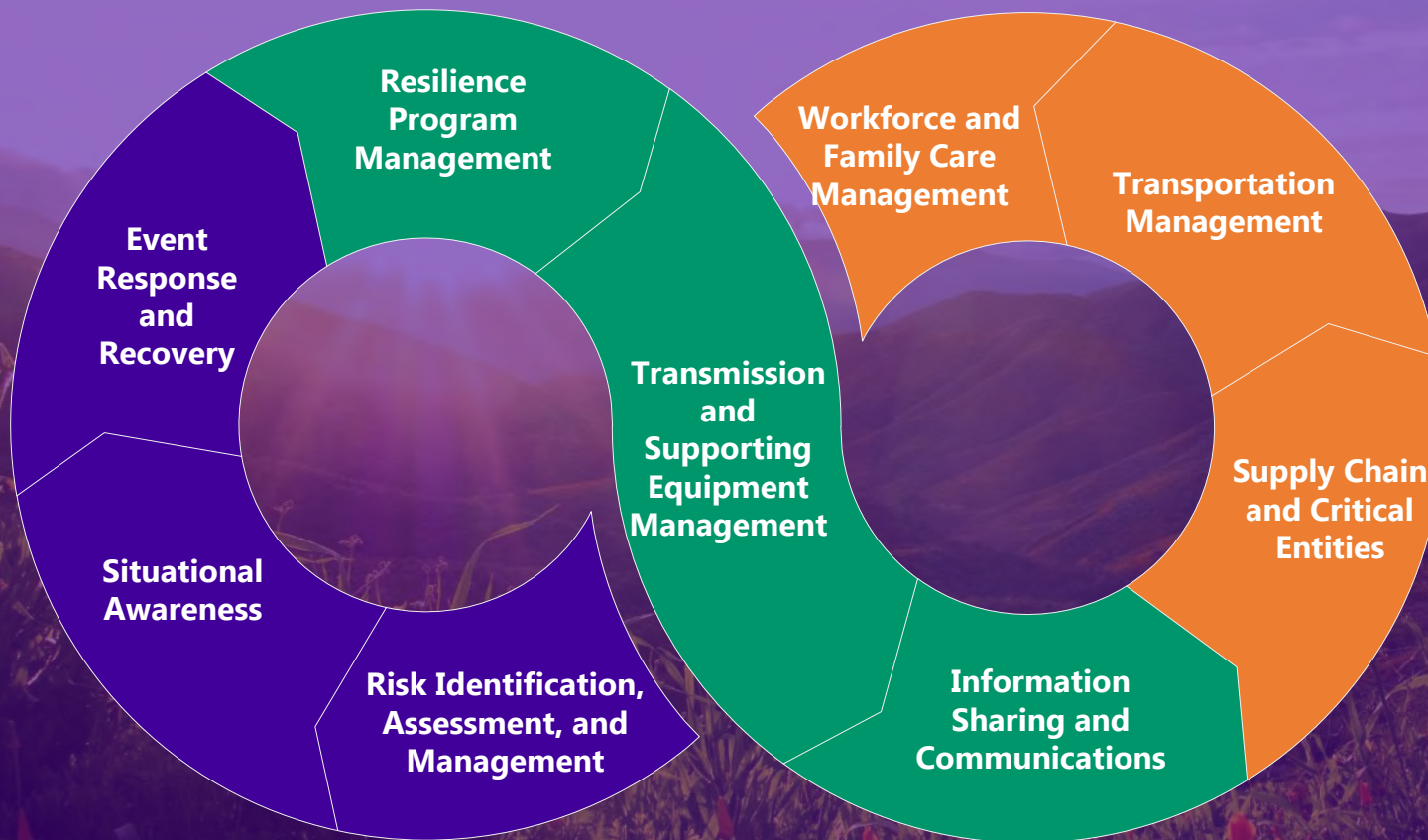
**Power flexibility:** balance of generation and demand in the short term.

**Transmission flexibility:** transmission constraints.

**Security:** reactive power, voltage and stability.



# Improving system resilience



## Market resilience

1. Persistence of market mechanisms to continue to function during abnormal conditions.
2. Ability of the Market operator to overcome market events that could damage or stop its operation.

### Methodology

- Events and risk identification
- Risk management and investment frameworks



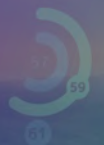
# Leading the Market operations team and contributing for market development with a holistic approach: Complete markets







xm



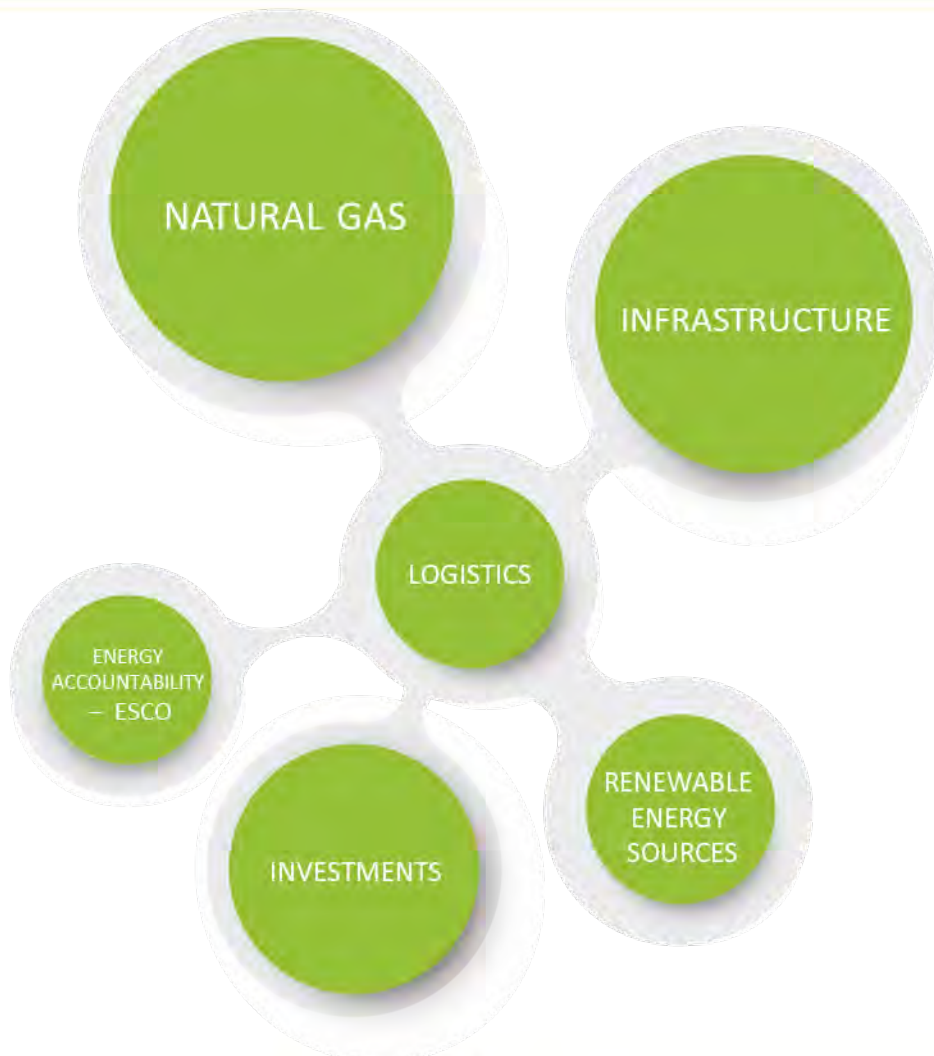


ENNA

**enna energia naturalis**

**ENNA OPSKRBA**





**ENERGIA NATURALIS (ENNA)** manages some 20 companies owned by the Group. Its special strength is the broad spectrum of its operations, ranging from trade and supply of natural gas to sustainable energy resources, to trading in oil products and other goods and to investment projects and transport operations.

# ENNA GROUP STRUCTURE

**enna** energia naturalis  
improving life



**IDENTITY CARD**  
**LEGAL FORM**  
 Limited liability company  
**MANAGEMENT BOARD**  
 Posao: Vujinovic, Danir Spudic,  
 Sabina Serdici  
**ADDRESS**  
 Gospodarska zona 13,  
 32000 Vukovar, Croatia  
**PIB**  
 65900776536  
**COMPANY REGISTRATION NUMBER**  
 059107258  
**COMPETENT COURT**  
 Commercial Court in Osijek  
**SHARE CAPITAL**  
 HRK 125,400,000.00

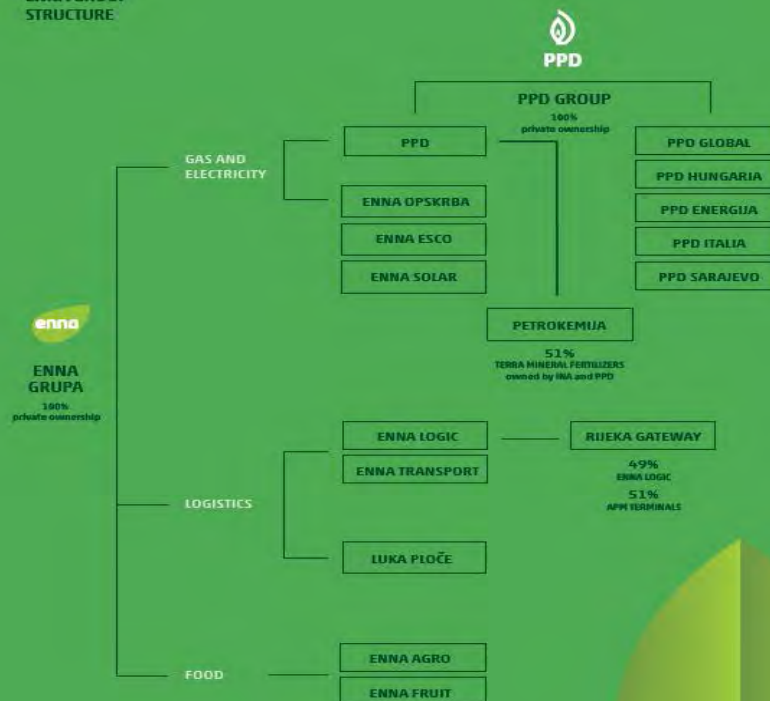
## ENNA IN NUMBERS (mil.kn)

TOTAL OPERATING REVENUE	NUMBER OF EMPLOYEES
2021 37.408.068	2021 734
2020 11.173.777	2020 694
2019 8.802.499	2019 291

EBITDA	EBIT
2021 429.431	2021 367.046
2020 352.074	2020 271.065
2019 337.140	2019 276.018

SEGMENTS	2021	2020	2019
Gas	35.719	10.690	8.427
Transport	155	123	109
LPG and merchandise	1.307	271	179
Other	227	90	87

## ENNA GROUP STRUCTURE



ENNA Supply is one of the leading entities on the Croatian markets for:

- Supply to electricity and gas to business customers
- Construction of renewable energy sources
- On the wholesale electricity market, we actively participate by offering the electricity produced from renewable sources
- ESCO Projects
- Automatic Frequency Restoration Process
- Battery Storages

**enna** energia naturalis

**Thank you!**  
**[nenad.ukropina@enna.hr](mailto:nenad.ukropina@enna.hr)**





Panel 1:  
Decentralization

# Panel-1 Decentralization: Solutions and Challenges in the Making

Siemens Grid Software US  
Sankaran.Rajagopal@Siemens.com



APEX Congress 2022 at CROPEX,  
Croatia, October 20, 2022

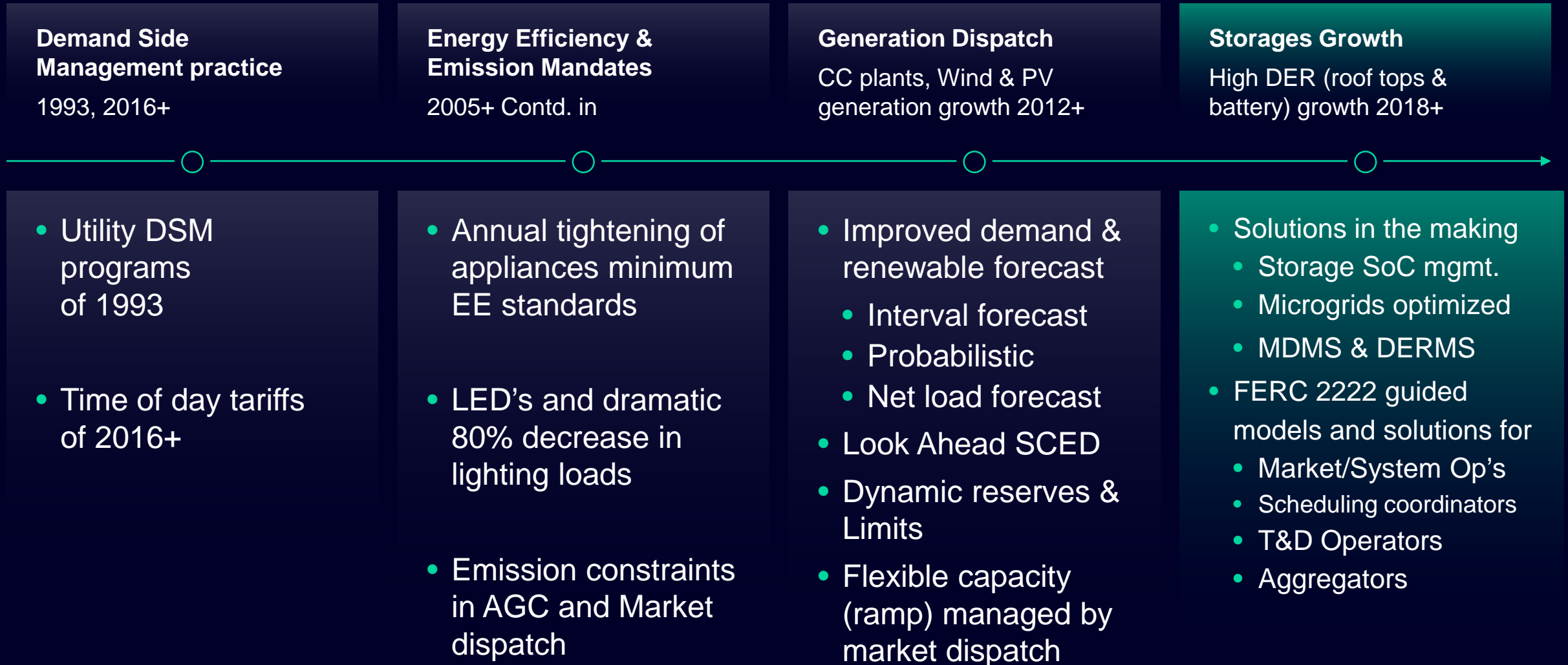
**SIEMENS**

# Decentralization

## Solutions and Challenges In the Making

Topic	Page No.
Leveraging from proven best practice in daily operations	3
Problem statement: US FERC 2222 – DER participation in energy market	4
Needs of wholesale & retail market integration	6
California Distributed Energy Resource Program (DERP) highlights	7
Modeling examples in Decentralization	11
Ecosystem use cases of Decentralization	16
Concluding Thoughts & Discussions	22

# Leveraging from proven best practice in daily operations ...



# Main Points of FERC 2222, FERC 2222A, FERC 2222B

Allows DERs aggregations to participate in RTO/ISO wholesale markets

---

## Capacity, Energy, and Ancillary Services

---

Requires RTO/ISO to remove existing barriers to participation of aggregations

---

Flexibility

---

Participation Models

---

Coordination with Transmission, Distribution utilities, Aggregators

---

Distribution utility can re-dispatch for reliability

172 FERC ¶ 61,247  
DEPARTMENT OF ENERGY  
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 35

[Docket No. RM18-9-000; Order No. 2222]

Participation of Distributed Energy Resource  
Aggregations in Markets Operated by Regional  
Transmission Organizations and Independent System  
Operators

(Issued September 17, 2020)

AGENCY: Federal Energy Regulatory Commission.

ACTION: Final rule.

## Defined DERs as:

- BESS, Generation, Energy Efficiency, Demand Response, Thermal Storage, EVs and EVSE, located on the distribution system in front of or behind the meter
- Order 2222B, recognizes Order 719. allows homogeneous aggregation of DR opt-out of participation in wholesale markets. Order 719 opt-out would **not apply** to Heterogeneous aggregations including DR
- **But FERC is still now taking a new look at rules for Demand Response opt-out (thru Notice of Inquiry, RM 21-14-000)**

# Ecosystem impact from FERC 2222 Order

### 3rd Party Aggregator

- Microgrids
- Generation
- Demand Response
- Batteries
- Thermal Storage
- Forecasting



### DER Owner

- Solar PV
- Batteries
- EV Charger
- Demand Response Assets



### Utility Aggregator

- Microgrids
- Generation
- Demand Response
- Batteries
- Thermal Storage
- Forecasting



### Distribution Utility

- Distribution Grid
- Distribution Planning
- Metering
- Billing and Settlement
- Emergency Re-dispatch
- Forecasting
- Outage Planning



### Transmission Utility

- Interconnection Study
- Wholesale Metering
- Forecasting
- Outage Planning



### RTO/ISO

- Market Clearing
- Wholesale Billing & Settlement
- Interconnection
- Registration
- Transmission Planning
- Forecasting





# Needs of Wholesale-Retail Market Integration

- Wholesale prices change every 5 minutes and there are reserves that can be released
- Demand elasticity as a reactional measure from price signals has not been effective

- Continuous range of load & generation dispatch and reserves are made possible by storages
- DER participation in ISO day ahead and hour ahead clearing commercializes the elasticity

## Bi-directional flows:

- Congestion management must be considered in distribution networks

## Value of lost load should not be a show-stopper:

- Local storages reduce the lost-load probability
- DER commercial offers are time based and are \$-MW segments)

## Essential needs in offers for energy and reserve balancing in Day Ahead & Hour Ahead clearing:

- Realizable capacities
- Cost basis for segments of MW range
- Forecasted limit and achievable rate of change

# California Distributed Energy Resource Program (DERP) highlights

- DERP is the California ISO's predecessor of FERC 2222
- Proxy demand resource, Reliability Demand Response & Non-Generating (NGR) resource models paved the way
- Started in 2017 with four phases through 2021
- DERP already meets the FERC 2222 mandate for California ISO

## **California LV network – as of September 2022**

- ❑ **12 GW of rooftops in service**
- ❑ **400 batteries/week are getting installed**

# CAISO DERP Initiative

## Retail Participation

### Distributed Energy Resource Provider Initiative

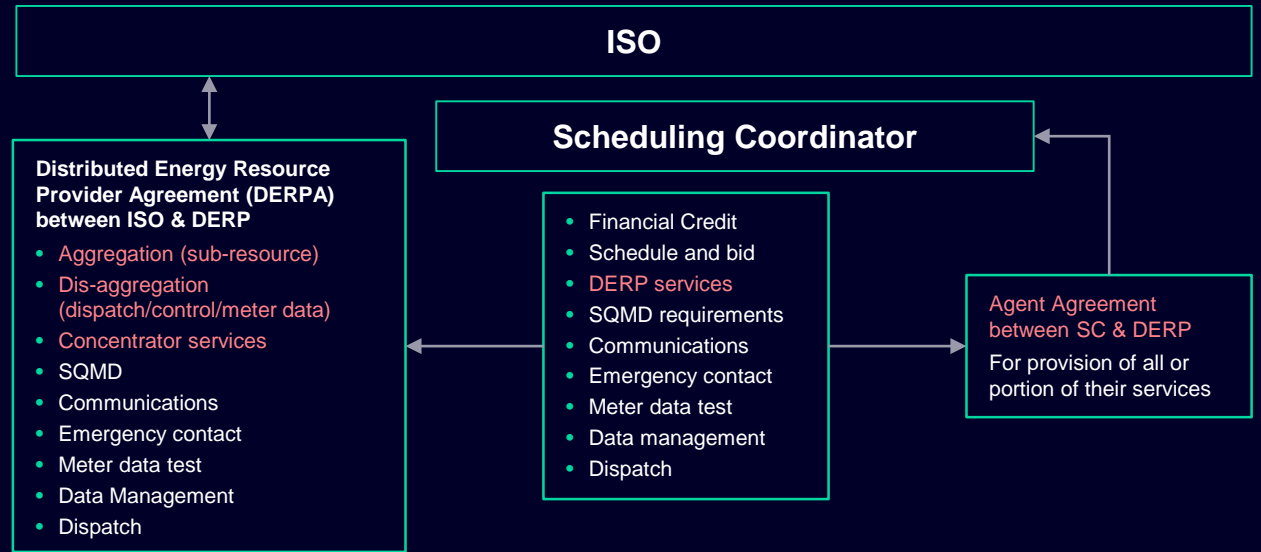
DER provider can be a scheduling coordinator (SC) to CAISO or provide services through an SC

DERP's bundle the roof-tops, storages, loads & gens. and offers them to the wholesale

Initiative impact the conventional generation dispatch

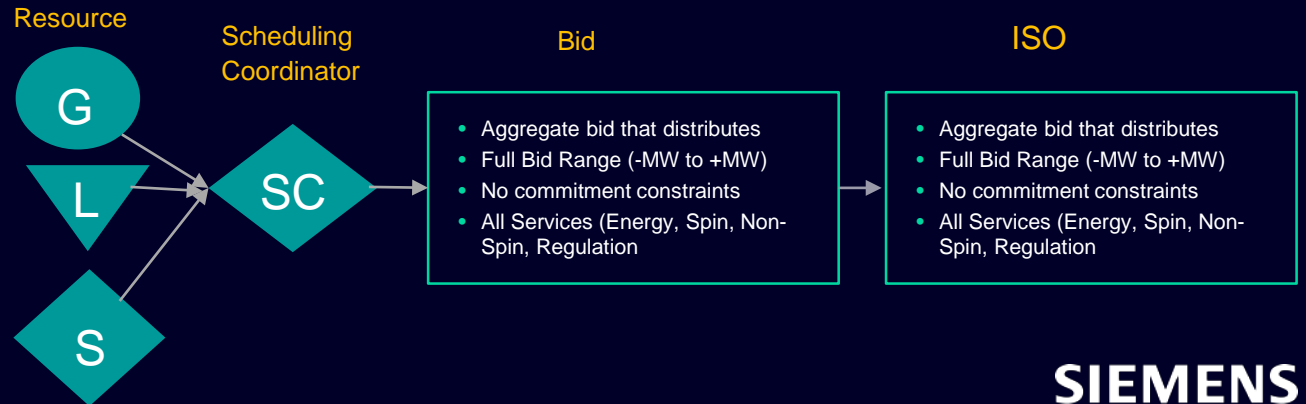
FERC 2222 is expected to stimulate more active participation of DER : Makes wholesale participation more attractive than net metering

Source: caiso.com



### Distributed Energy Resource Provider – DERP

Distributed Energy Resource Aggregation



# ESDER

## Energy Storages and DER in wholesale

A model that supports a standard, aggregated and hybrid configuration and facilitates accurate scheduling and reliability impact. Bidding is supported at individual or aggregate level

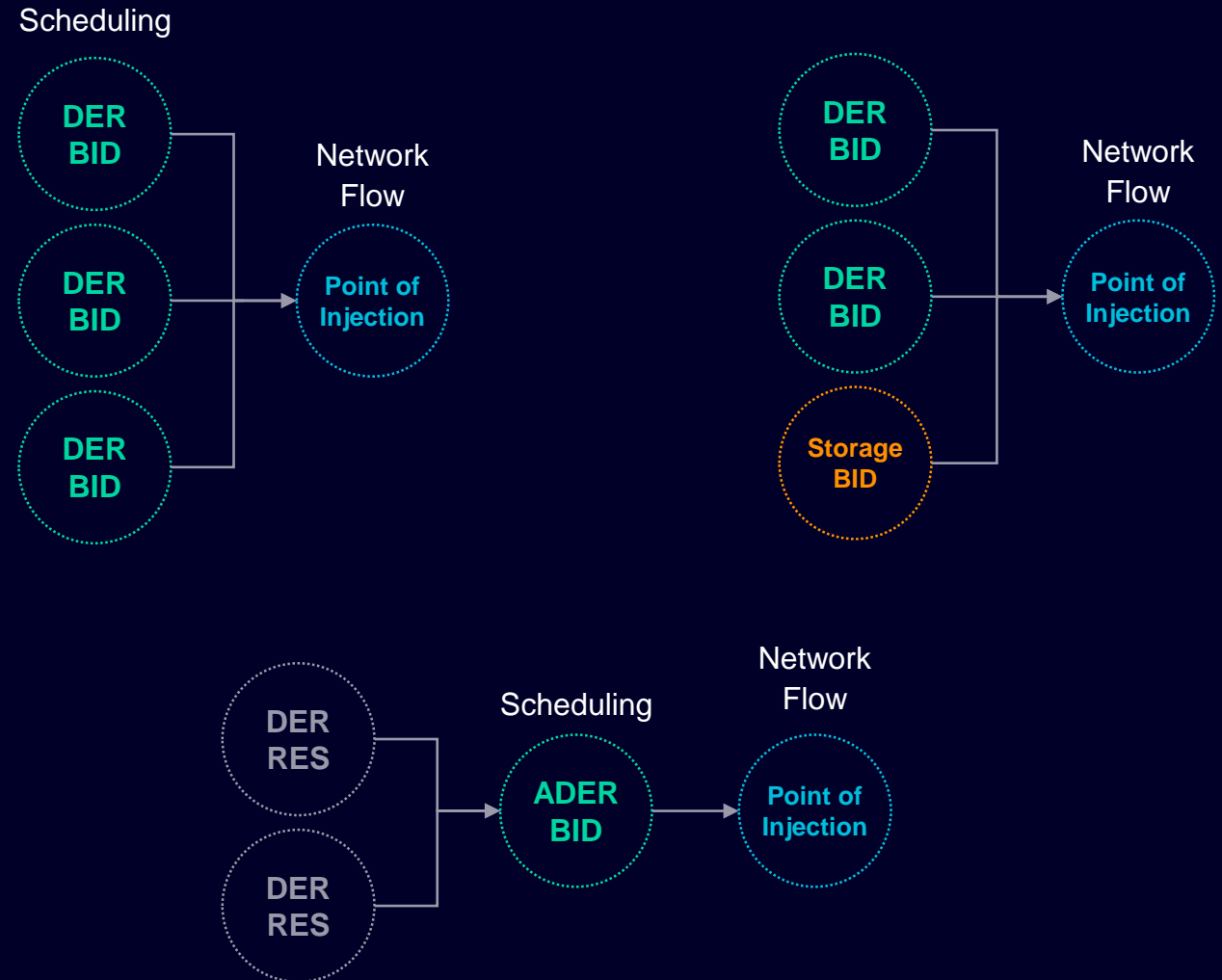
Simultaneous Co-optimization (using mixed Integer – Linear Programming solver) of DER, storage, and conventional resources

Commitment/dispatch for **Forward and Real Time Markets** in a look-ahead horizon (multi-interval form) subject to resource and network constraints

Model can be extended to DER , DR, and storage combinations

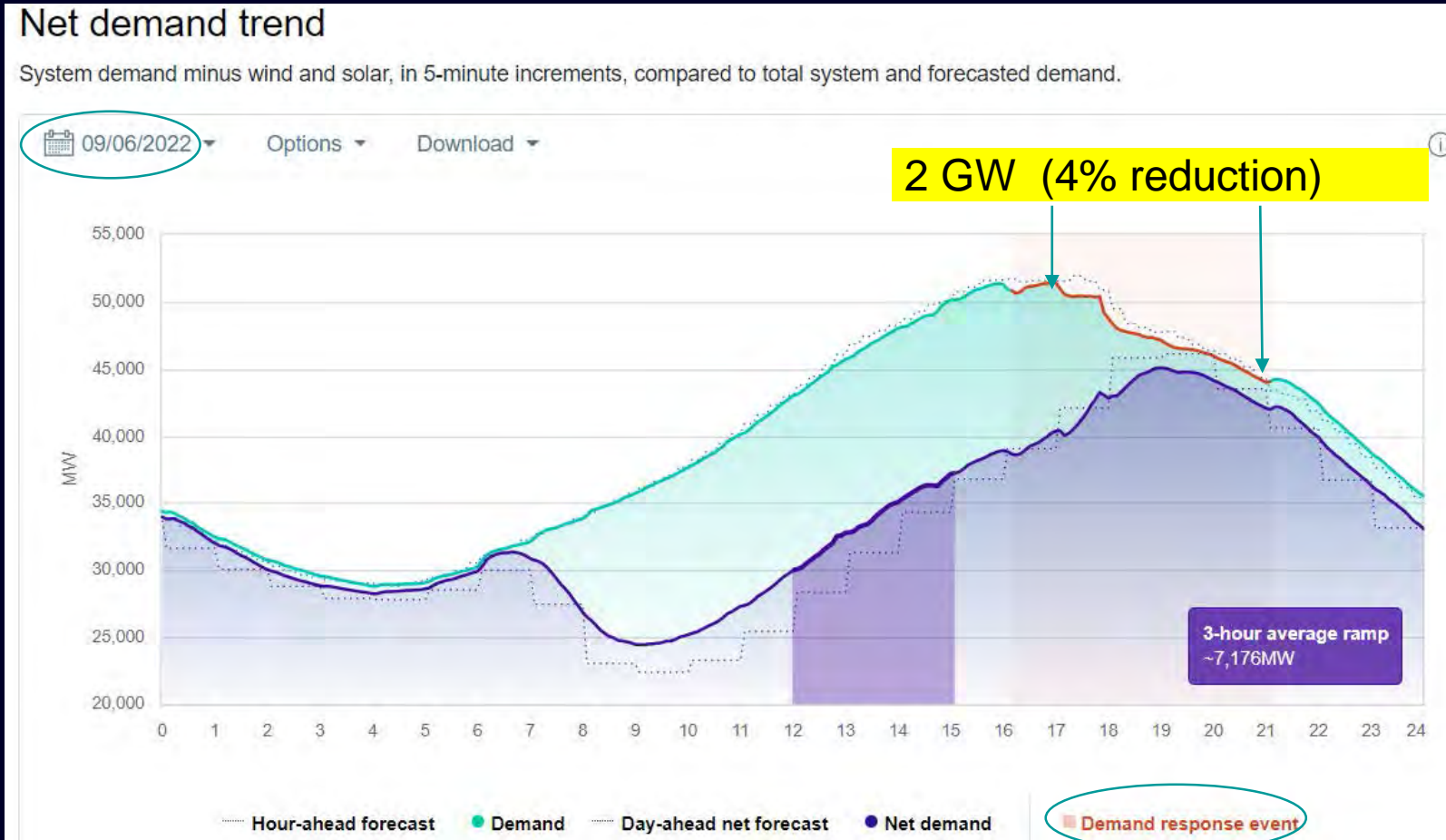
**Legend:**  
DER: Distributed Energy Resource – Load or Generation)  
ADER: Aggregated DER  
Storage: Can be load (charging) or generation (discharging)

Illustrations of the DER and Storage Participation in Market



# Demand Response : Actual event on 06-SEP-2022

Excessive and sustained heat wave for weeks in California in August/September



CA Governor Newsom's alert message & appeal reached 26 Million CA residents at 5+ PM

Result: 2 GW (4%) load reduction & successful avoidance of rotating load shed.

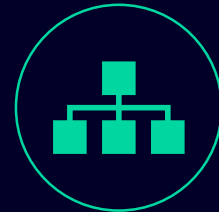
# Modeling Examples needed in Decentralization

## Storage optimization models

Continuous heterogeneous model (battery, load & generation)



## Structuring DER Forecast



## Nodal models for commercialization

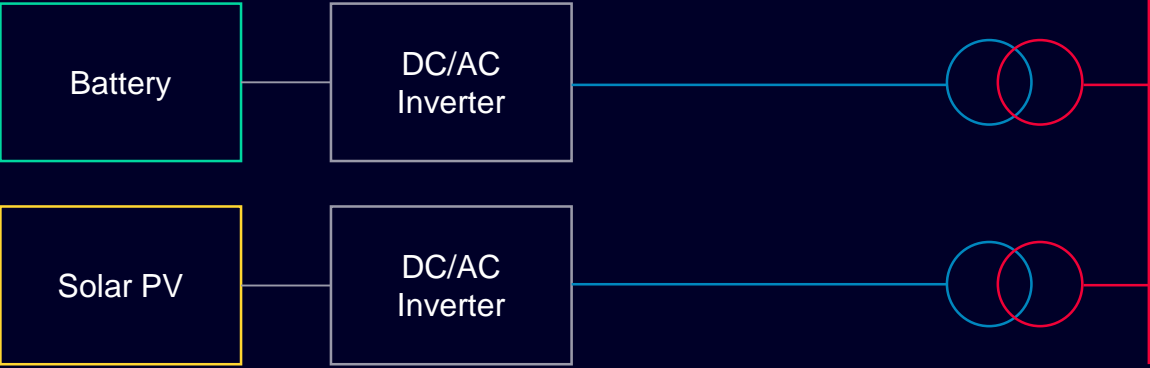




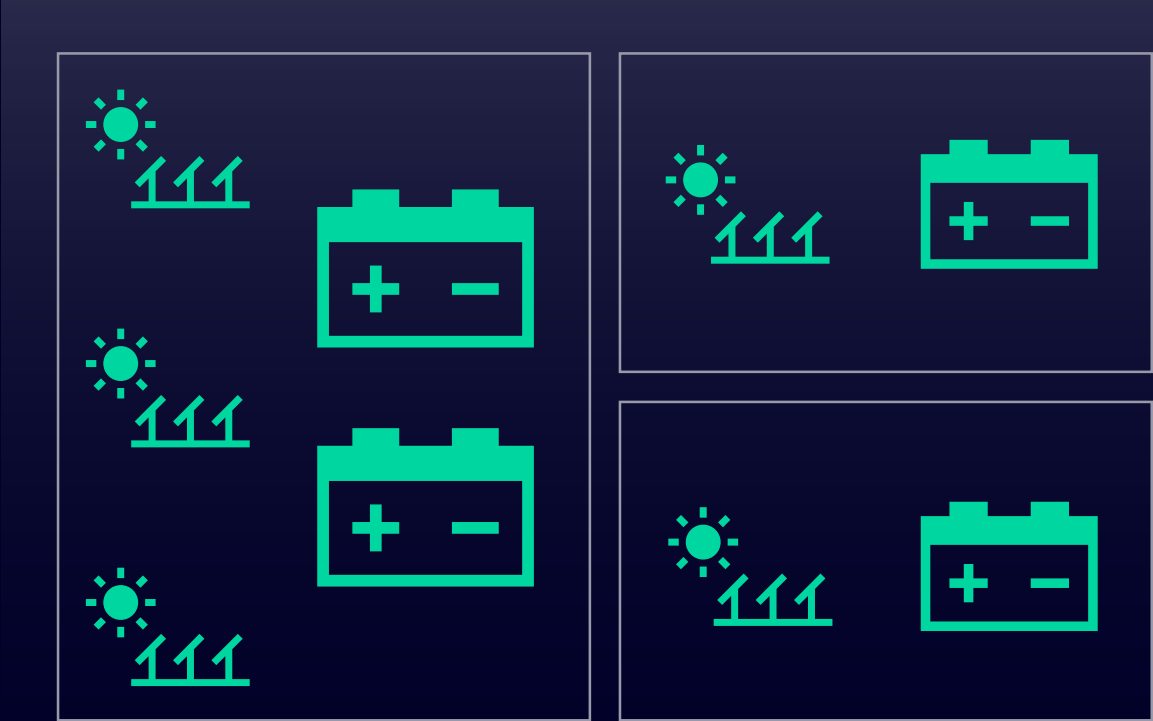
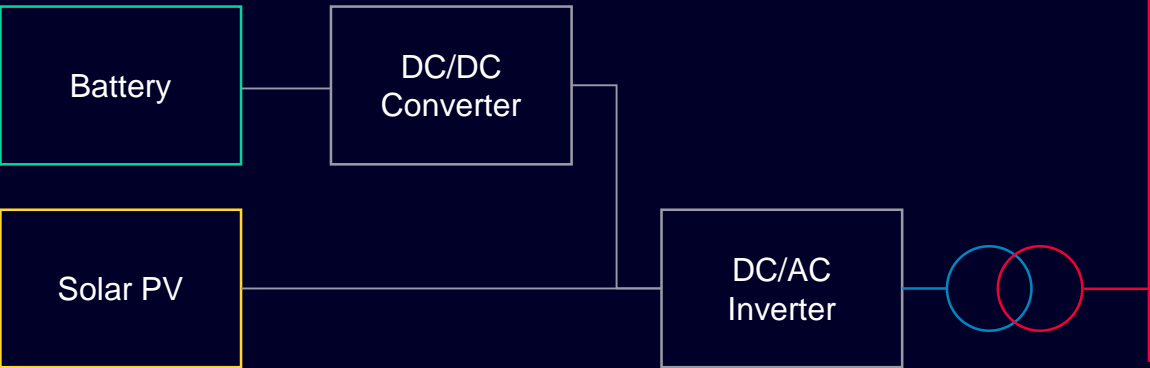
# Storage – Individual and Group Configurations

## Generalized Models and Optimization

### A.C. Coupled Systems



### D.C. Coupled Systems



Other Generation, DER Mix, Standalone Storages

#### Groups:

- Any combinations represented in generalized Formulation
- Hybrids under Local or ISO optimization

# Battery Models and Optimization (implemented solutions)



## Roof-Top Forecast Example in 2017 Datasets DoE Project / Sunshot Initiative

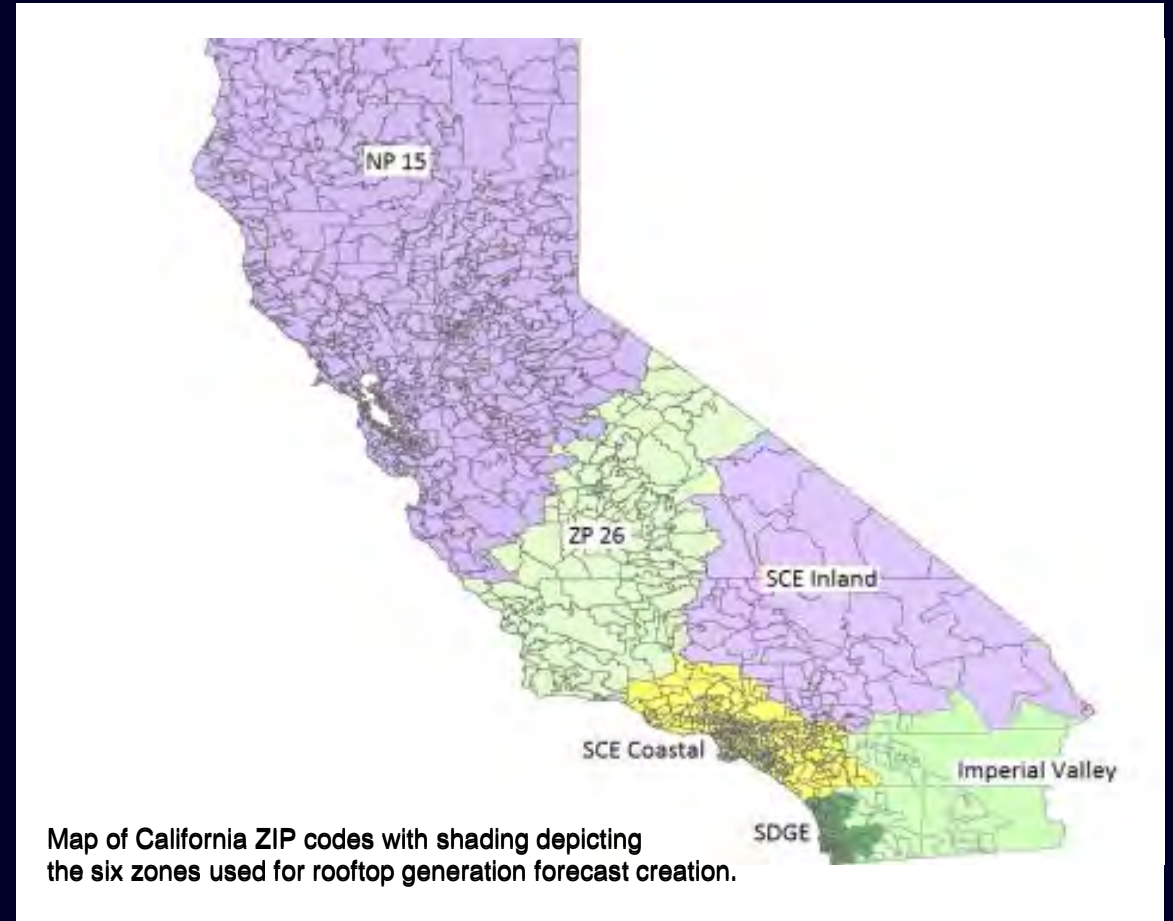
DER (roof top) solar forecast calculated in zip code granularity, for hourly intervals for a day, and 5-minute intervals for the next hour.

Bottom-up forecast for each one sq. km granularity is technology already available

DG Zones	Installed Capacity (MW)
Imperial Valley	64.0
SDGE	161.0
SCE Inland	59.4
SCE Coastal	523.3
ZP26	257.9
NP15	584.8

Source: DE-EE0006327 US DoE

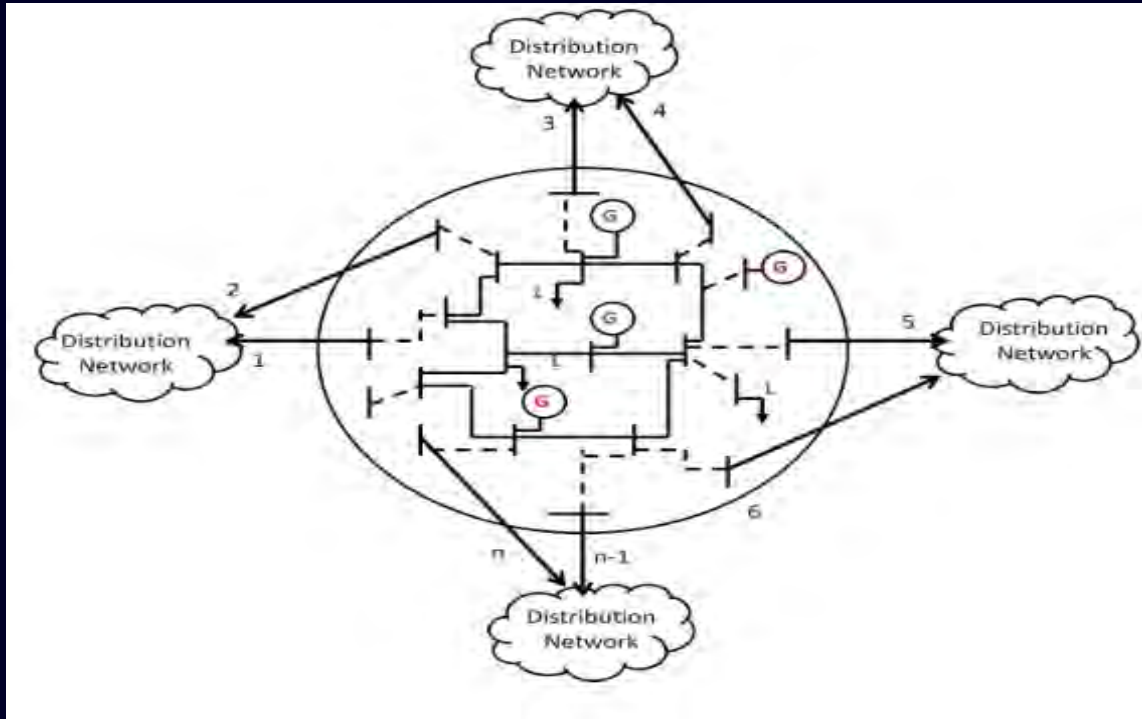
**Fast forward to 2022 in California LV network:  
12 GW of rooftops  
400 batteries/week are installed**



# Identifying DER quantity & cost basis subject to grid physical constraints for Distribution Operators in forward time intervals – Leveraging Technology

## DLMP Calculation

(using proven Standard Market Design (SMD) for ISO optimization and MILP based on Cplex or Gurobi solver)



## Calculate

Multi-Interval Dispatch Targets for Wholesale, DER and Storage

## By Minimizing sum of Costs

- Wholesale Power Cost
- DER and Storages

## Subject to

- Power Balance Constraints
- DER Forecast (Capacities)
- Storage Constraints
- Network Constraints

# Ecosystem use cases needed in shaping Decentralization

Microgrid optimization – while connected to grid

MDMS and analytics use for DERMS

FERC 2222 use case for Aggregators (Day ahead, Intra day, and real time markets for normal and emergency)



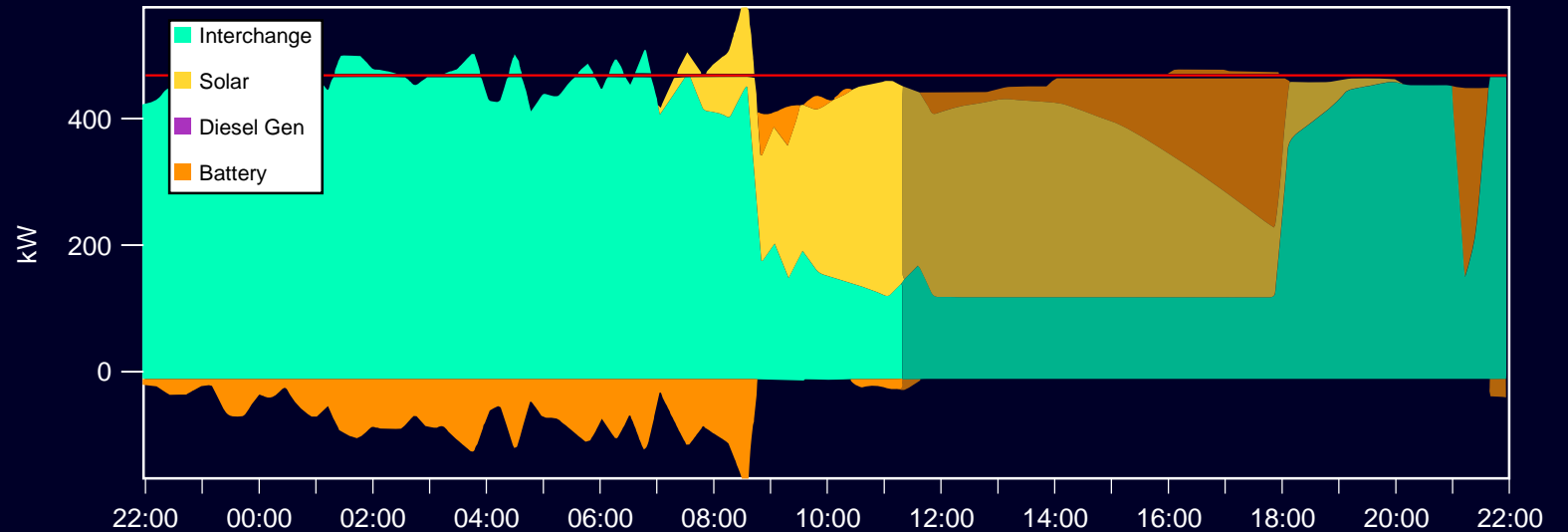
# Complex Campus Microgrid Blue Lake Rancheria, CA

## Normal Operation

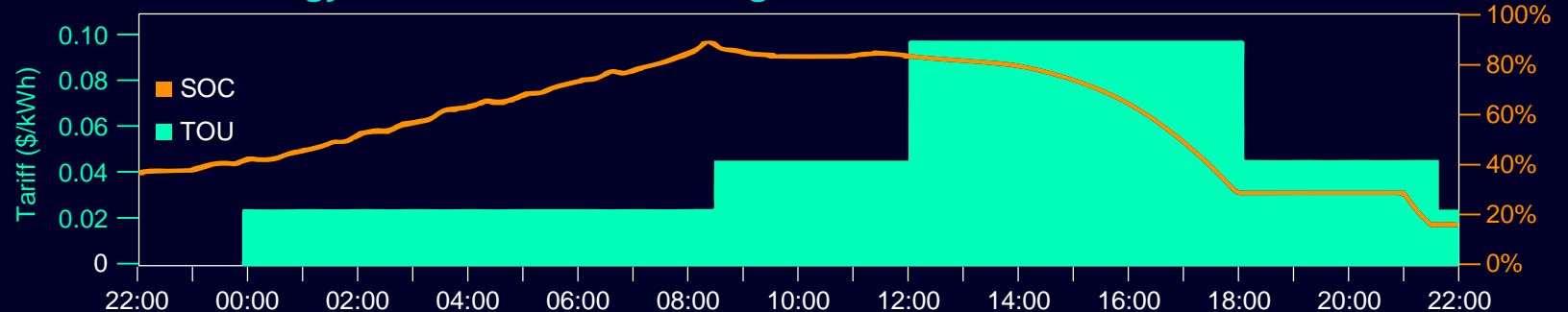
- MGMS installed to integrate and automate: 700kW Casino, hotel and office load, 1MW diesel gen, 175kW fuel cell + biomass and 500kW PV + 1MWh battery
- Site is not allowed to export to grid.
- Generation mix reflects what would be expected of site designed to meet majority of load via solar.
- Pull grid power at night to charge battery and meet load.
- Escalating tariff creates incentive for site to consume battery storage during 12-18h period.

## Normal Operation

### Generation (kW)



### Grid Energy Tariff and State of Charge



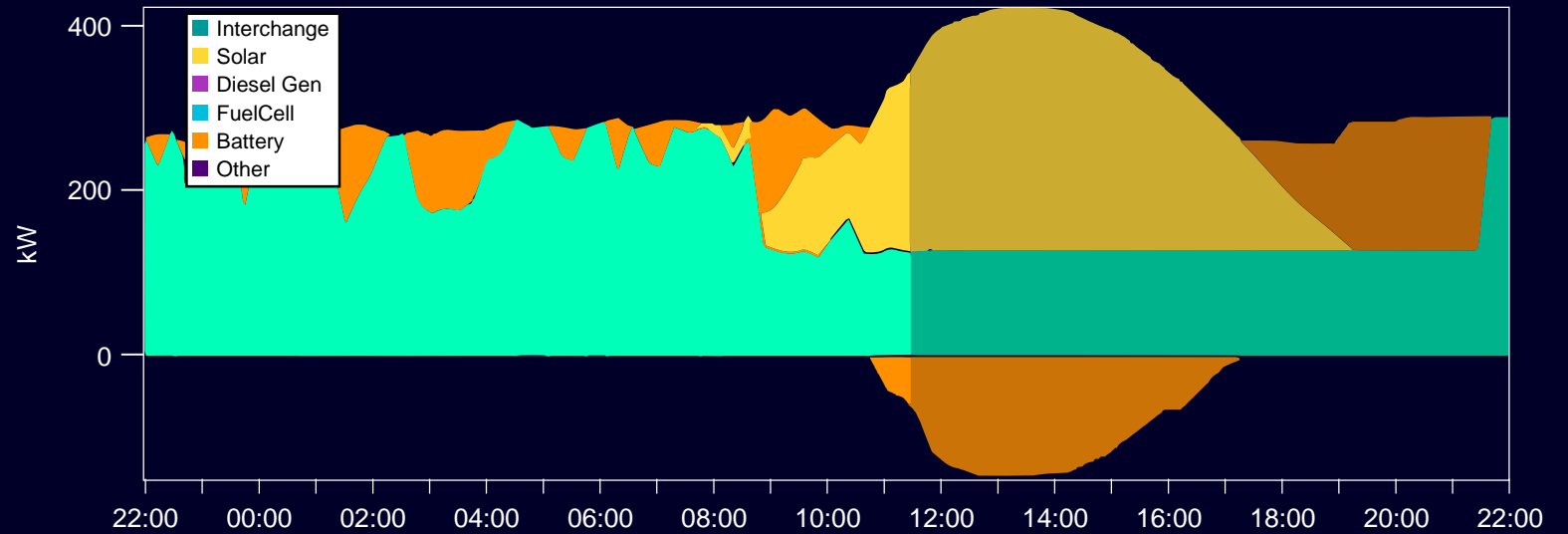
# Complex Campus Microgrid Blue Lake Rancheria, CA

## Covid Operation

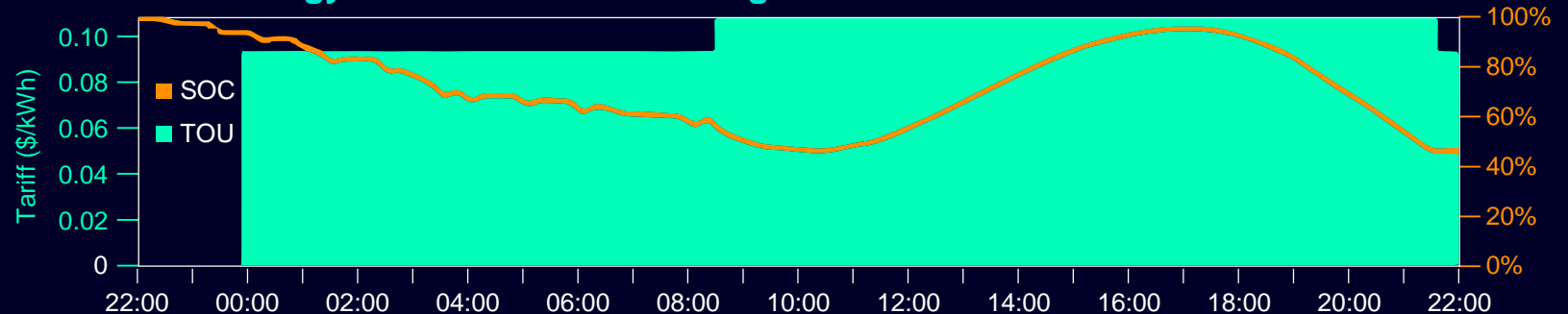
### COVID-19 Operation

- Note: site is not allowed to export to grid.
- Casino and hotel at reduced operation and load drops significantly (~450 -> 250 kW).
- PV still produces as much as before so must be curtailed (increase cost) or consumed.
- MGMS re-optimizes, **without human interaction** to discharge battery at night to ensure solar is still used as much as possible to minimize cost.

### Generation (kW)



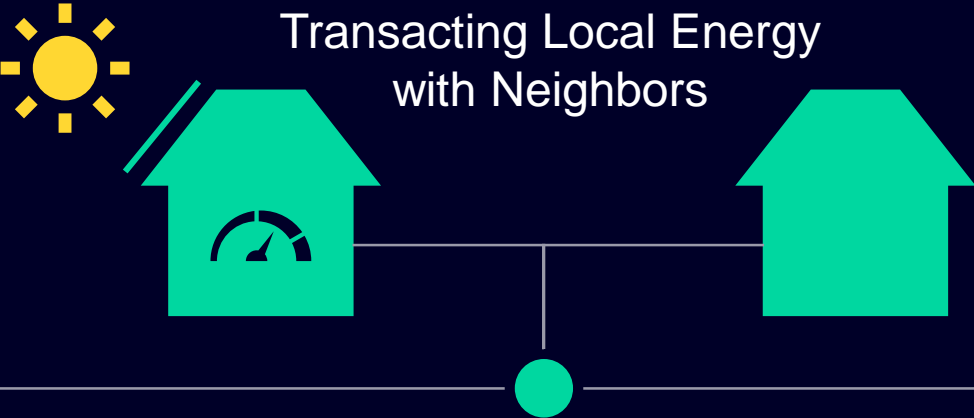
### Grid Energy Tariff and State of Charge



# Transactive Energy is in nascent stage, but can be an Enabler - Microgrids in Community Solar projects

Success story of Blockchain in the energy sector by Siemens Grid Software, LO3, and the startup financier : Siemens Next47

## The Brooklyn “Microgrid” Project



To enable the silent-majority we will ideally need:

- Consent & signed agreement from the consumer / prosumer
- Intelligent & automatic scheme to perform P2P selections, transactions & payments





conEdison, inc.

# Consolidated Edison

Smart metering at its best.

## Solution

EnergyIP Meter Data Management to handle 5 million+ smart electricity and gas meters in Manhattan



## Benefit

Reduce power consumption by up to 15% as stated by NY REV goals



SIEMENS





**125,000  
virtual  
meters**

EnergyIP MDM provides unprecedented LV network transparency

**3 weeks**

Case analysis effort saved each data review period due to Analytics Foundation

**20% DER**

Analytics provides visibility into transformers and electricity flow from customers to the electricity grid

## EnergyIP Meter Data Management and Analytics for Konstant Net A/S, Denmark

**“It’s a new world. The way electricity is produced differs from the past. Clients are buying rooftop solar panels and producing energy. You may not have the right cable for energy to go the opposite way. Being able to facilitate flexible electricity consumption requires you to know your load on the grid in great detail.”**

*Poul Berthelsen - Innovation Manager, KONSTANT*



## A zero-carbon system will have to evolve to accepting renewable generation and managing storage & loads

### Technology and analytical solution kits are more-or-less available from proven practice

- Standardization & adaptation by the ecosystem is a bigger hurdle
- MDMS, MGMS & Analytics are paving the way for DERMS
- IEC CIM framework – increasing level of data exchange is essential (61970 Network Models, 61968 Asset Models, 62325 Market Communication are associated standards)

### New Challenges

- Increased variability of generation, low inertia, frequency response, adapting flexible loads and managing BESS, lack of long-term storages

### Regulatory measures to guide the ecosystem

- Consensus building – many parties are involved
- Silent majority buy-in is complex
- State mandates & incentives to assist the regulators

### Overall ecosystem's wide adaptation takes time and efforts

- Pilots followed by standardization is ideal to ease and accelerate adaptation
- Behavioral economists' techniques can accelerate participation of a large population (e.g., Thaler's \*Nudge Theory - a proven success)

\*Nudge: Improving Decisions About Health, Wealth & Happiness, 2009, by Thaler & Sunstein

# Contact



## Sankaran Rajagopal, Ph.D., E.E.

Senior Director, Energy Markets Business Solutions  
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Mail: Sankaran.Rajagopal@siemens.com



## Bio of Sankaran Rajagopal. Siemens Grid Software

**Sankaran Rajagopal** is currently a Senior Director responsible for Energy Markets-Business Solutions at Siemens **Smart Infrastructure – Grid Software** out of Minneapolis, Minnesota, USA. He is an Iowa State Ph.D. in E.E. He's been with Siemens for over two decades.

### His salient and active engagements at Siemens over the years have been:

- Power System Applications Development, Operator Training Simulators, Regional Black-start Drills & System Restoration
- Development and Product Release management
- Program Management for Siemens delivered market system at California ISO
- Engaged in Siemens Market system solutions thru' the rapid progression of game changers: shale gas, renewable penetration, energy imbalance market, storage penetration and now FERC 2222
- Global engagement in the topics of market design and the needed IT/OT Systems
- New business solutions dealing With Energy Markets and Market Participants

He is a regular volunteer as a teacher for children in the Sunday school and for non-profits fundraising. His fun activities are: running, road bike, puzzles, Bridge, classical music and face-time with his grand daughter.

# Project EDGE (Energy Demand & Generation Exchange)

APEX Congress 2022  
Panel 1: Decentralization

October 2022

## ARENA ACKNOWLEDGEMENT AND DISCLAIMER

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.



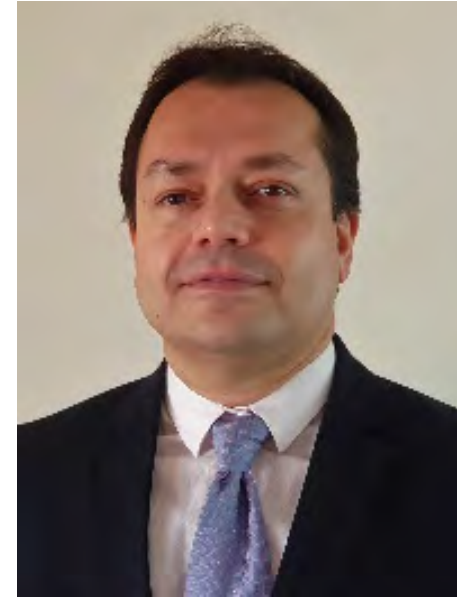
# Project EDGE | A collaboration between AEMO, AusNet & Mondo



**Nick Regan**  
Australian Energy  
Market Operator



**John Theunissen**  
AusNet Services



**Anoop Nambiar**  
Mondo Power

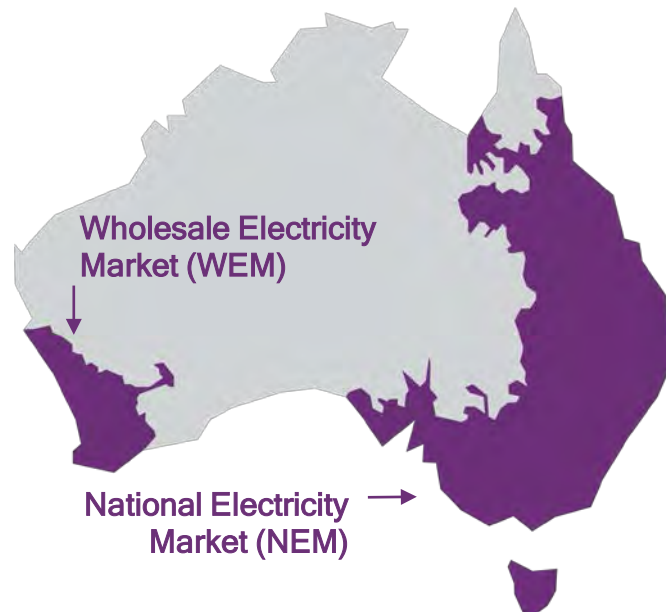
**Project EDGE** (Energy Demand and Generation Exchange) is a collaboration between the **Australian Energy Market Operator** (AEMO), **AusNet Services** (AusNet) and **Mondo Power** (collectively, the Project Partners), with financial support from the **Australian Renewable Energy Agency** (ARENA).



# The National Electricity Market

## How the NEM Works

- The National Electricity Market (NEM) Operates one of the world longest interconnected power systems, a distance of around **5,000** kilometres.
- The NEM spans Australia's eastern and south-eastern coasts and comprises of **five** interconnected states that also act as price regions
- There are over **100 generators** and **retailers** participating in the market, so it's highly competitive and therefore an efficient way of maintaining relatively competitive electricity prices in the wholesale market.



## Fast Facts



There are over 504 registered participants in the NEM, including **Market Generators**, **Transmission Network Service Providers (TNSP)**, **Distribution Network Service Providers (DNSP)**, and **Market Customers**.



The NEM commenced operation as a **wholesale spot market** where supply and demand is matched instantaneously in December 1998.



The NEM incorporates around **40,000 km** of transmission lines and cables.



The NEM supplies about **204 terawatt** hours of electricity to businesses and households each year.



**\$11.5 billion** was traded in the NEM in FY 2020-21.



The NEM supplies approximately **10.7 million** customers.



The NEM has a total electricity generating capacity of **65,252 MW** (as at December 2021).



The NEM has approximately **14 GW** of distributed solar (as at Dec 2021). Collectively the **largest** generator in the NEM.

# Project EDGE | Collaboration



**ARENA**  
Funding Partner

## Tech. Partners



DSO capability



energy web

Digital identity & data exchange

**PXiSE**

Energy Solutions, LLC  
Market logic/intelligence

Distribution  
System  
Operator

**AusNet**  
services



Aggregators



Power System & Market Operator

## Supporting Partners



Networks, Research &  
Knowledge Sharing



Customer Insights

**Deloitte.**  
Cost Benefit Analysis

**EY**  
Knowledge Sharing

**nous**  
Independent Project Manager

# Project EDGE – Key functions Overview



## Dynamic Operating Envelope (DOE)

- A dynamic operating envelope provides upper and lower bounds on the import or export power, in a given time interval, for either individual DER assets or a connection point.



## Bi-directional Offer (BOffer)

- Bi-directional Offer means an offer that includes both generation & load across the aggregator's registered portfolio of NMI's. As the trial progresses through various phases the application of BOffers will also go through a progression.



## Wholesale Dispatch Instruction

- Dispatch Instructions are issued by AEMO to Aggregators for the purpose of meeting the supply and demand balance in EDGE by either generating (i.e. export to grid) or by consuming (i.e. import from grid) as a DER portfolio

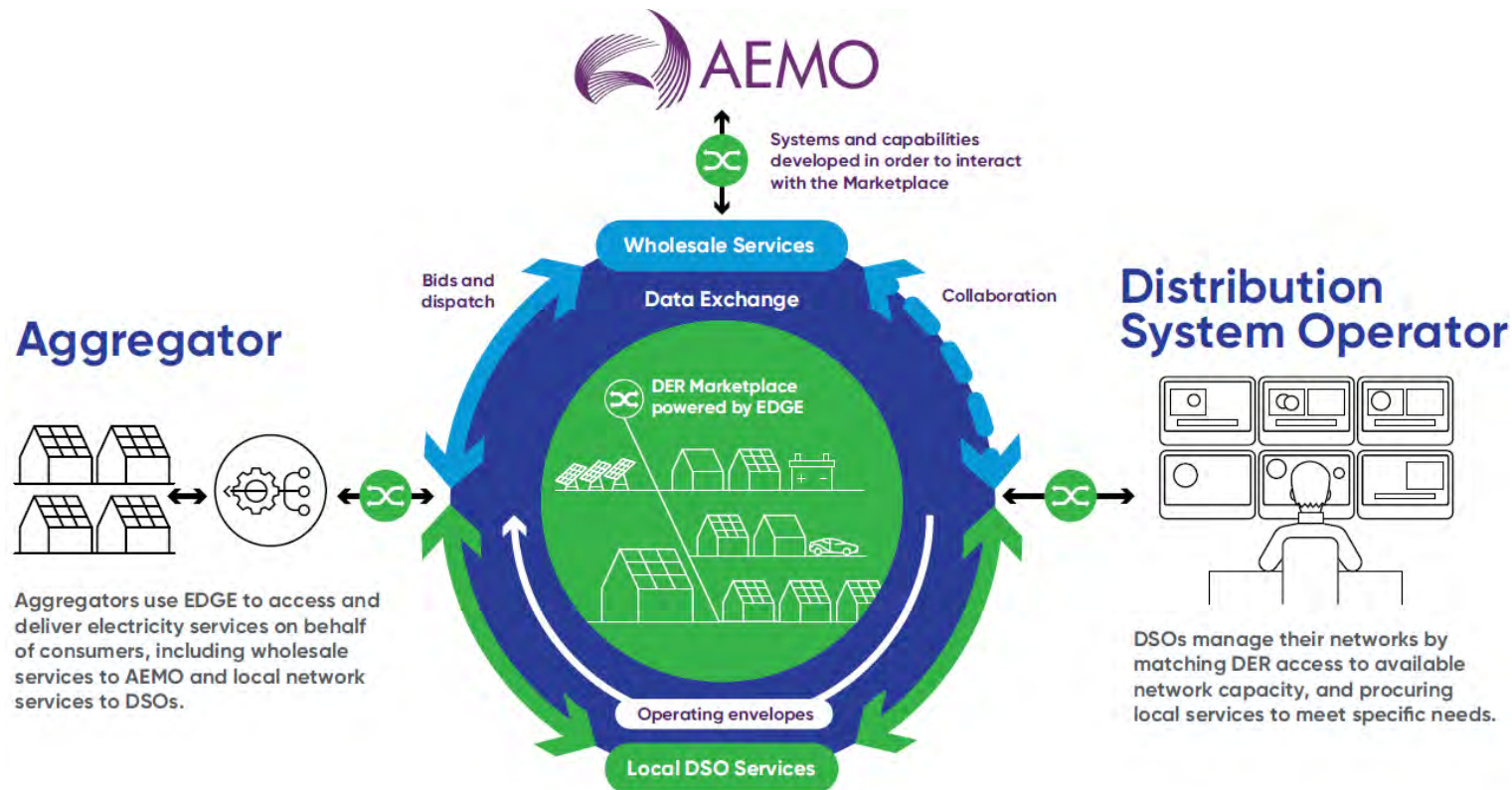


# Project EDGE seeks to demonstrate an efficient model for DER integration at scale



## Building on the Open Energy Networks Hybrid model

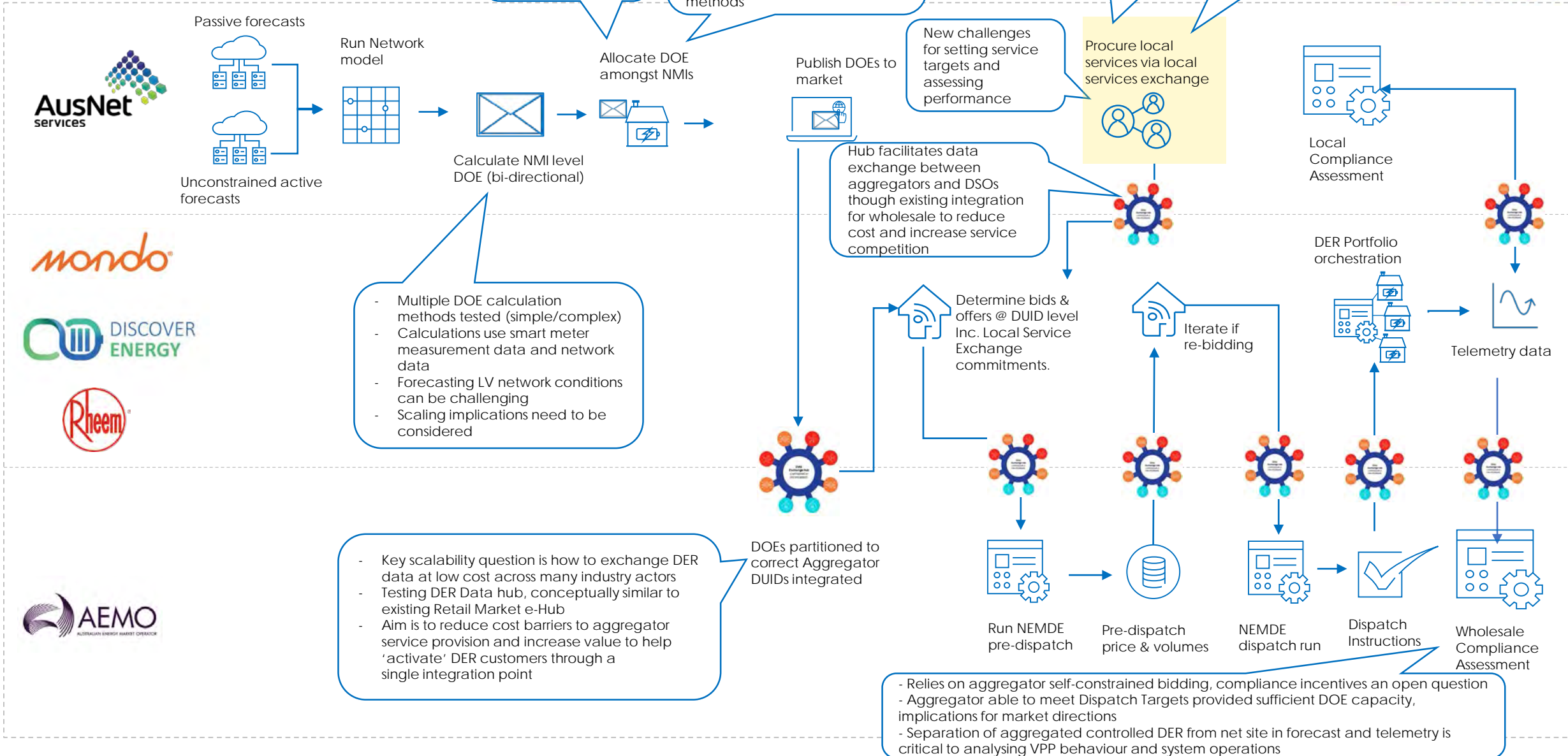
- Building on OpEN with detailed design underpinned by the NEO
- Open and collaborative approach between partners (AEMO, AusNet & Mondo) and industry
- Scientific approach to delivering a robust evidence base and independent CBA



*The DER Marketplace is not a single, AEMO-run platform or capability. Rather, it is an integrated digital ecosystem that links many systems and capabilities across various industry actors to enable the efficient and scalable exchange of data and services.*



# Wholesale Market services



# Project EDGE exists to provide evidence-based insights to benefit all customers.



We have **three** key pillars that will inform policy decisions to provide value to industry and customers.



## Research Plan

A detailed research plan has been developed by the University of Melbourne to guide the activities undertaken to ensure the data obtained supports the objectives of the project and can be used as part of an evidence base for change and development of the future energy market and systems.



## Cost Benefit Analysis

The purpose of the CBA for Project EDGE is to identify and analyse whether the implementation of an operational DER marketplace is in the long-term interests of consumers consistent with the NEO. Deloitte Access Economics has been commissioned to conduct the CBA and will also assess under which scenarios adding more complexity and sophistication to the DER marketplace may be justified.



## Customer Insights Study

Together with Deakin University, Project EDGE is running a multi-year consumer study that examines perceptions of, and decision-making around, Virtual Power Plants (VPPs) among potential residential and business customers, and current residential battery owners.

# Project EDGE Publications



Publications	Publication Date
<a href="#"><u>Project EDGE CBA Methodology Consultation Paper</u></a>	July 2022
<a href="#"><u>Project EDGE Public Interim Report</u></a>	June 2022
<a href="#"><u>Project EDGE Customer Insights Study</u></a>	June 2022
<a href="#"><u>Project EDGE Research Plan</u></a>	March 2022
<a href="#"><u>Project EDGE MVP Showcase</u></a>	December 2021
<a href="#"><u>The National Electricity Market Fact Sheet</u></a>	November 2021
<a href="#"><u>Project EDGE Lessons Learned Report #1</u></a>	May 2021
<a href="#"><u>Project EDGE Public Webinar #1</u></a>	March 2021
<a href="#"><u>Project EDGE Factsheet</u></a>	January 2021

For further news and knowledge sharing publications, please visit the [Project EDGE Website](#)

For any questions, comments or feedback, please contact: [EDGE@aemo.com.au](mailto:EDGE@aemo.com.au)



Thank you!

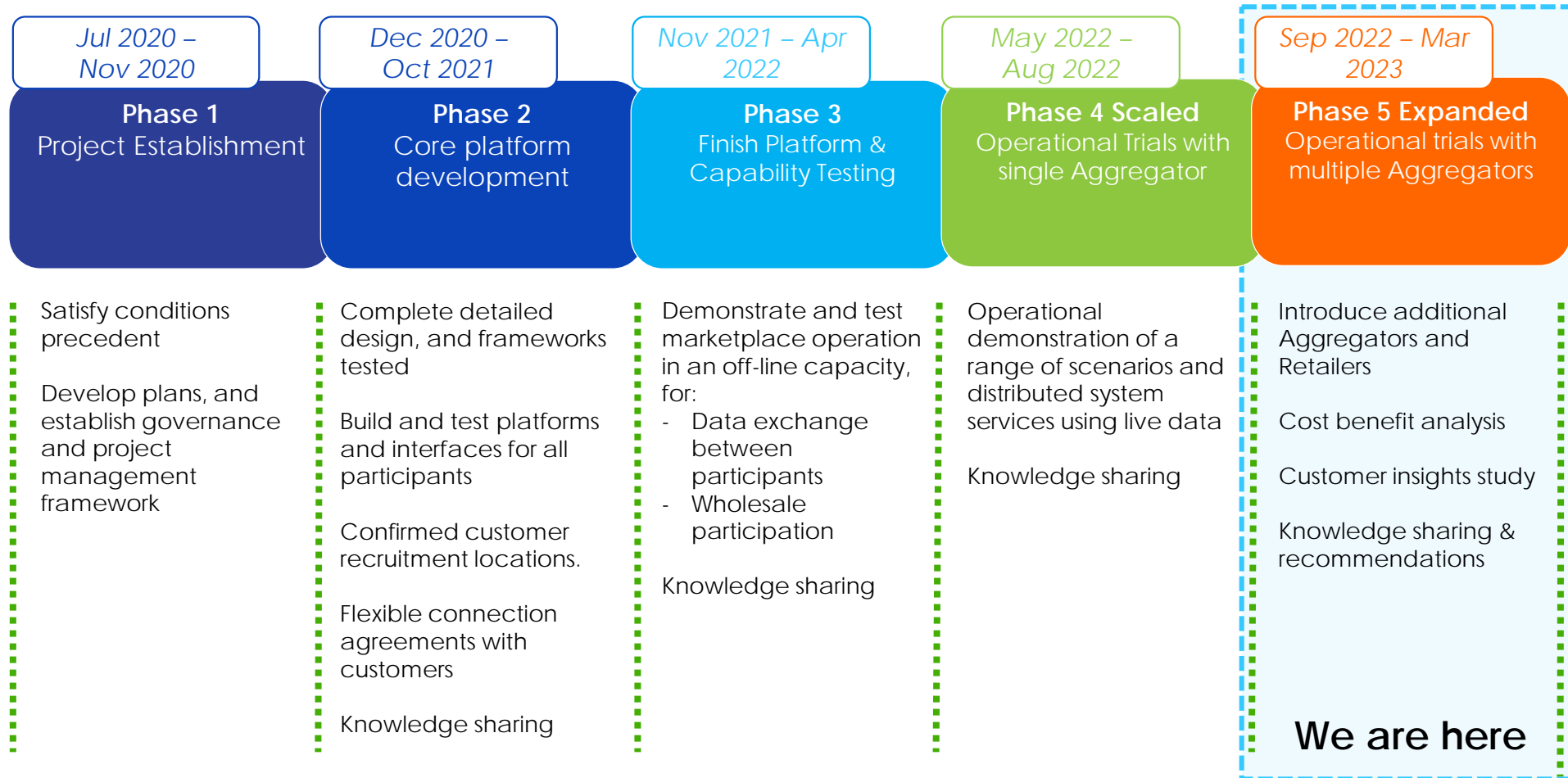


# Appendix

# Project EDGE | Timeline

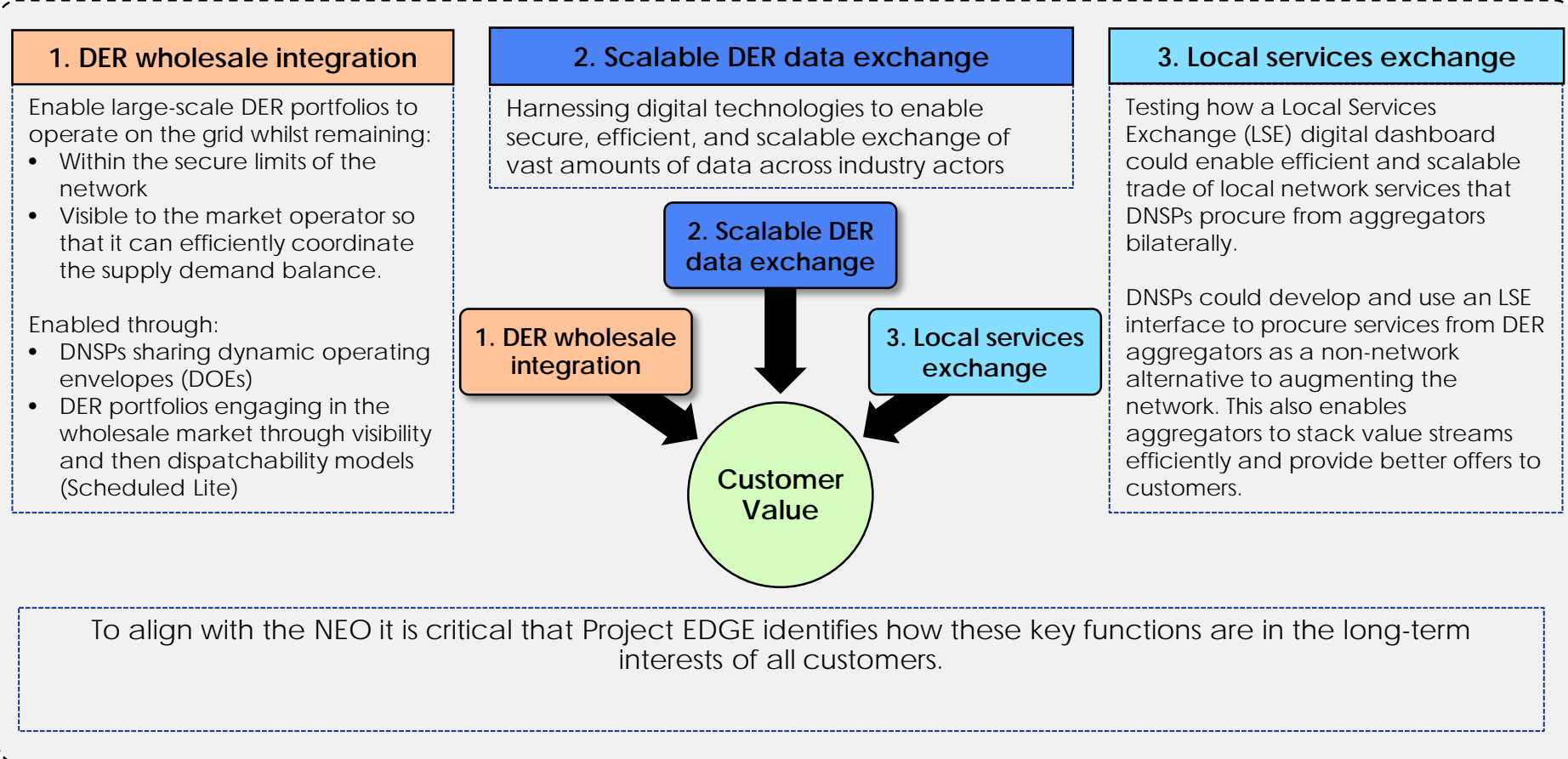
*Based in Hume region of Victoria*

*Five Phases, from July 2020 – March 2023*



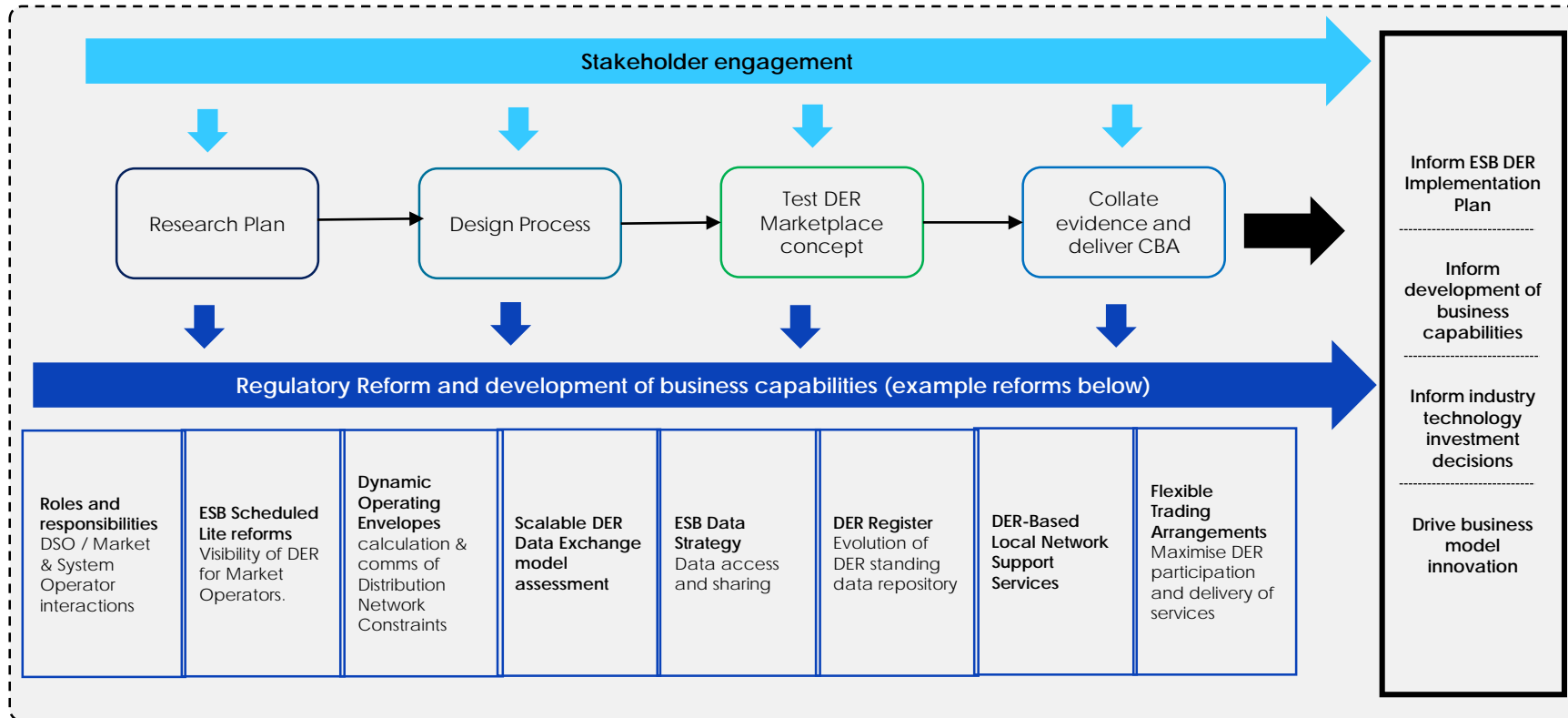
# Project EDGE will test the core functions of a digitised, decentralised power system and market

Project EDGE will test the three key function sets that are vital elements of efficient and scalable DER integration, which are combined in Project EDGE in a concept called the DER Marketplace.



# Evidence generated by Project EDGE is supporting the Energy Security Board's Market Reforms

- The Energy Security Board's (ESB's) Post 2025 National Electricity Market redesign identified that the change in energy consumers' behaviour provides a strong opportunity to develop a two-sided energy market.
- This would result in lower overall system costs for everyone, increase the efficiency of existing network assets, and optimise the utilisation of flexible loads and variable renewable energy.
- The evidence-based approach by Project EDGE will support recommendations that inform policy, regulatory and market decisions relating to reforms needed by industry to operationalise a two-sided market.





**APEX conference 2022**

**Round table «decentralisation»**

**Julien COSSE, Chief Strategy Officer  
NORD POOL**

**“How to address flexibility in a more  
decentralized European market: 2 case studies”**

**NORD  
POOL**

**The need for a more flexible European market**

# Nord Pool at a glance

- Operates since 1993
- Power exchanges in 16 European countries
- Nord Pool offers day-ahead and intraday trading, clearing and settlement services, compliance services and data services, all under one roof
- ~ 400 customers from 20 countries trade on Nord Pool's markets
- > EUR 200.000.000 daily cleared
- ~140 employees, 25 nationalities, offices in Oslo, Stockholm, Helsinki, London, Tallinn and Brussel



963 TWh  
day-ahead



25 TWh  
intraday



400  
customers

**NORD  
POOL**

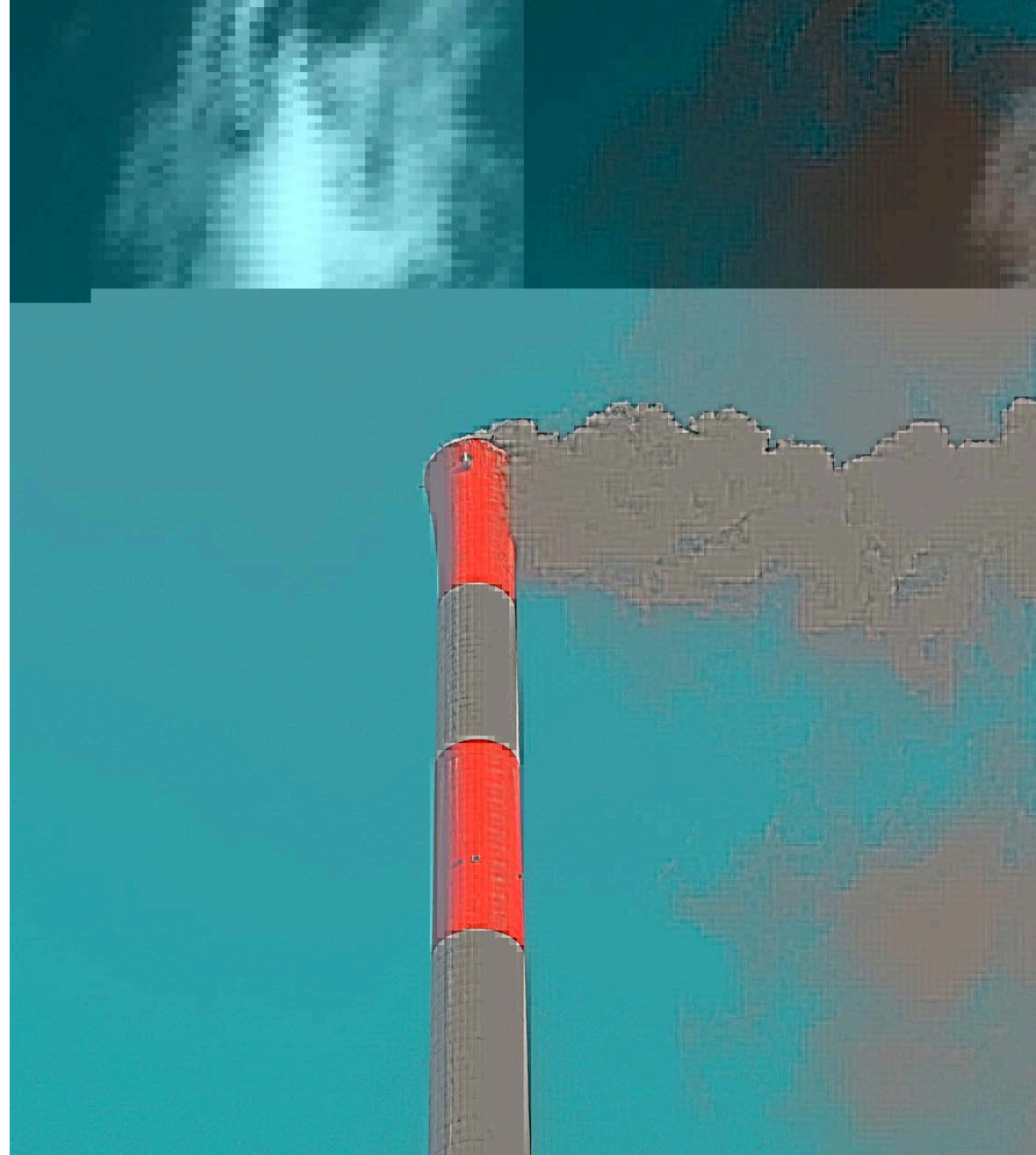
Note: 2021 numbers



# Current European market and the need for flexibility

The need for more flexibility in Europe was already high, it is now exacerbated with the energy crisis

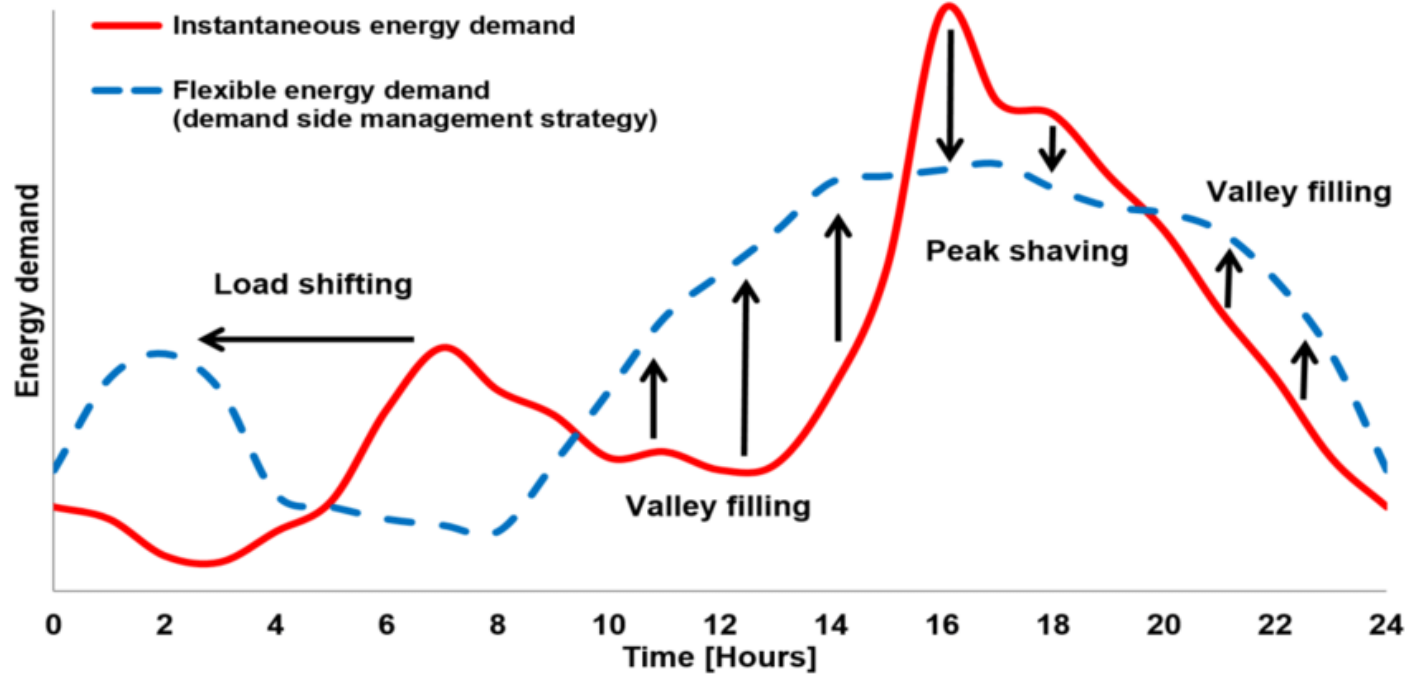
- Electricity markets are moving from centralised to **distributed generation**, from conventional to weather-dependant renewable sources, and from fixed to variable supply and demand.
- In addition, **electrification** is starting to reach neighbouring sectors—from transportation to industrial processes.
- Finally, an outdated **bidding zone configuration** and **insufficient market integration** hinder the transformation of the electricity sector
- As a consequence, today **European grids are congested** and markets are becoming more volatile.



# Flexibility fundamentals

Flexibility is the ability of network-connected assets to deviate from their planned electricity consumption or production profile in response to the needs of system operators

## Examples of demand-side flexibility actions



## Key benefits

### System operators

- Avoid curtailment of renewables
- Improve congestion management
- Defer grid reinforcement

### Market participants

- Portfolio optimisation
- Self-balancing

### Microgrids, energy communities, prosumers

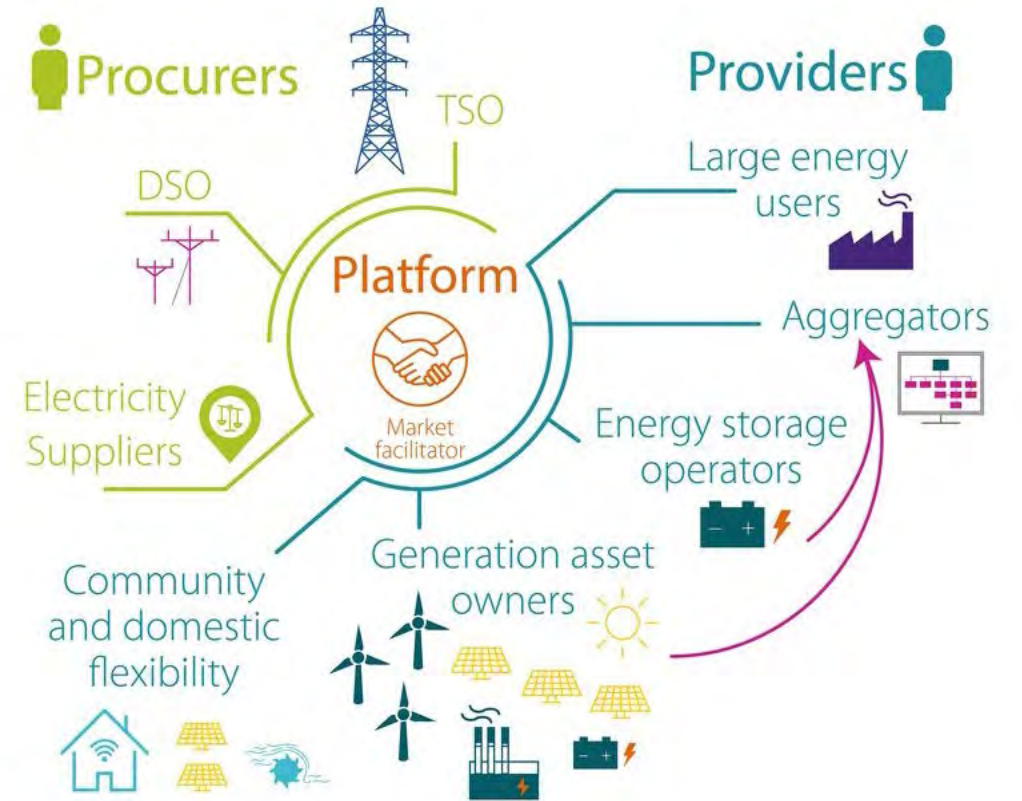
- Demand/supply optimisation



# Flexibility fundamentals

Diverse types of decentralized assets should find a way to value their flexibility

SCALE	Residential	Commercial	Large-scale/industrial	
FLEXIBILITY SOURCES	<b>Generation</b>	Solar PV Micro-CHP	Medium-size CHP On-site generators Building-integrated PV	Centralized power plants (gas CCGT, pumped hydro) Industrial CHP Renewables curtailment
	<b>Storage</b>	Electric vehicles Home batteries	Batteries	Pumped hydropower Grid-based battery storage Large-scale mechanical storage
	<b>Demand-response</b>	Electric vehicles Electric heating/cooling (warm water boilers)	Smart buildings Heating/cooling installations	Manufacturing installations Steam/heat generators



regen, 2018. [Local flexibility markets guide](#).

# Flexibility fundamentals

Market-based procurement is one way to incentivize a more flexible EU energy market

## Network tariffs

Cost-reflective network charges that factor in time, location, direction and capacity could better expose users to prices and untap implicit DSF.

## Regulated approach

Network codes and regulations that impose detailed flexibility requirements.

## Connection agreements

Variable network access (SOs save on grid expansion) in exchange for lower connection charges (users save on tariffs).

## Market-based procurement

System operators acquire flexibility in the market

Flexibility providers value their assets on the market

**How to address market-based flexibility in Europe?  
2 use cases with complementary approaches**

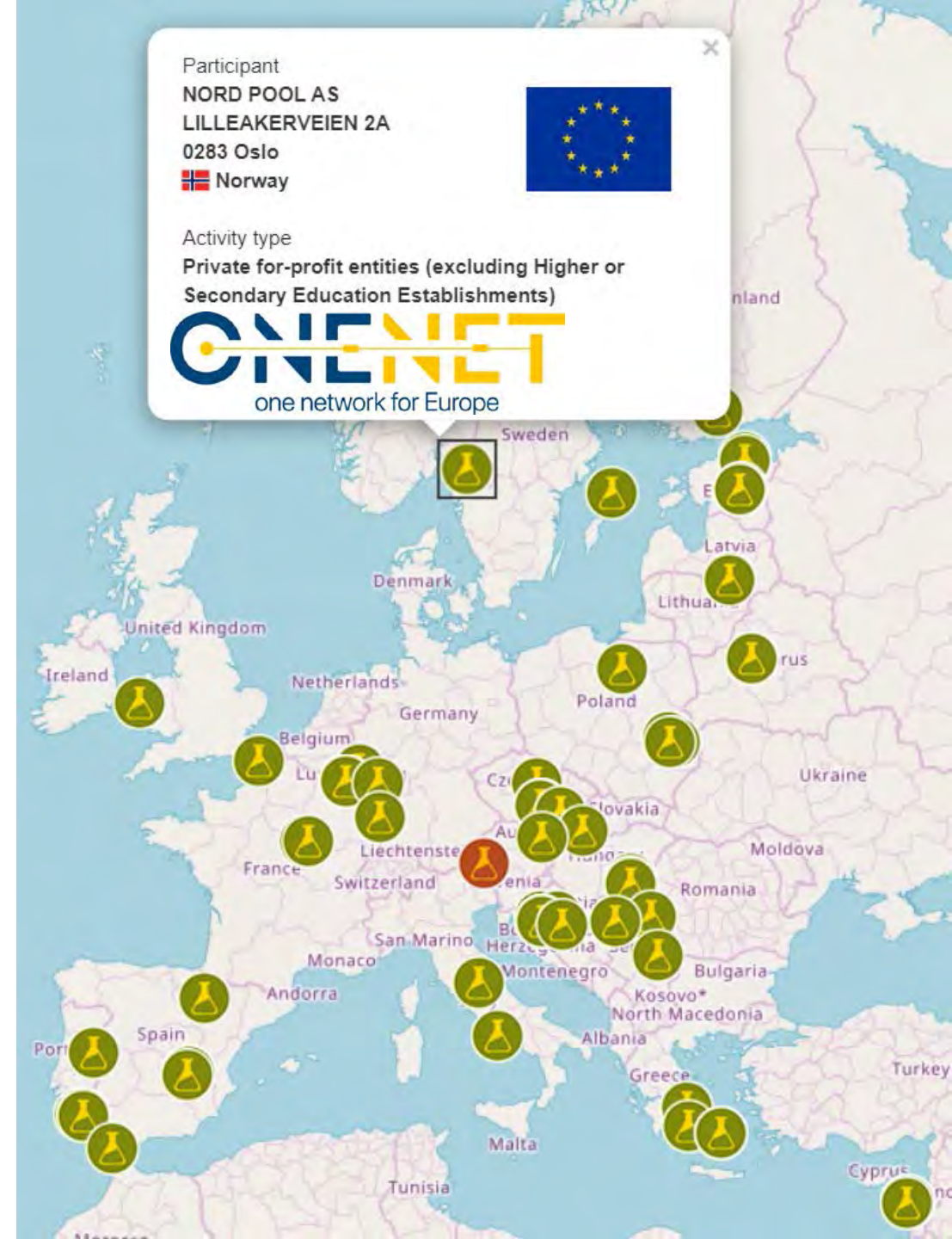
# ONEnet project

Nord Pool enables TSOs and DSOs to purchase their flexibility needs on the wholesale intraday market

Nord Pool is part of the **Northern Cluster Demonstrator\***.

- **Key goal:** to allow customers **access to TSO balancing markets** through Nord Pool's user interface in addition to the intraday markets.
- Implementation must be "balancing-market compliant" (frequency and congestion management)
- Part of EC's Horizon 2020 program: consortium of over 70 participants lead by the Fraunhofer Institute

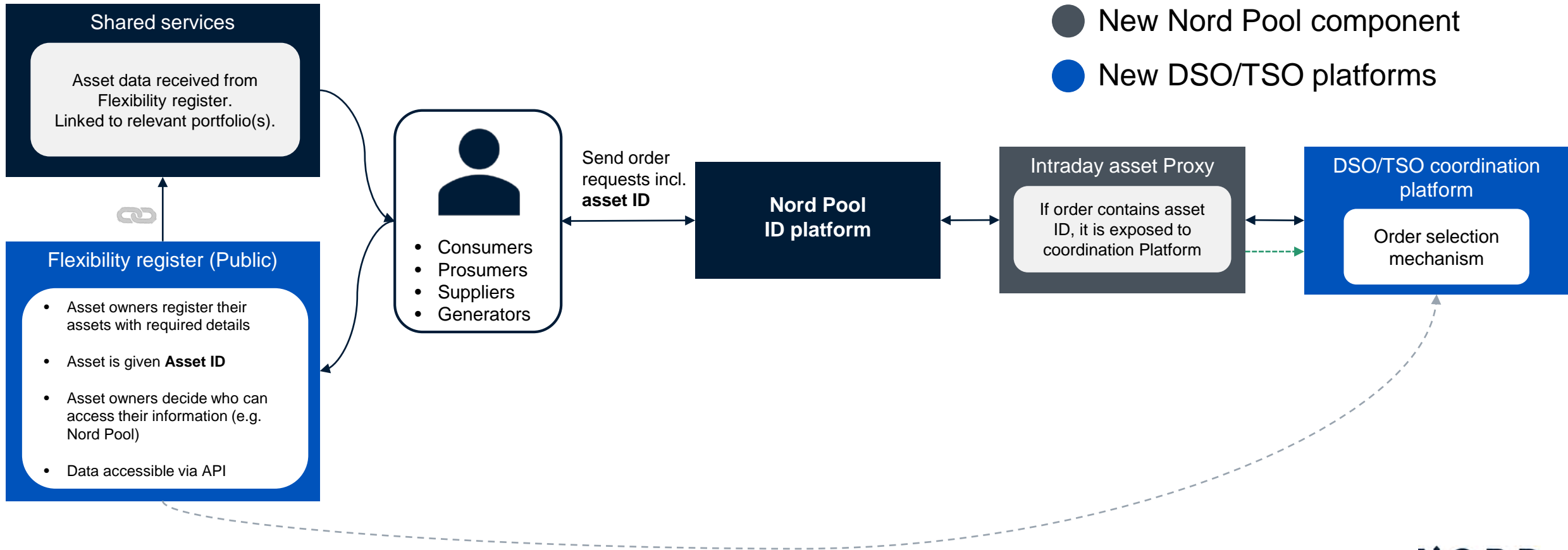
\*Ireland, Norway, Sweden, Finland, Estonia, Latvia, Lithuania.



# ONEnet project

Development of a solution with which TSOs can access to orders on the intraday platform with balancing attributes (geographical tags)

- Existing Nord Pool components
- New Nord Pool component
- New DSO/TSO platforms



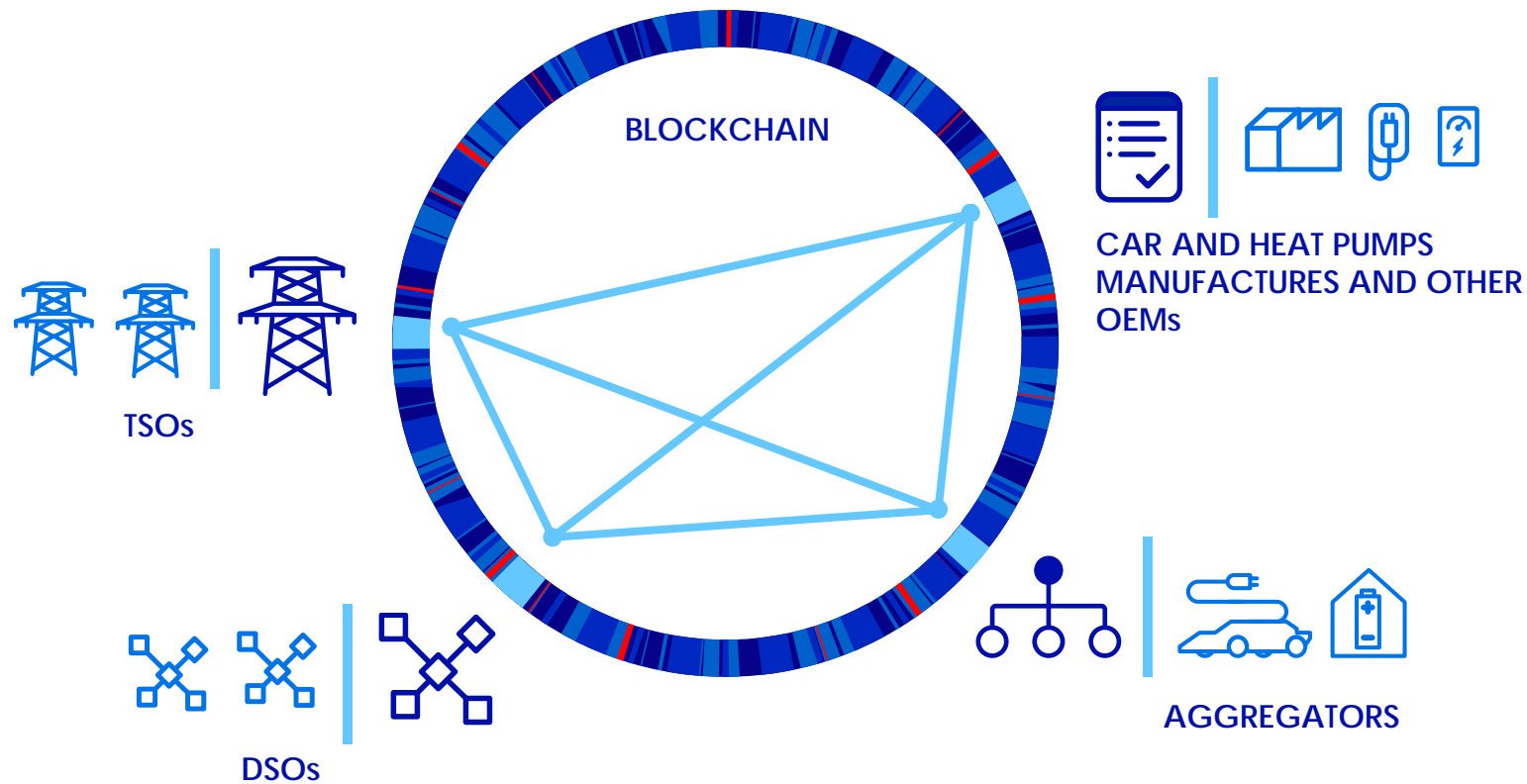


# Equigy flexibility platform and crowd balancing

**EQUIGY**

crowd  
balancing  
platform

Equigy is a technology provider enabling small scale flexibility sources to participate to the electricity markets



- Provide the required transparency and allow TSO and DSO to add system constraints
- Facilitate interaction between aggregators & OEMs
- Facilitate an increasingly decentralised energy market
- Improve validation methods for the TSO and DSO
- Scaling possibilities over country borders for Aggregators and BSPs

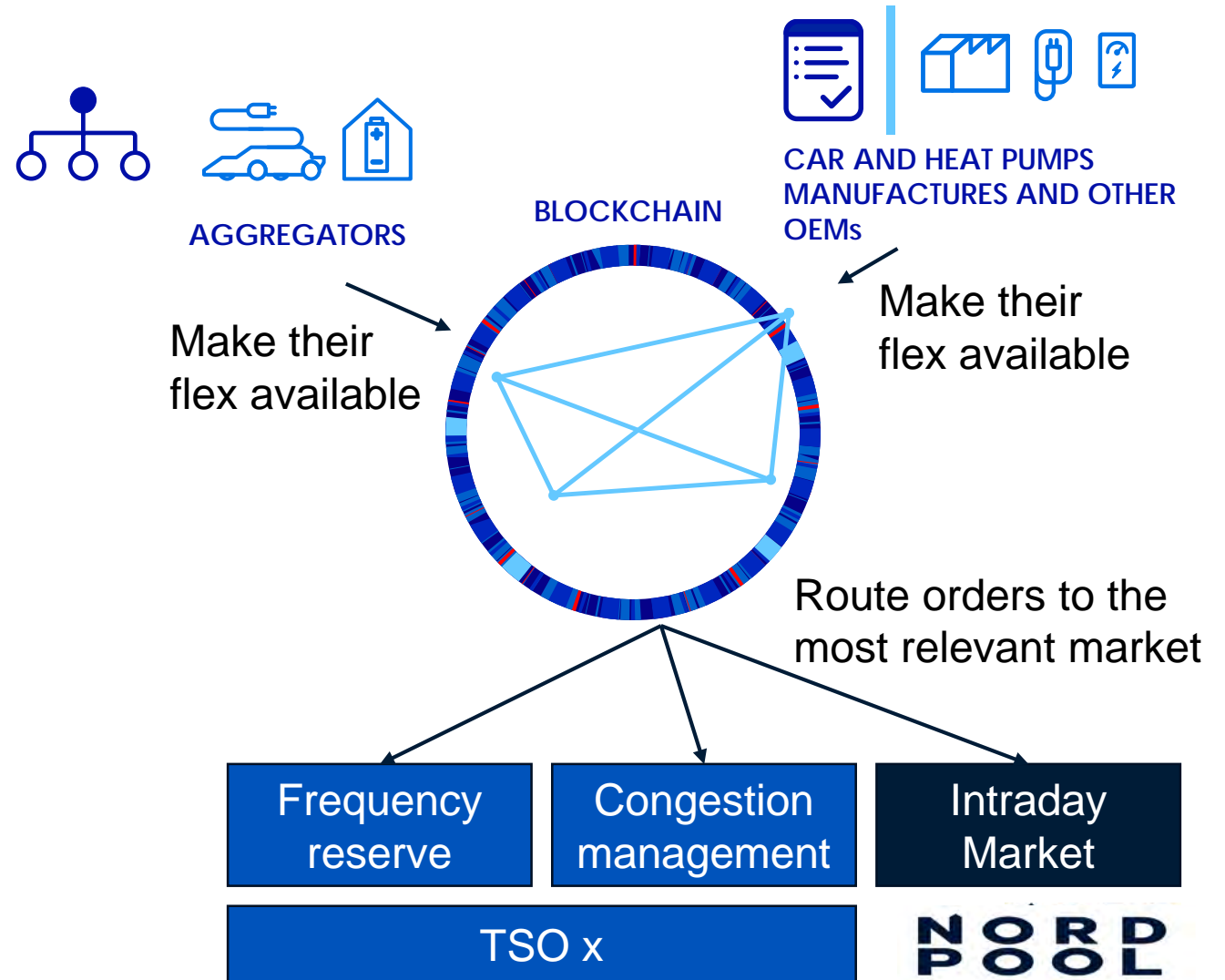
**NORD  
POOL**

# Equigy flexibility platform, crowd balancing and intraday

Nord Pool and Equigy are partnering to help flexibility providers to find the best possible value to their assets

Nord Pool and Equigy are offering together a better optionality to flexibility providers so they can offer their flexibility where it is the most valued:

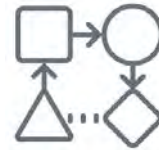
- **Key goal:** to allow **small flexibility providers** using Equigy technology not only to **access to TSO balancing markets** but also to access **Nord Pool's intraday markets**, through an automated API
- Implementation in line with balance responsibility as defined in Europe as step 1, step 2 is to introduce handling of multiple balance responsible parties



# Major relevant components and success factors



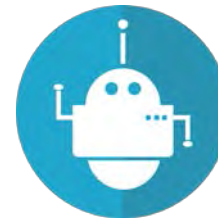
**One open platform** for all to trade flexibility services in a transparent and cost-effective way



**Dynamic market model** exposing flexibility to all DSOs & TSOs in a coordinated way



Unlock the value of local flexible power resources by **lowering barriers of entry**



Customer centric approach, supporting existing **automation** abilities

# Challenges with market-based flexibility procurement in Europe

Ideally designed markets should incentivise more flexibility

- **Competitive** – many available sellers
  - **Liquid** – sufficient volumes and capacity
  - **Transparent** – full information and clearly defined products and services
  - **Non-discriminatory** – supply, demand and storage participate on equal footing, including small participants
  - **Low entry or exit barriers** – thanks to technology and business models
- Existing market design (with some tweaks) and technology are 2 key enablers of revealing the potential of flexibility***

**BUT** lack of clear legal framework

- EU vs National regulation and harmonisation
- Clarified roles and responsibilities between platforms, market operators, TSOs/DSOs and flexibility providers
- Flexibility in network regulation and incentives (buy vs build) Relevance to wholesale market regulation (balance responsibility, role of aggregators)

**APEX conference 2022**

**Round table «decentralisation»**

**Julien COSSE, Chief Strategy Officer  
NORD POOL**

**“How to address flexibility in a more  
decentralized European market: 2 case studies”**

**NORD  
POOL**



Panel 3:  
New Technologies and Emerging  
Energy Forms



# BREAKTHROUGH LOW-COST, MULTI-DAY ENERGY STORAGE

Investor Overview



Energy Storage  
For A Better World

CONFIDENTIAL





# The Challenge

*~50% reduction in emissions needed by 2030 to limit global warming to 2°C.*

*The grid needs to fundamentally transform to meet this challenge.*



Carbon mandates require retirements of fossil assets



Intermittency of renewables creates periods of undersupply



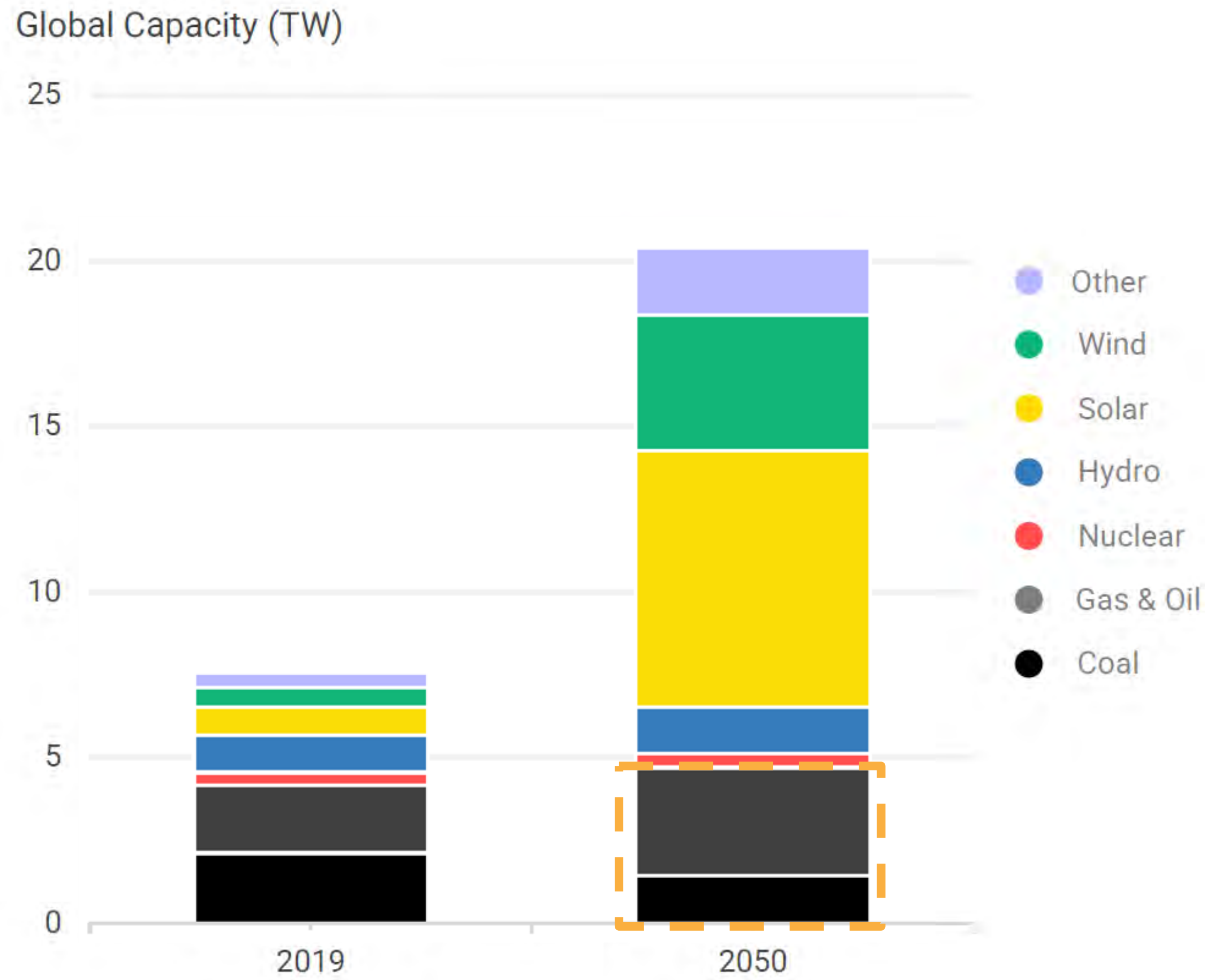
Transmission congestion & interconnection queues slow renewable buildout



Extreme weather events are more frequent and disruptive

# >\$4T opportunity to achieve full global decarbonization

*Reducing 2-4 gigatons emissions per year*



Source: BNEF New Energy Outlook 2020

The Demand: As the grid electrifies & renewable costs plummet:

- >4x growth in renewables
- ~13 TW additional capacity

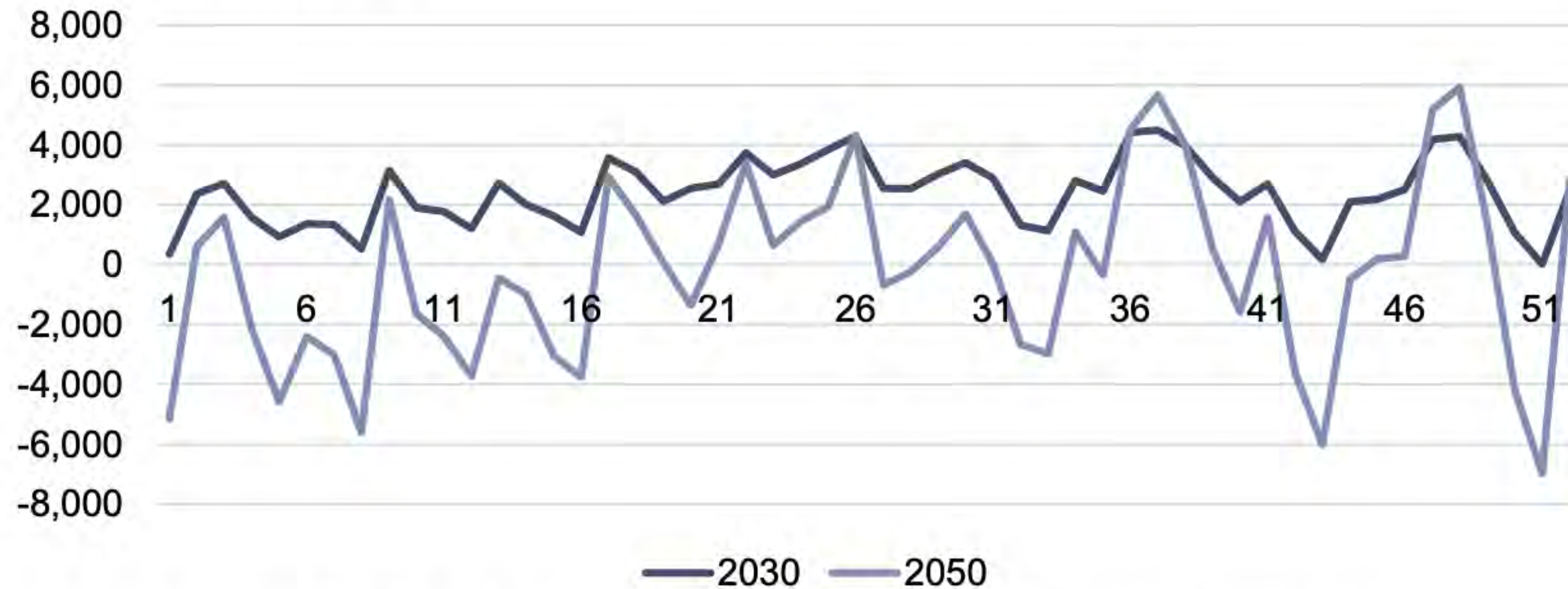
**The Opportunity:**

- Firm renewable generation with Form multi-day storage
- Eliminate ~4.7 TW of fossil plants
- Provide new source of reliability to the grid

# UK Needs 12 – 21 GW of LDES (12 Hours +) to Achieve Net-Zero by 2035

Deep decarbonization via renewables will make firm zero carbon capacity a requirement

**Exhibit 1.1 – Weekly net total residual demand variability, illustrative patterns based on 2014 weather pattern (GWh)**



Over time residual demand gets more extreme and more volatile

In 2030 system is almost continuously net short of power and therefore requires firm capacity to meet demand

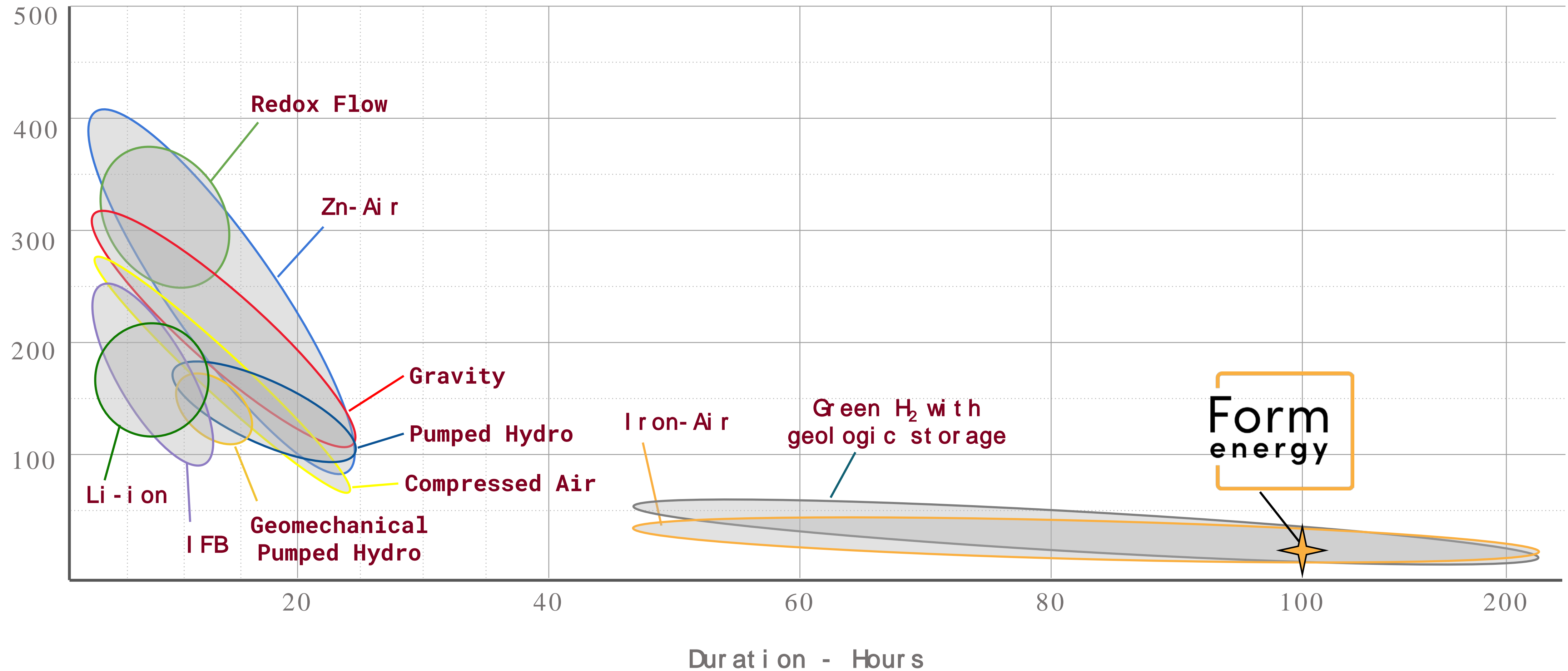
By 2050, net imbalances last for weeks at a time

Note: Positive values indicate a deficit and negative values indicate a surplus of generation



# Form MDS is the only technology targeting multi-day duration without geographic constraints

2030 Installed Cost - \$/kWh



# Rising to the challenge of climate change with a team that will deliver



LED BY ENERGY STORAGE VETERANS

Decades of cumulative experience in energy storage

■ 100's of MW of storage deployed



## OUR INVESTORS: LONG-TERM AND IMPACT-FOCUSED

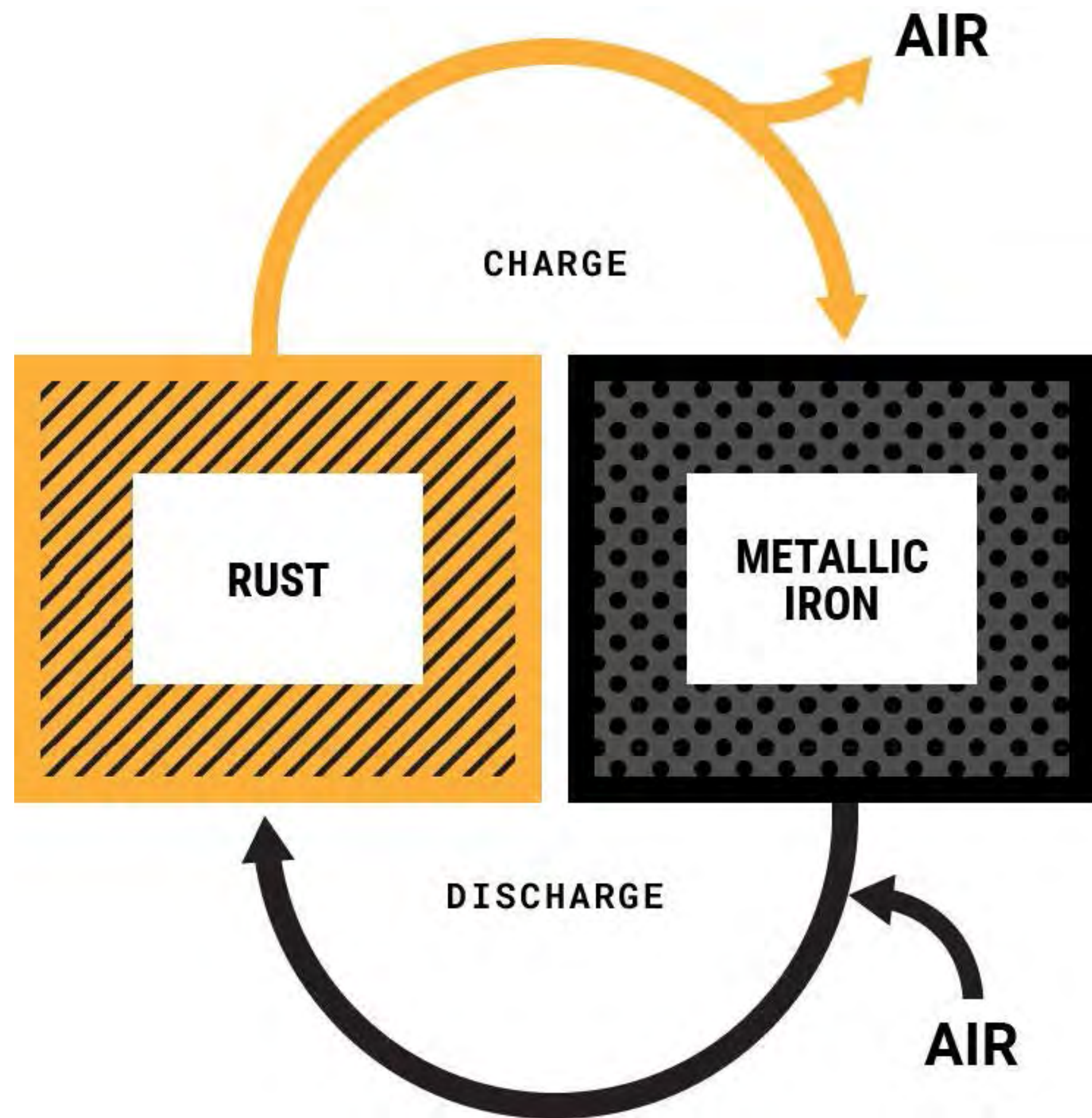
**\$817M** in venture capital from top investors including: TPG Rise, CPPIB, Breakthrough Energy Ventures (BEV), Coatue Management, NGP Energy Technology Partners III, ArcelorMittal, Temasek, Energy Impact Partners, Prelude Ventures, MIT's The Engine, Capricorn Investment Group, Eni Next, Macquarie Capital

# Form Multi-Day Storage Iron-Air Technology Overview



# Rechargeable iron-air is the best technology for multi-day storage

## Reversible Rust Battery



### COST

Lowest cost rechargeable battery chemistry.  
Chemistry entitlement <\$1.00/kWh



### SAFETY

No thermal runaway (unlike li-ion)  
Non-flammable aqueous electrolyte



### SCALE

Iron is the most globally abundant metal  
Easily scalable to meet TW demand for storage



### DURABILITY

Iron electrode durability proven through  
decades of life and 1000's of cycles (Fe-Ni)



# Modular design enables easy scaling to GWh systems

## Cell



< 1 kW

1 x 1 m

Electrodes + Electrolyte

Smallest Electrochemical Functional Unit

## Battery Module



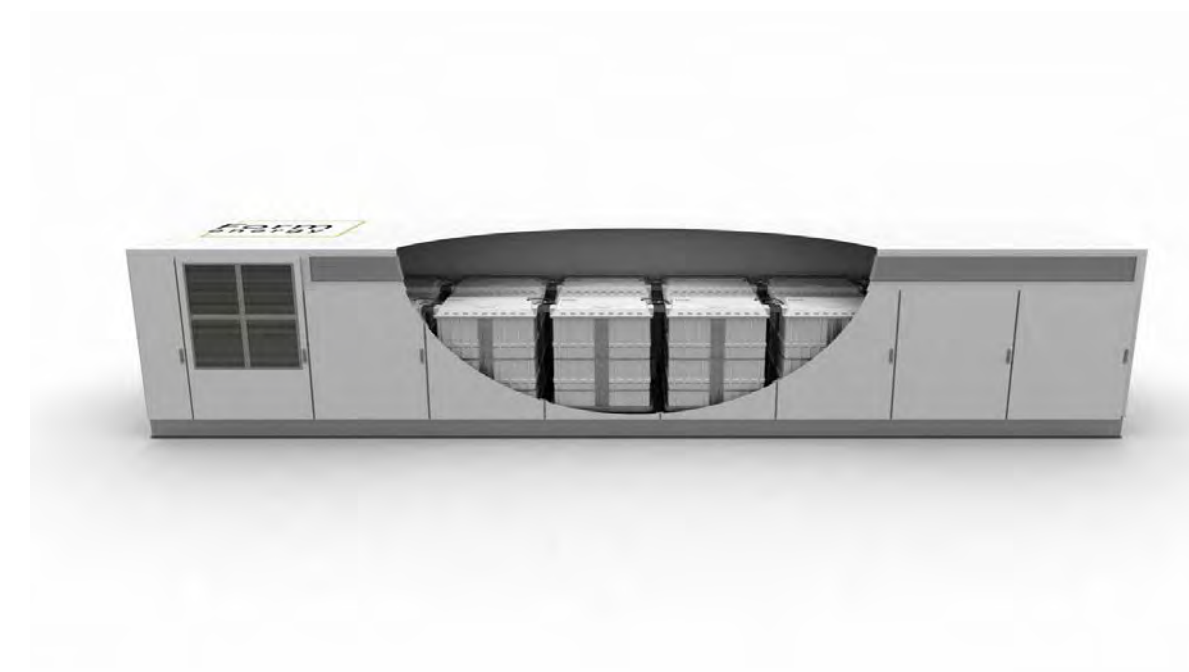
~ kW

1 x 1 x 1 m

~ 10s **Cells**

Smallest Building Block of DC Power

## Enclosure



~ 10s kW

10' x 40'

~ 10 **Modules**

Product Building Block with Integrated Module Auxiliary Systems

## Energy Storage System



100s MW / 10s GWh

50+ acres

1,000s of **Enclosures**

Commercial Scale System



# Form's multi-day storage delivers reliable capacity year-round

## System Overview

<b>Rated AC System Power</b>	10 - 500+ MW
<b>System Capacity</b>	1 - 50+ GWh
<b>Repeatable Power Block</b>	3.5 MW / 350 MWh
<b>Discharge Duration</b>	100 hr
<b>Average Round Trip Efficiency*</b>	40%
<b>Ramp (offline to full power)</b>	< 10 minutes
<b>Areal Energy Density</b>	> 200 MWh/acre
<b>Operating Temperature</b>	-40°C to 50°C
<b>System Lifetime</b>	20 years



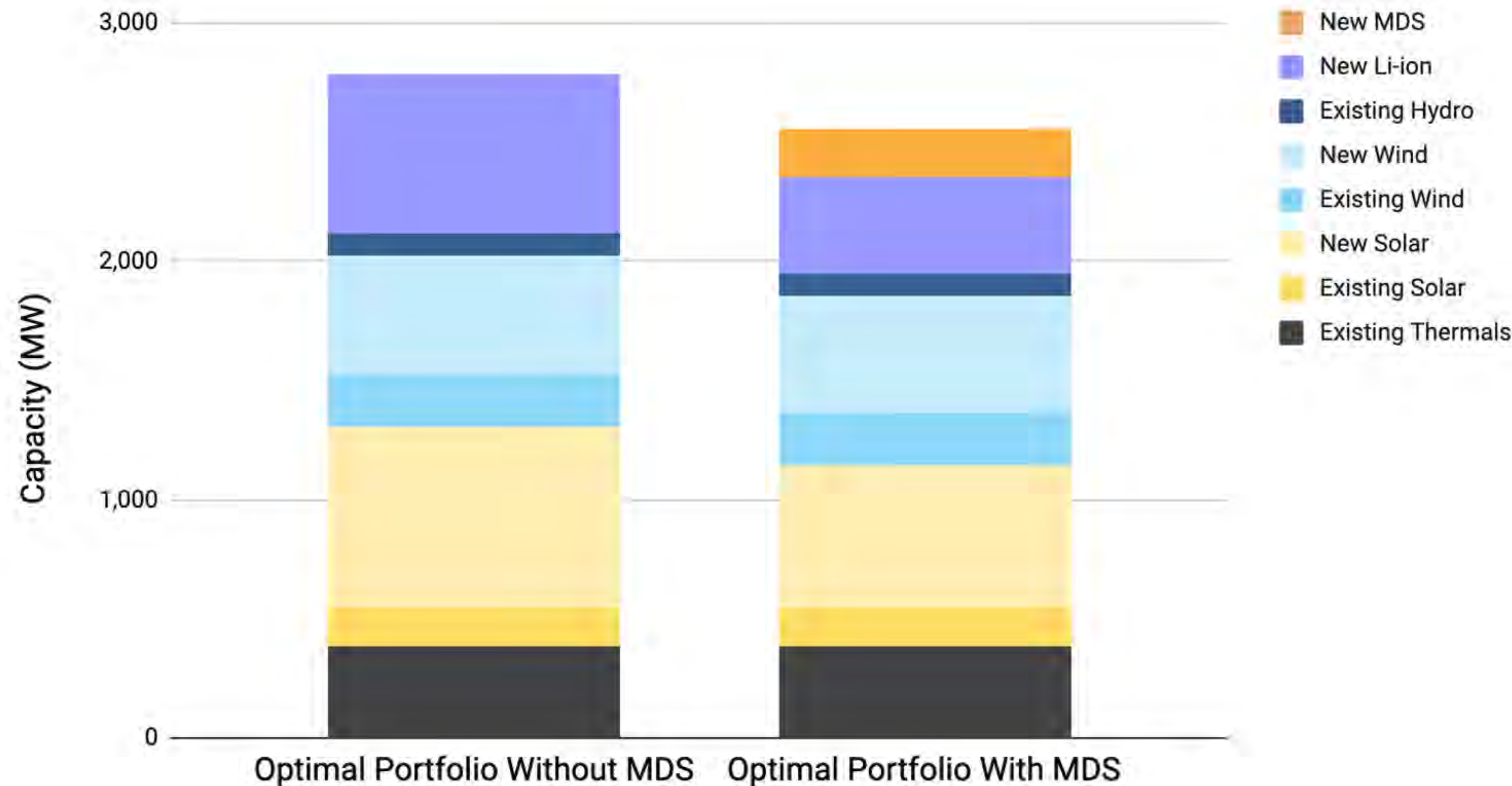
*\*System round-trip efficiency inclusive of losses from power conversion and auxiliary loads at full power*

# Commercial Benefits



# Portfolio Integration: MDS Reduces Overall Capacity Build for Zero Carbon

## Customer Example: Optimal Portfolio Options for Zero Carbon



### Key Takeaways

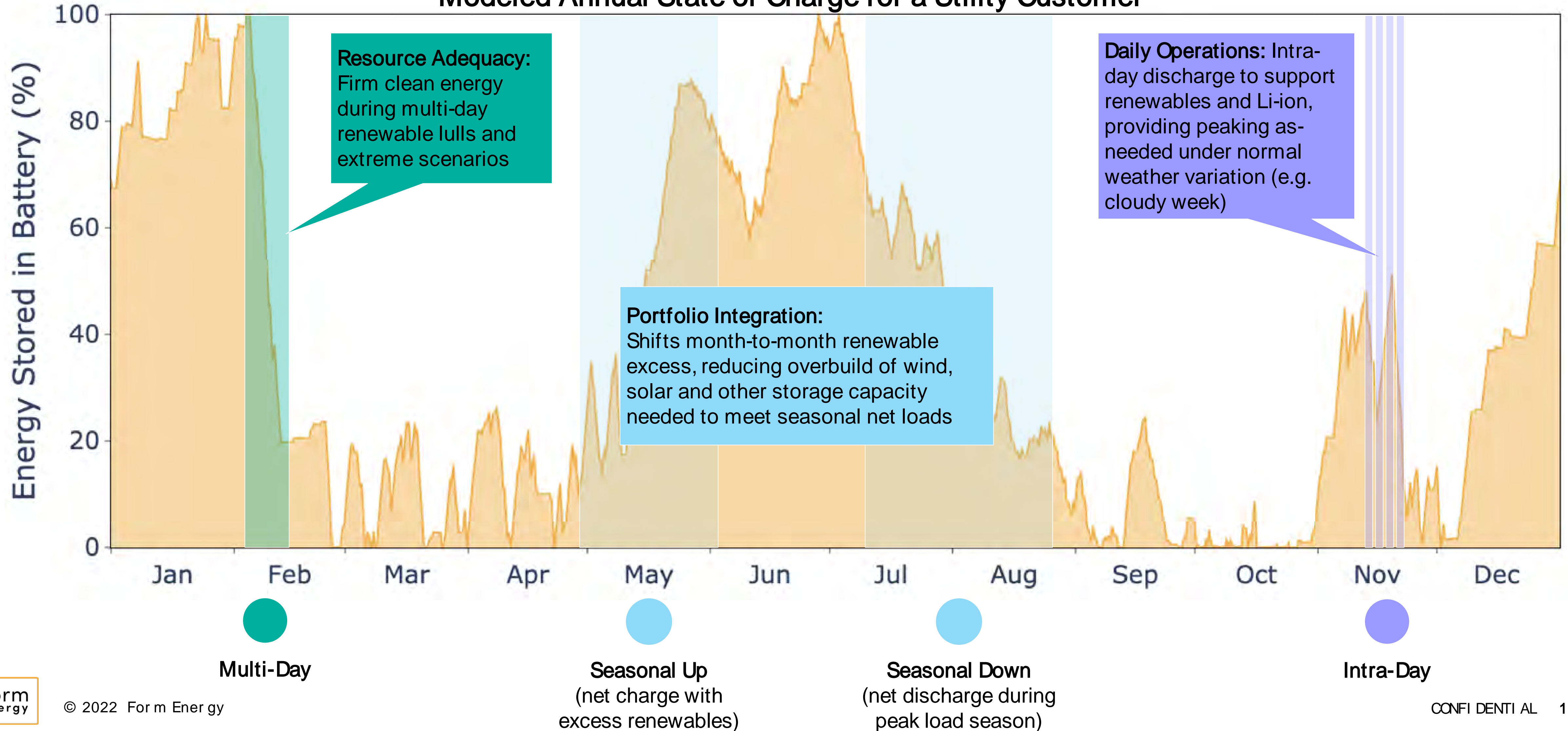
- MDS inclusion enables a reduced asset build while maintaining firm capacity requirements
- Lifetime costs are reduced as MDS displaces over 250 MW of Li-ion and ~170 MW of Solar/Wind



# Why 100 Hours - Value Drivers Today for 100 Hour Storage

Li-ion supports daily cycles. 100 hr. MDS provides additional value in Resource Adequacy and Portfolio Integration

Modeled Annual State of Charge for a Utility Customer



# Typical Customer Use Cases

Formware is technology-neutral and optimizes portfolios to minimize cost to potential partners

## 24/7 OR RENEWABLE FIRING

- “Firming” renewable profiles at both the asset- and system-level, including over multi-day generation lulls
- Shaping renewable output to meet any load profile, including flexible and fast ramping needs

## FOSSIL REPLACEMENT

- Paving the way to retire legacy fossil assets by providing a clean, firm, and dispatchable alternative to existing fossil units

## COST-OPTIMIZED PORTFOLIOS

- Determining the most cost-effective portfolio of clean, firm, and dispatchable alternative to replace or augment existing fossil units

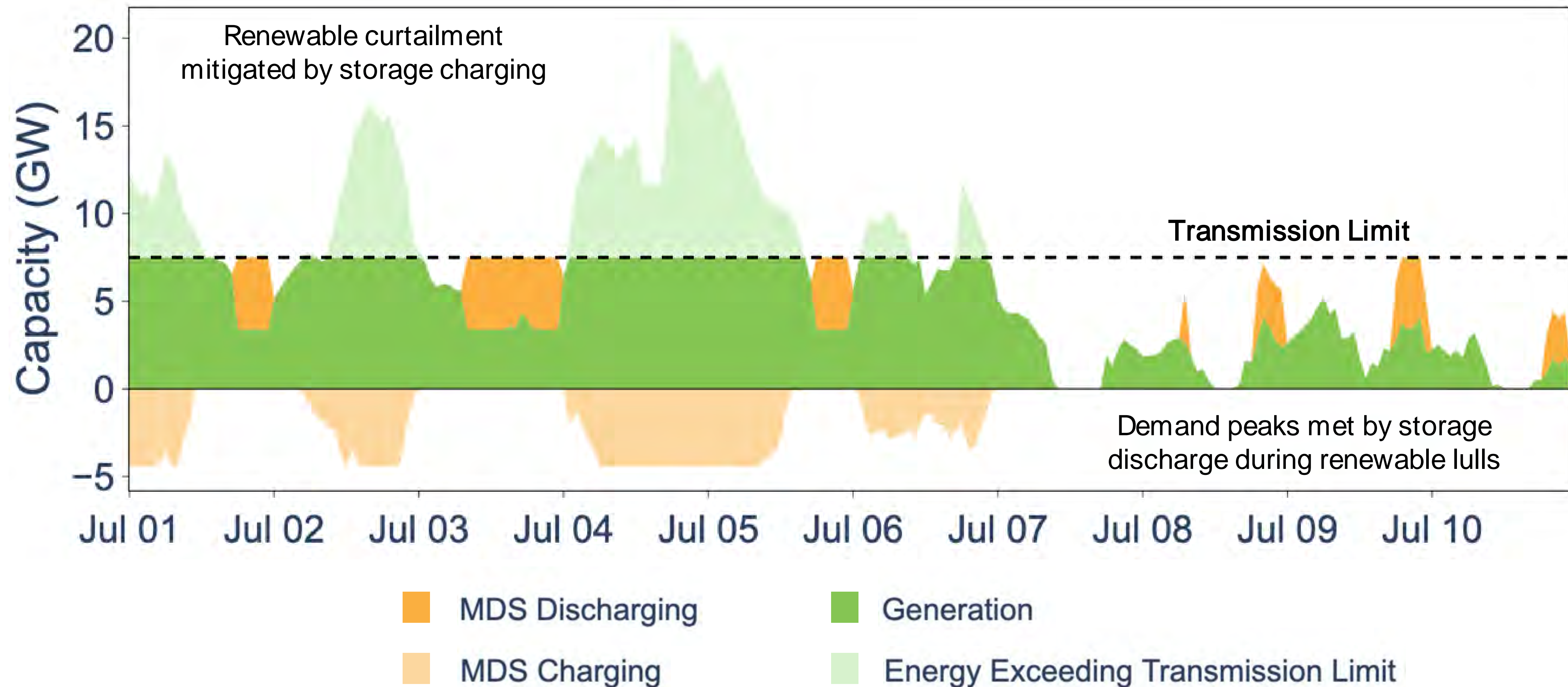
## TRANSMISSION OPTIMIZATION

- Reducing renewable energy curtailment and transmission grid congestion while increasing the total amount of low-cost renewable energy that flows across transmission boundaries, reducing needs for new transmission lines.

# Transmission Optimization: Managing Oversupply

Minimizing curtailment, reducing transmission needs, and lowering system cost

## Optimal Use of Transmission During 10-Day Renewable Peak + Lull

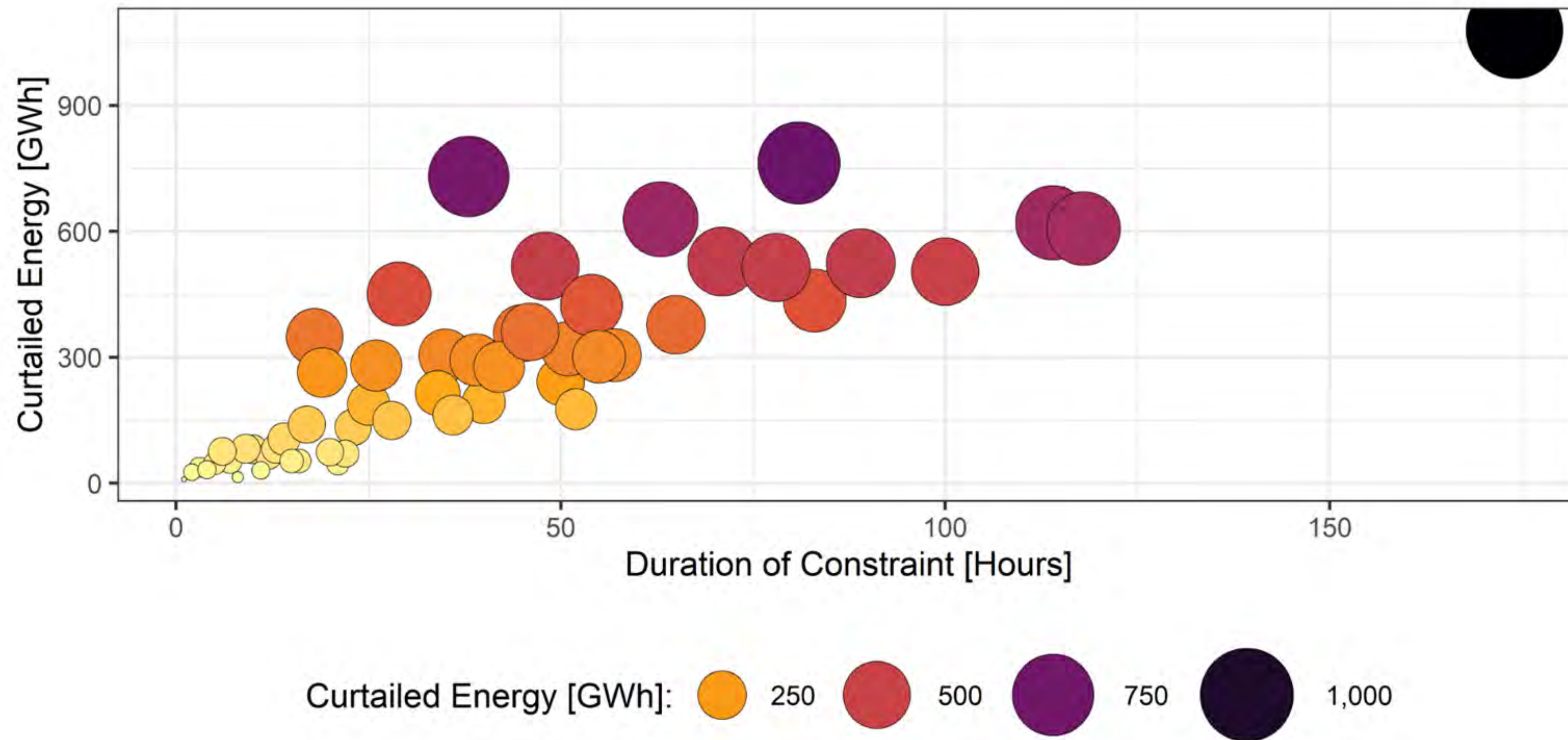




# Transmission Optimization: Managing Oversupply

## Minimizing curtailment, reducing transmission needs, and lowering system cost

Constraint Duration and Total Curtailed Energy, B7a Boundary and TD Scenario, 2025



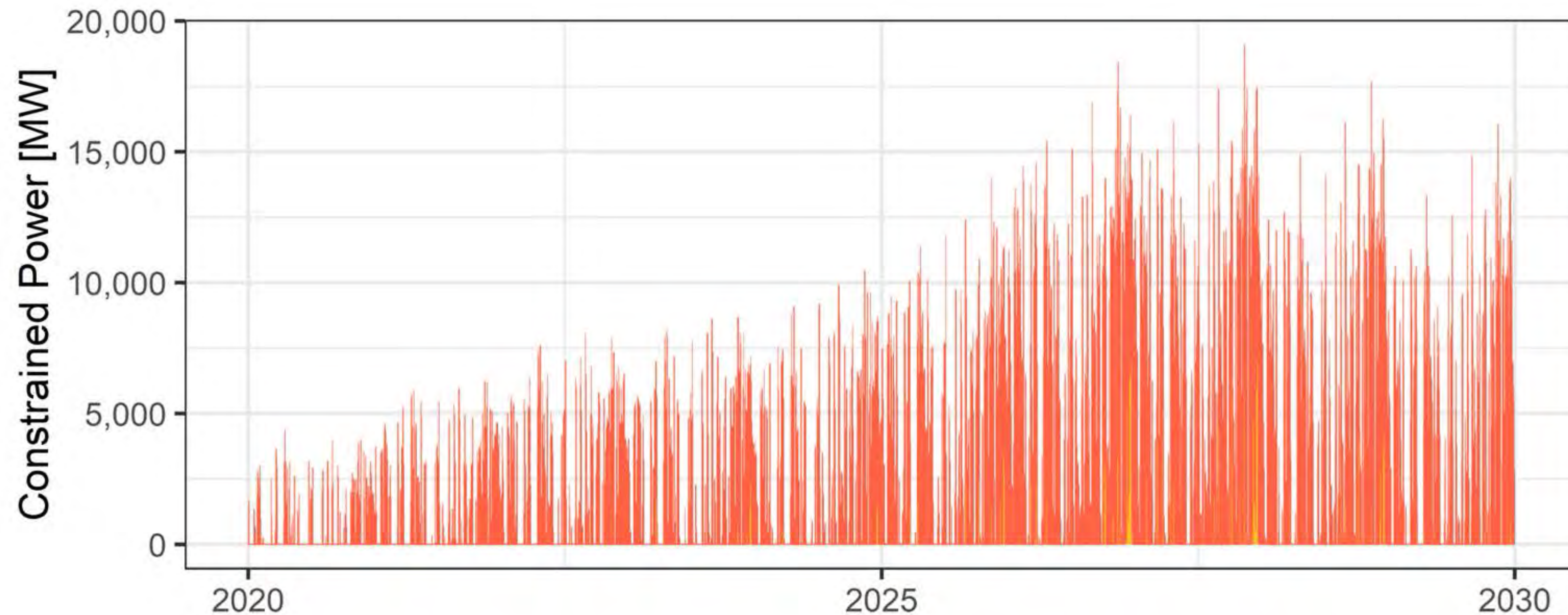
National Grid ESO's 2019 Future Energy Scenarios predicted constraint events regularly lasting more than 48 hours, with many lasting more than 100 hours. By 2025, more than 12% of curtailment events will last for more than 48 hours, accounting for more than 60% of total curtailed energy. Nearly 20% of total curtailed energy will occur during curtailment events lasting more than 100 hours. These multi-day constraints require multi-day solutions, which helps explain the previous results.



# Transmission Optimization: Managing Oversupply

## Minimizing curtailment, reducing transmission needs, and lowering system cost

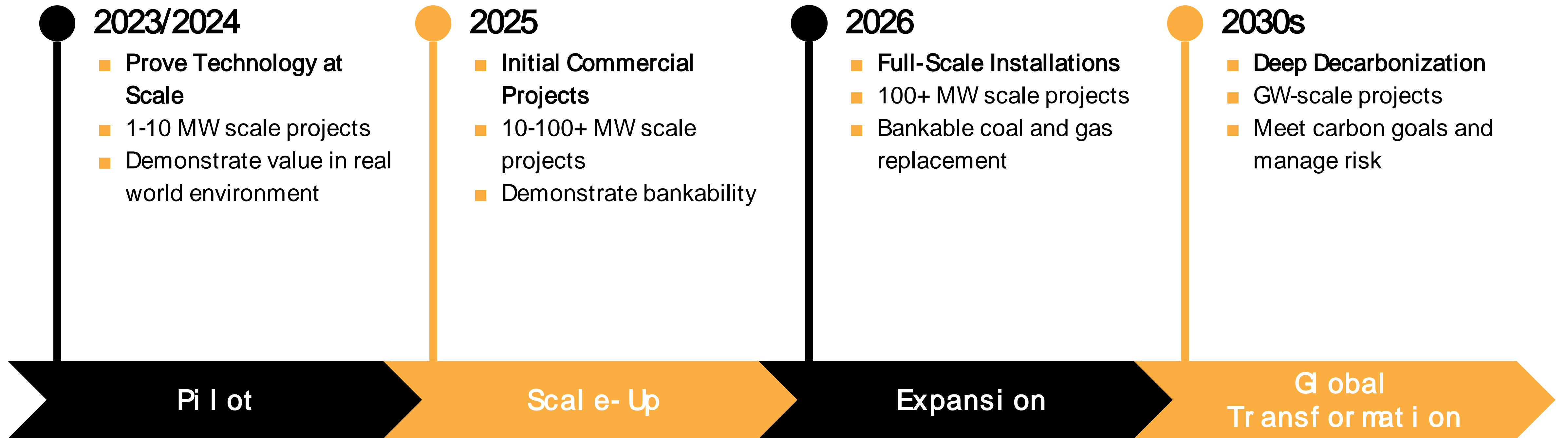
Constrained Power Over Time, B7a Boundary and TD Scenario. These multi-day constraints are the primary driver of the value of the multi-day energy storage systems modeled in this project.



This plot shows a time series of constrained power - that is, the excess energy that would be curtailed absent intervention. The graph underscores the frequency and magnitude of the potential constraints across B7a boundary, and highlights how National Grid ESO expects congestion to increase in frequency and magnitude unless action is taken.

# Where are we today?

# Form's clear path to transforming the global grid



30 years after commercial availability, global lithium-ion manufacturing capacity was 500 GWh/yr in 2020.

Form Energy will exceed that scale before 2030.

# Commercial progress to-date: announced collaborations

## 1.5 MW / 150 MWh project

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*Cambridge, Minnesota in 2023*



“Great River Energy is excited to partner with Form Energy on this important project. Commercially viable long-duration storage could increase reliability by ensuring that the power generated by renewable energy is available at all hours to serve our membership,” said **Great River Energy Vice President and Chief Power Supply Officer Jon Brekke.**

## Up to 15 MW / 1500 MWh project

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*Georgia Power service area*



“At Georgia Power, we know that we must make smart investments and embrace new technologies now to continue to prepare for our state’s future energy landscape,” said **Chris Wrack, Chairman, President and CEO of Georgia Power.** “We’re excited to have Form Energy as a partner to help us build on Georgia’s solid energy foundation.”



# Thank You



**Dii**

**Dii Desert Energy**

**APEX 2022 Dubrovnik**  
New Technologies and  
Emerging Energy Forms  
Cornelius Matthes  
*21<sup>st</sup> October 2022*



**Just to give an impression of the wealth of the Arab Deserts:**

About 5% of the vast MENA Deserts alone would in theory be more than sufficient to power the world's 150.000 TWH Energy Consumption!

## **Our Mission: No Emissions!**

**The deserts of Northern Africa and the Middle East (MENA)** are still almost fully 'fossil' based, but they a potential supplier of lowest cost green energy for their 500 mln inhabitants and the world

**Dii Desert Energy (Desertec3.0)** is an international industry initiative, founded in 2009 in Germany as an international industry **Market Enabler** for 'Green Electrons and Molecules' (e.g. Hydrogen, PtX), connecting people and countries for accelerating the energy transition in MENA and for MENA to become an exporter to the world energy markets.

# More than 80 industry partners from 29 countries



## OUR STRATEGIC PARTNERS



## OUR LEAD PARTNERS



All Partners of Dii Desert Energy are members of the MENA Hydrogen Alliance

## OUR ASSOCIATED PARTNERS





# Desertec 3.0: creating good momentum and positive vibes in the market



## MENA Hydrogen Alliance

A platform for members to meet and discuss pathways forward to kick start a **low-carbon hydrogen economy**



## Think Tank

**Studies and papers** well received by the market and available freely to increase knowledge for a greater impact

## Knowledge partner

Strong presence in leading industry event to help shape programs by providing **exclusive insights and market updates**



## RE Initiative Toolkit

**Levelized Cost of Energy (LCoE), Storage (LCoS), Hydrogen (LCoH) and Ammonia (LCoA)** financial models integrate the toolkit.



## A reinforced and unique platform

Since 2019, **more than doubled** its industrial partners (now 66 from over 25 countries, 4 continents)



## Social Media

Maximize social media platform to amplify our **activities and partners achievements**

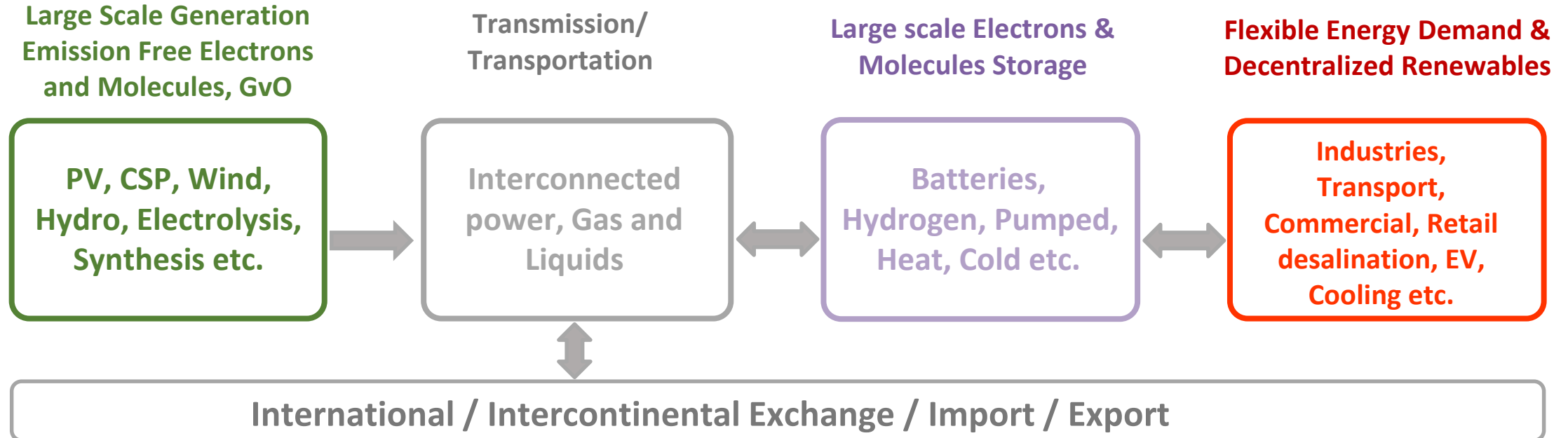


# Integration of Green 'Electrons' and 'Molecules' along the Emission-Free Energy Value Chain



## Objectives: Lowest cost, secure, emission free and local benefits

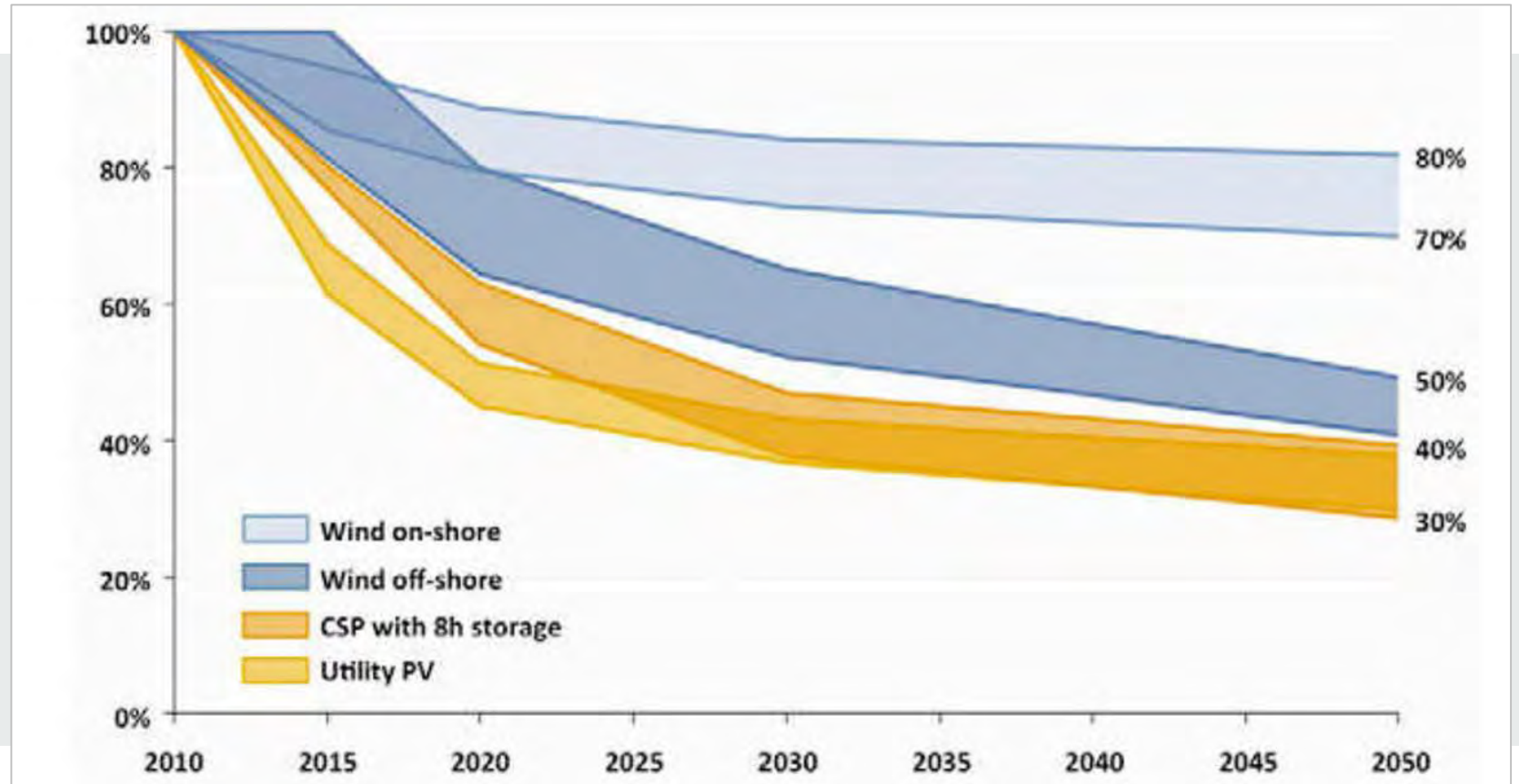
### *Chain Optimization: Virtual (Guarantees of Origin) and Physical Trading*



# Long term estimates for Desert Power 2050

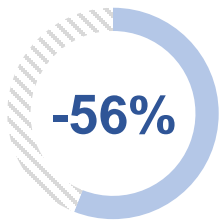
- **Emission-free technologies** in the MENA region have become competitive **much quicker** than even the greatest optimist would have ever expected
- In the Dii study published in 2012, the optimistic scenario predicted in 2050 was over-achieved!

System cost development per kW<sup>1</sup> in percent of 2010 cost estimate



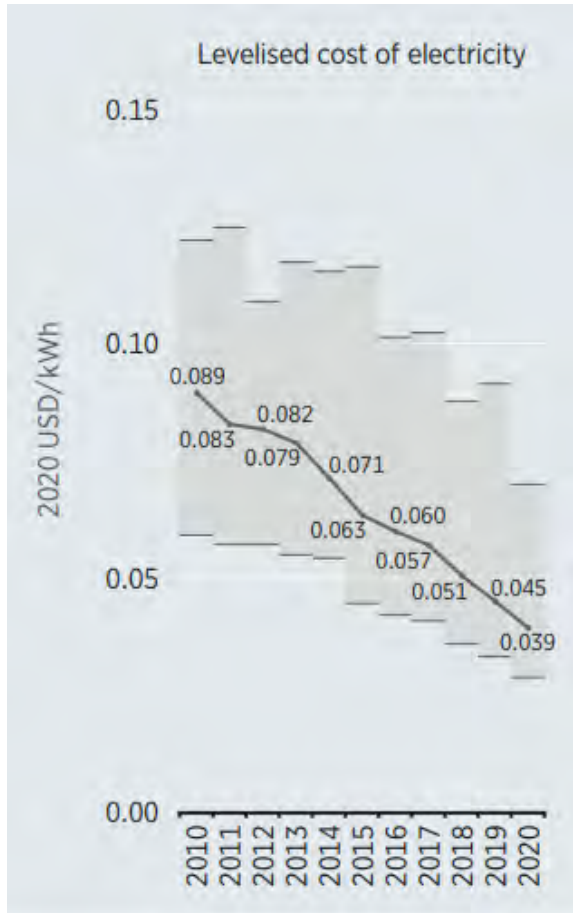
Source: Dii 1. Refers to nameplate capacity, i.e. kW<sub>p</sub> (kW peak) for Utility PV and Wind and kW<sub>E</sub> (kW Electric) for CSP

# Onshore Wind and PV decline in LCOE

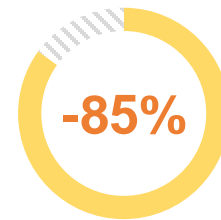


## Onshore Wind

Between 2010 and 2020, the global weighted-average LCOE for onshore wind fell 56%, from USD 0.089/kWh to USD 0.039/kWh.

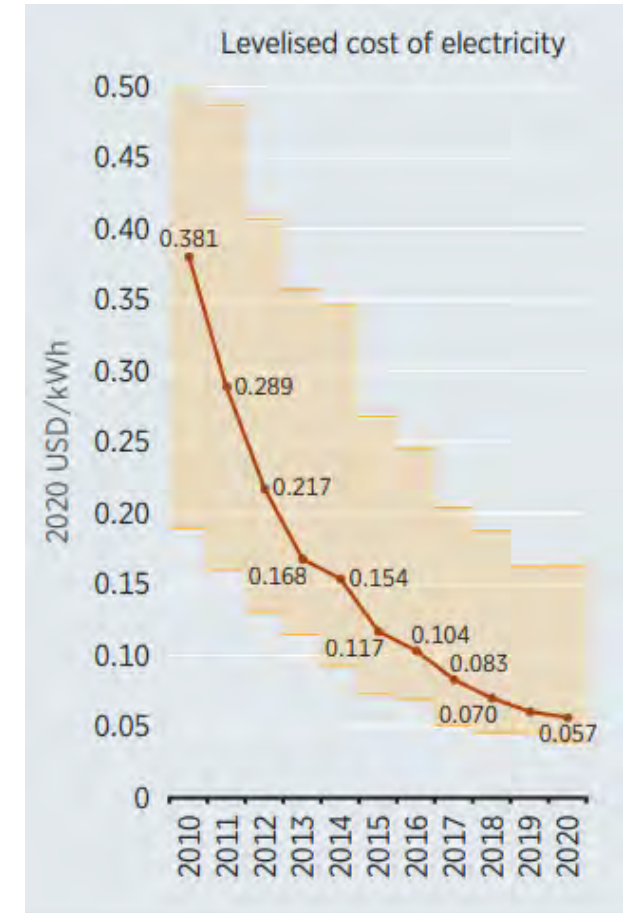


Global weighted-average LCOE for onshore wind, 2010-2020  
Source: IRENA Renewable Cost Database



## PV

Between 2010 and 2020, the global weighted-average LCOE for PV fell 85%, from USD 0.381/kWh to USD 0.057/kWh.



Global weighted-average LCOE for PV, 2010-2020  
Source: IRENA Renewable Cost Database



# Prominent government and private sector initiatives want to bring down cost of green H2 at par with grey in this decade!



## UN launches Green Hydrogen Catapult to halve production costs

By Matthew Farmer | 08 Dec 2020

Some of the world's largest energy companies have signed up to the UN Green Hydrogen Catapult to bring down the cost of hydrogen production.

The project aims to drive down the cost of hydrogen to \$2/kg by 2026, approximately half its current price. The partner companies aim to do this with 25GW of green hydrogen production by 2026, approximately 50 times more than is currently produced.

## Australia's pathway to \$2 per kg hydrogen

Prosperity, emissions reductions and opportunities for Australia to lead on a global stage — all underpinned by the most common element in the universe.

## India has potential to meet global green hydrogen demand: Jitendra Singh

Explaining India's 'aspirational' goal of 'Hydrogen 2-1-2', the minister said, "2 means green hydrogen that nation costs for less than \$2 per kg; 1 means hydrogen storage plus distribution plus refuelling that cost less than \$1 per kg and the last 2 is for replacement of incumbent end-use technology with green hydrogen technology of less than 2 millions."

## The Hydrogen Stream: US government wants to reduce green hydrogen cost by 80% to \$1 per kilogram in one decade

The US Department of Energy (DOE) launched the Energy Earthshots Initiative to accelerate energy breakthroughs within the decade. The first Energy Earthshot — Hydrogen Shot — seeks to reduce the cost of clean hydrogen by 80% to \$1 per kilogram in one decade, the DOE said in a statement released on Monday. At the

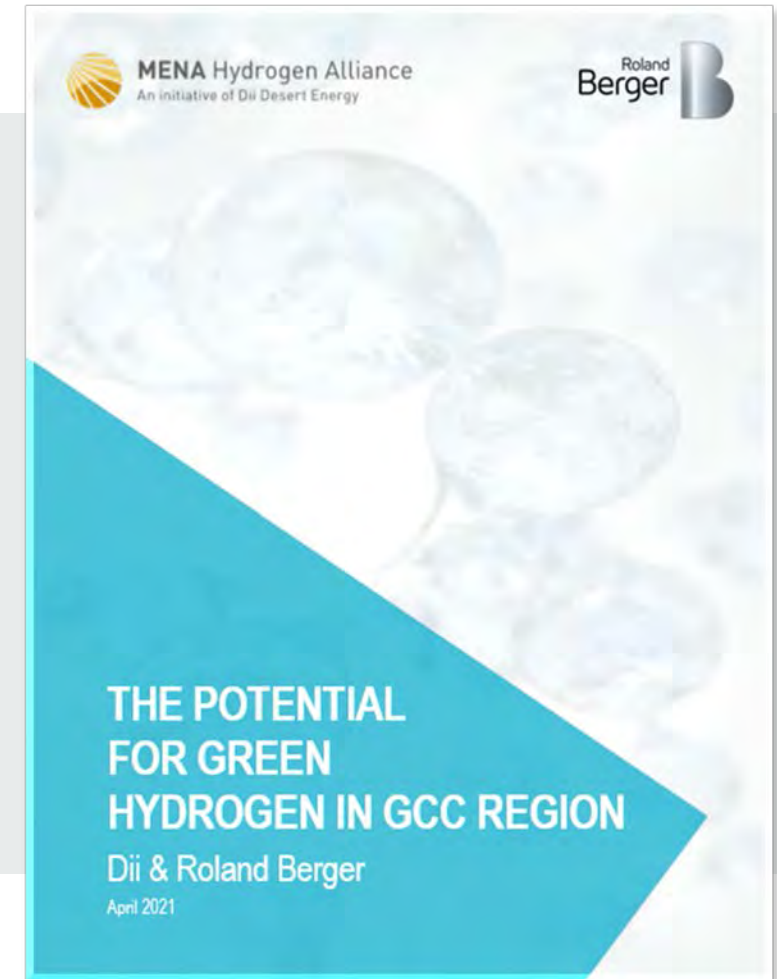
A total of 30 major companies from across Europe are laying the foundations to create HyDeal Ambition, a value chain promising to provide 100% green hydrogen for €1.5/kg by 2030, matching the current price of fossil-fuel produced 'grey' hydrogen.

# Green Hydrogen Study on Jobs!

## Dii Desert Energy, Roland Berger, Masdar!



- Joint study with Roland Berger on **‘The Potential of Green Hydrogen in GCC Region’**
- Focus on **localization** of hydrogen value chain **and job creation**
- Launched in April at the **World MENA Hydrogen** (virtual) Congress
- Joint Press Release with **Masdar** for a greater impact



# Key findings of Dii-Roland Berger Report

## Deployment and production

Long term renewable energy deployment of up to 1,000 GW, with up to 500 GW electrolyzer capacity, leading to the production of approximately 100m MT of green hydrogen.

## Revenues

Annual revenues from green hydrogen in GCC could grow up to USD 200 bn by 2050.

## Job Creation

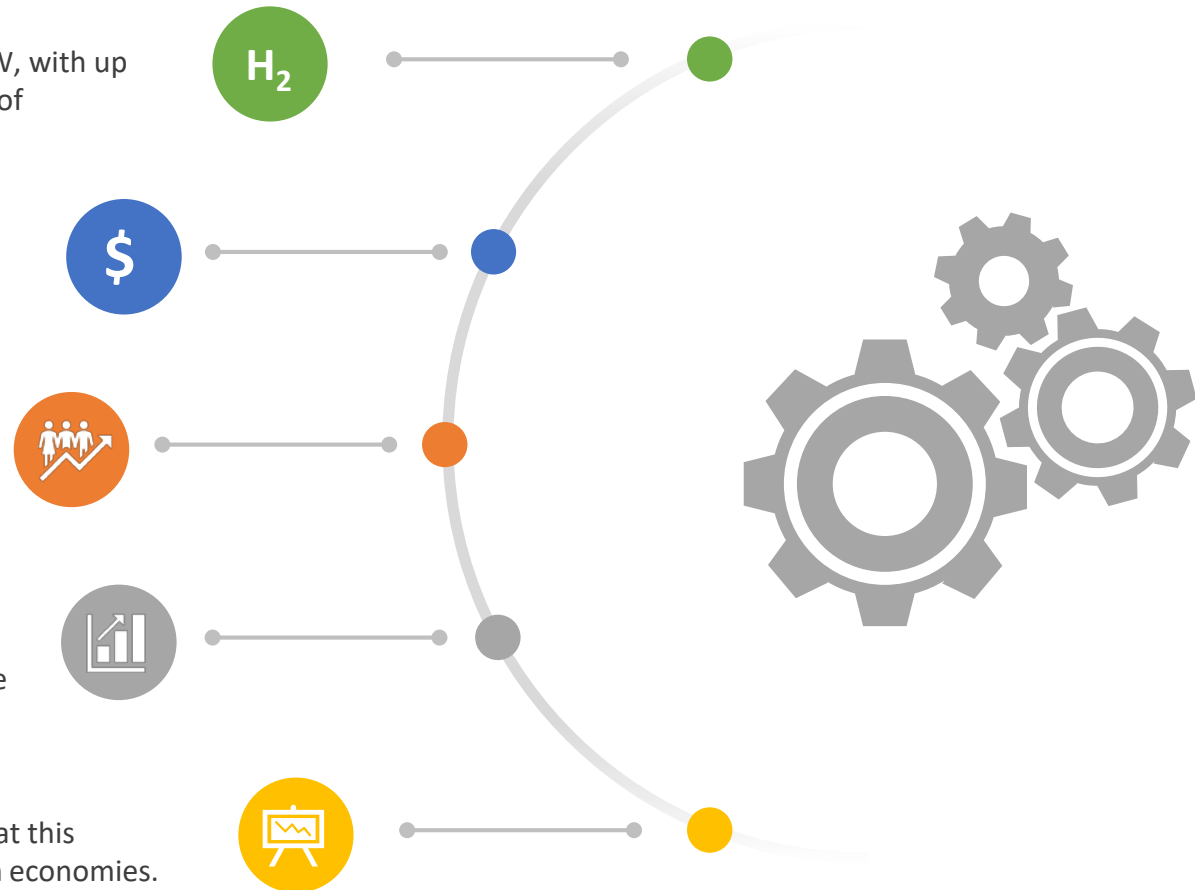
High job creation potential across different parts of the value chain: Up to 1 million jobs by 2050.

## Big movement

Different projects under development mark the start of a big movement with countries like Saudi Arabia e.g. planning to become the world's largest exporter of green hydrogen.

## Hydrogen economies

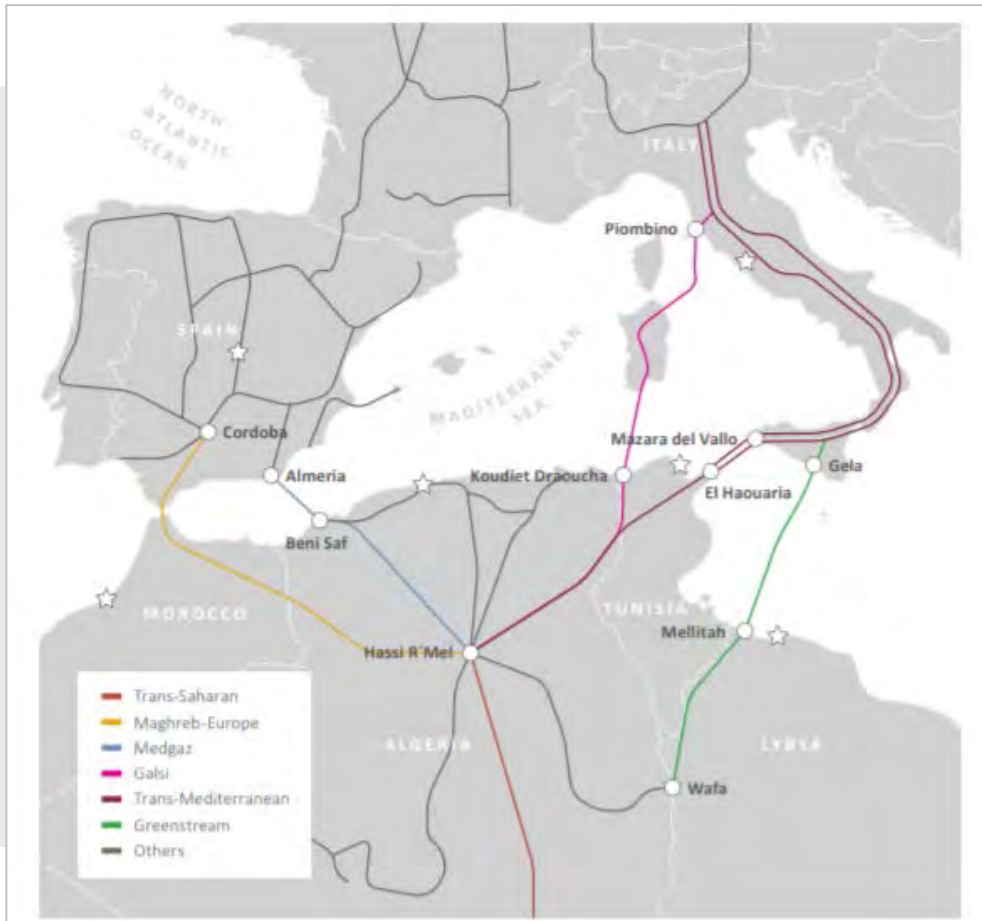
International experiences from hydrogen valleys show that this concept could be a key enabler in creating local hydrogen economies.





# The MENA Gas infrastructure is ideally positioned for a fast exchange and export of green hydrogen!

Natural gas infrastructure Europe - North Africa



First outline for a hydrogen backbone infrastructure Europe-North Africa



- An existing gas infrastructure from Algeria and Morocco could be **converted** to a hydrogen infrastructure (grey-orange lines). A “new” hydrogen transport pipeline must be realized **from Italy to Greece**, crossing the Mediterranean Sea to Egypt, which could eventually be **extended to the Middle East** (orange line).

Source: *The North Africa-Europe Hydrogen Manifesto*, Prof. Dr. Wijk A. v., Frank Wouters F., Ikken, B., Samir, R.



# NEOM (Saudi Arabia), an emerging world leader in green ammonia export as part of an emerging hub!

- New 'city', the size of Belgium (26,000 km<sup>2</sup>)
- One of three strategic projects of **Saudi Agenda 2030**
- **Saudi's Public Investment Fund** and others have committed \$500 billion
- NEOM will be powered by **100% low-cost renewable energy** (40 – 60 GW)
- Given the availability of competitive and low-cost renewable energy, NEOM will produce **green hydrogen at scale** for local and world markets
- **NEOM, ACWA Power** and **Air Products** signed in July 2020 an Agreement for 6.5 Billion\$ Solar-based Green Hydrogen for producing **1.2 mln tons of Green Ammonia per year**



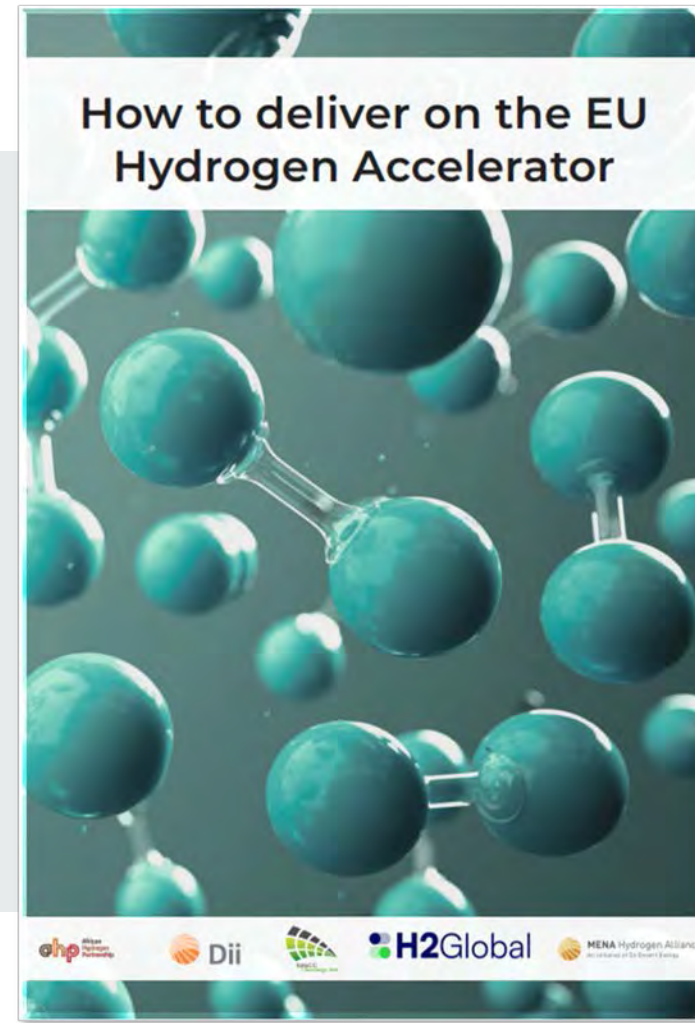
# Hydrogen Accelerator requires 300-400 GW installed electrolyser capacity in 2030



2*10 million ton green hydrogen	Renewable Resource			Electrolyser		Hydrogen Production	
	Capacity	Full load hours	Electricity Production	Capacity	Full-load hours		
	GW	hr/yr	TWh	GW	hr/yr	Million ton	TWhHHV
2030							
<b>EU production</b>							
Offshore	30	5.000	150	30	5.000	3	118
Onshore wind	35	3.000	105	30	3.400	2	79
Solar PV	150	1.500	225	125	1.750	4	158
Grid connected electrolyzers	Renewable/Nuclear electricity from grid			7	7.000	1	39
<b>Import</b>							
Onshore wind	30	3.500	105	25	4.100	2	79
Solar PV	150	2.100	315	115	2.650	6	237
Offshore wind	10	5.000	50	10	5.000	1	39
Hydropower/Nuclear	8	6.000	51	8	6.000	1	39
<b>Total</b>				<b>350</b>		<b>20</b>	<b>788</b>

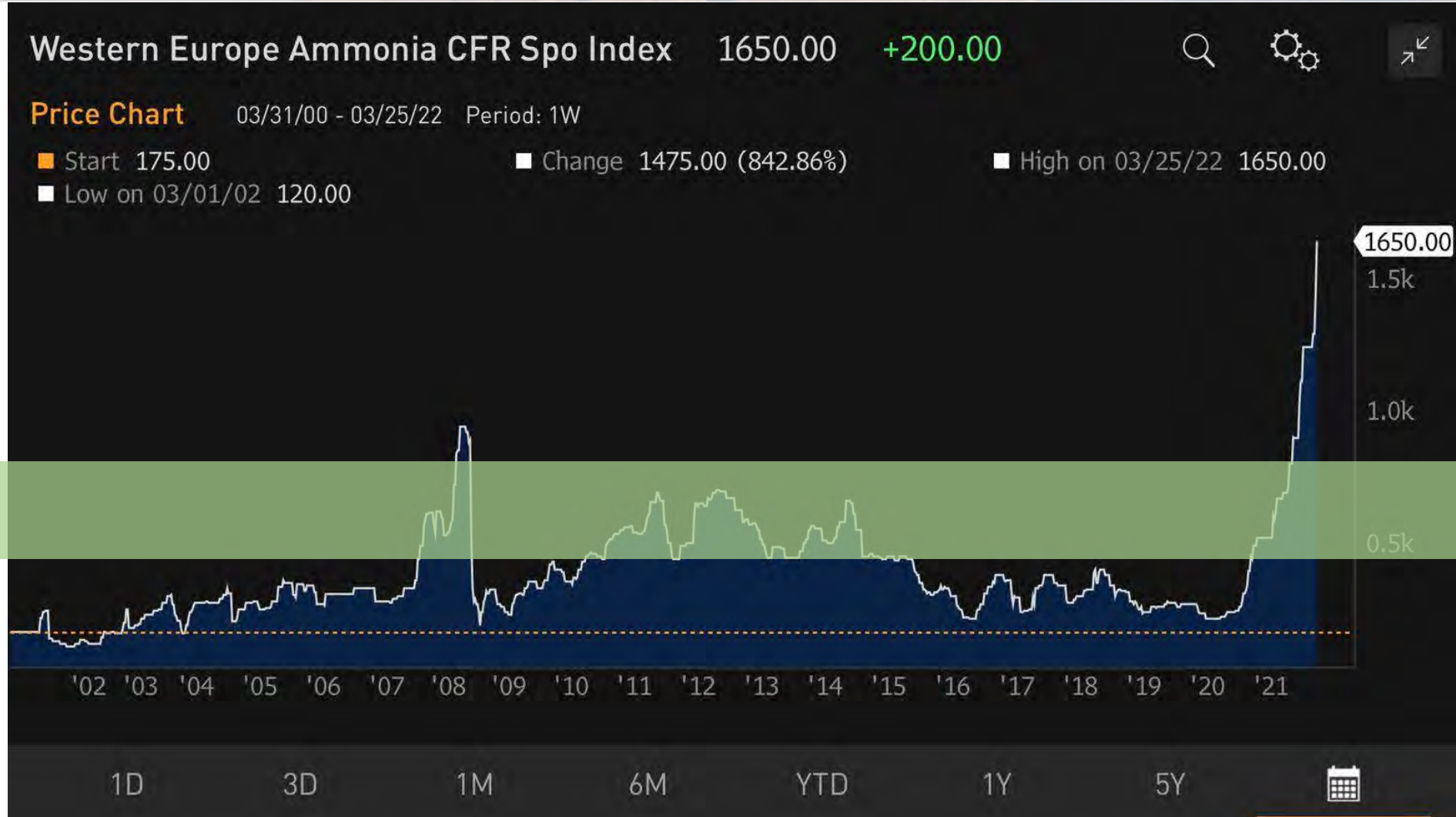
<https://hydrogeneurope.eu/reports/>

# Dii's MENA Hydrogen Alliance: connecting MENA with Europe





# Green ammonia currently far cheaper than grey!



Green ammonia in MENA from USD 450/ton in Neom to 500-700 in Morocco and 600-800 in Egypt!



# Hydrogen Tracker in cooperation with Roland Berger



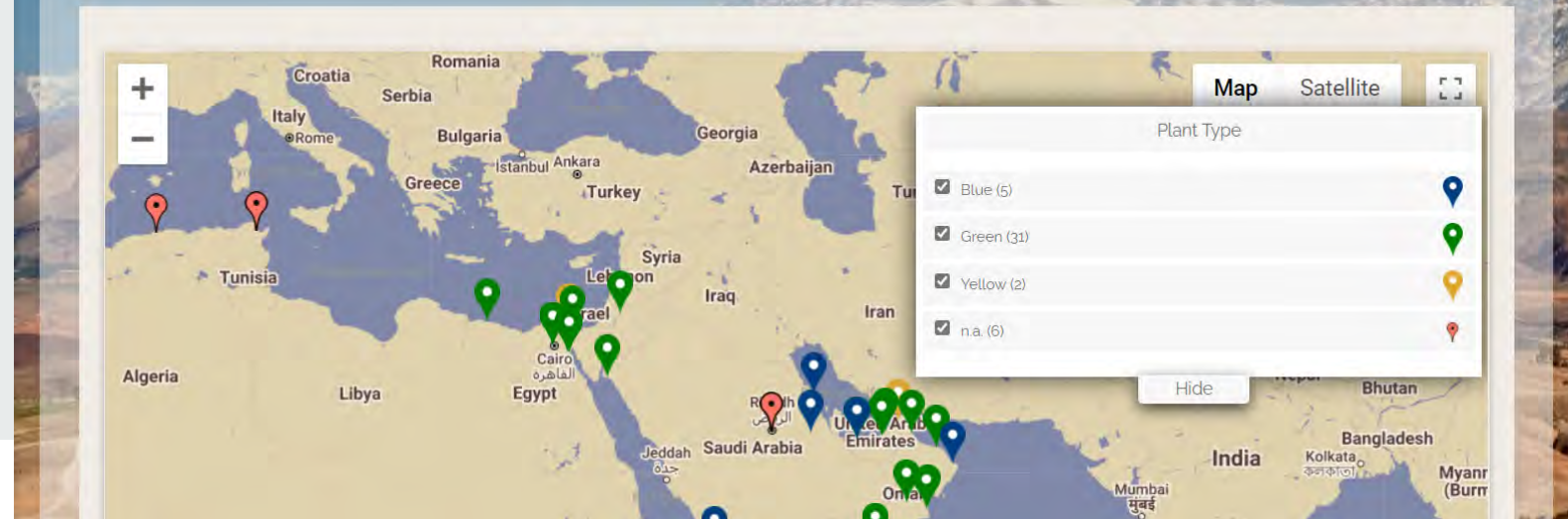
- Produced in cooperation with **Roland Berger**
- A collection of hydrogen projects recently announced in the MENA region with the majority focusing on **green hydrogen**
- Includes – among others - project **partners**, estimated **investment**, renewable energy **capacity** and **technology**, off-take, and import-export component

Roland Berger and Dii Desert Energy are pleased to join forces once again to make another step towards the acceleration of the energy transition by sharing knowledge and enhancing capacity building.



The MENA hydrogen project tracker is a collection of hydrogen projects that have recently been announced in the MENA region with the majority focusing on green hydrogen. Leveraging Dii's network and expertise of the joint team, the projects have been assessed and listed by location, project partners, estimated investment, hydrogen colour, renewable energy capacity and technology, hydrogen technology type and provider, conversion, off-take, and import-export component among other factors.

Particular importance was given to the off-take and import-export element, as the majority of projects in the region target international off-takers with Europe being one of the largest markets.



# Various hydrogen projects have recently been announced in the MENA region – with the majority focusing on green hydrogen



Non-exhaustive

## Hydrogen project announcements in MENA

v7: 02-Sept-2022

Total of **60** projects across the **MENA** region – with **~85%** projects geared towards production of **green hydrogen**



1) Includes some yellow H<sub>2</sub> projects

Green H<sub>2</sub> projects 
 Blue H<sub>2</sub> projects 
 Projects with undisclosed color

Source: Desk research, Roland Berger



# Various hydrogen projects have recently been announced in the MENA region – with the majority focusing on green hydrogen



Non-exhaustive

v7: 02-Sept-2022

## Recent H<sub>2</sub>-related project announcements across the MENA region

Country and project name	H <sub>2</sub> color	Country	Project name	H <sub>2</sub> color	Country/project name	H <sub>2</sub> color
Cooperation ENI / Sonatrach	●		Green H2 industrial complex	●	AMAN	●
TAQA & MAN Hydrogen Project	●		n.a.	●	Project Nour	●
Egypt Ministry of Electricity and Renewable Energy	●		n.a.	●	n.a.	●
Scatec Green Ammonia Egypt	●		n.a.	●	Helios - NEOM Green Hydrogen Plant	●
n.a.	●		n.a.	●	SABIC & IEEJ Blue Ammonia	●
Scatec Green Hydrogen 100 MW	●		Green H <sub>2</sub> & NH <sub>3</sub> Feasibility Study	●	Jazan IGCC Complex	n.a.
Siemens & EEHC H <sub>2</sub> Project	●		Green Energy Oman	●	Jafurah Onshore Gas Field	●
Hyport Gargoub	●		Salalah <sub>2</sub>	●	n.a.	n.a.
ENI Hydrogen Project Egypt	●		HYPORT Duqm Green Hydrogen Plant Phase 1	●	n.a.	●
Waste-to-H <sub>2</sub> Hub Egypt	●		H2Oman	●	TuNur Green Hydrogen	●
Green Hydrogen 4 GWe by 2030	●		Oman Green H <sub>2</sub> Project, phase 1	●	H2Vert.TUN	●
Green Ammonia 390 ktpa	●		Green Hydrogen Hub	●	Helios	●
Green Ammonia 350 ktpa	●		Hydrogen from Flare Gas	●	Masdar City Green H <sub>2</sub> & E-Fuels (Green Falcon)	●
Green Ammonia 300 ktpa	●		Waste-to-H <sub>2</sub> Plant	●	TAQA-Emirates Steel Green H <sub>2</sub>	●
Green hydrogen 480 ktpa (feasibility study)	●		Green Hydrogen to Mobility	●	TA'ZIZ Blue Ammonia Plant	●
n.a.	●		Green Hydrogen Plant	●	Green Hydrogen Hub	●
Green Ammonia Facility	●		HEVO Ammonia Morocco	●	Sharjah Bee'ah waste-to-hydrogen	●
Green H2 Complex	●		OCP Green Ammonia Pilot Plant	●	TAQA/AD Ports Green Ammonia	●
9.2 GW green hydrogen project	●		AMUN	●	Green Hydrogen Project	●
n.a.	●		Ammonia-7 blue Nh3 project	●	Kubbutz Yotvata	●

Source: Desk research, Roland Berger

# Application of Hydrogen – Green Steel

8 Sep 2022 16:15

thyssenkrupp is accelerating the green transformation: Decision taken on the construction of Germany's largest direct reduction plant for low-CO<sub>2</sub> steel

## Thyssenkrupp to Invest \$2 Billion to Build Plant for Green Steel in Germany



thyssenkrupp is accelerating the green transformation: Executive Board of thyssenkrupp AG releases capital resources for construction of Germany's largest direct reduction plant for low-CO<sub>2</sub> steel at the Duisburg site. Investments of more than two billion euros - subject to public funding - planned.

## The biggest change in steel production in over 1,000 years

HYBRIT stands for HYdrogen BReakthrough Ironmaking Technology. It's an initiative where we aim to create fossil free steel using fossil free electricity and hydrogen with the goal of fully eliminating CO<sub>2</sub> emissions throughout the value chain from mining to steel production.



We launched the initiative in 2016 together with our partners LKAB and SSAB. Thanks to HYBRIT we are now one step closer to fossil free living within one generation.

## Green Steel Provider Secures \$191M Funding

H2 Green Steel raised €190 (US\$191) million in funding from investors in its latest series B round to scale up its hydrogen, iron and steel facilities.



# Application of Hydrogen – Refineries

## REFHYNE <sup>2</sup>

CLEAN REFINERY HYDROGEN FOR EUROPE

German refineries kick off complex green hydrogen switch



16 June 2021 | IHS Markit Energy Expert

## Sinopec embarks on green hydrogen plan as refiners look to diversify

### HIGHLIGHTS

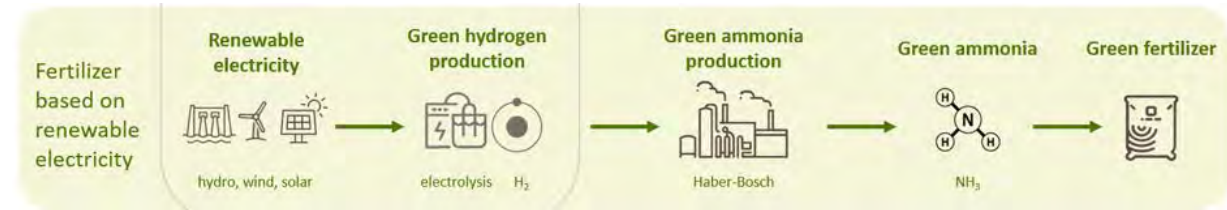
- Sinopec owns around 30% of China refining capacity
- Starts construction of 20,000 mt/year solar-based green hydrogen project
- High transportation and storage costs to act as hurdles

## BP and Ørsted launch green hydrogen project at German oil refinery

# Application of Hydrogen – Fertilizers

15 JUNE 2022

**His Majesty the King inaugurates Fertiberia's green ammonia and green fertiliser plant in Puertollano, the first in the sector worldwide**



Yara and Lantmännen sign first commercial agreement for fossil free fertilizers

JANUARY 13, 2022



# Application of Hydrogen – Mobility

## ZERO EMISSION HYDROGEN VEHICLES



HYZON CLASS 8



HYZON Hymax



HYZON HIGH-FLOOR COACH

## Migros Zurich + Hydrogen: The Future Rushes Quietly

By FuelCellsWorks | December 14, 2020 | 4 min read (22 words)

No Comments



## Germany inaugurates world's first hydrogen-powered train fleet

*A fleet of 14 trains powered entirely by hydrogen is launched in Germany's Lower Saxony state.*



A fleet of 14 trains were provided by French industrial giant Alstom [Alstom handout/EPA]

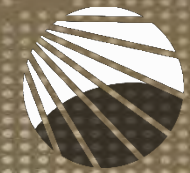
# Agenda at Glance

- **Invited keynote addresses: The Accelerated Energy Transition in MENA**
  - ✓ H.E. Dr. Mahmoud Mohieldin, UN Climate Change High-Level Champion for Egypt, COP27
  - ✓ Paddy Padmanathan, Vice-Chairman and CEO, ACWA Power
  - ✓ Layla El Hares, Managing Director, Siemens Energy, Egypt
  - ✓ Cord Landsmann, CEO of thyssenkrupp Uhde
  - ✓ Li Peng, Chief Engineer of CEPRI, State Grid Corporation of China (SGCC)
- **Ministerial Panel: MENA leading an accelerated energy transition**
- **High-level Panel - Country Focus: Egypt as a Green Energy Hub**
- **CEO Panel discussion: The Momentum of the Energy Transition**
- **Panel Discussion: Spotlight Concrete Projects**
- **Case Studies session: Green Electrons and Molecules Shaking Hands**
- **Interactives 'Dii Style' Roundtables:** the interactive roundtables along the emission-free energy value chain
  - ✓ *Certification, Transportation and Storage of Green Molecules*
  - ✓ *Carbon Trading*
  - ✓ *Human Capital and Technology Development to Accelerate the Energy Transition*
  - ✓ *The Future of Clean Mobility*
  - ✓ *The convergence between electricity and gas markets*
  - ✓ *Fast-track levelized costs of green hydrogen through focused CAPEX/OPEX cost minimization*
  - ✓ *Concrete opportunities for off-take of green hydrogen*
  - ✓ *Wind and storage solutions*



The 12th Dii Desert  
Energy Leadership Summit  
is happening on 3 November 2022  
at The St. Regis Cairo





Dii

Thank You For  
Your Attention!



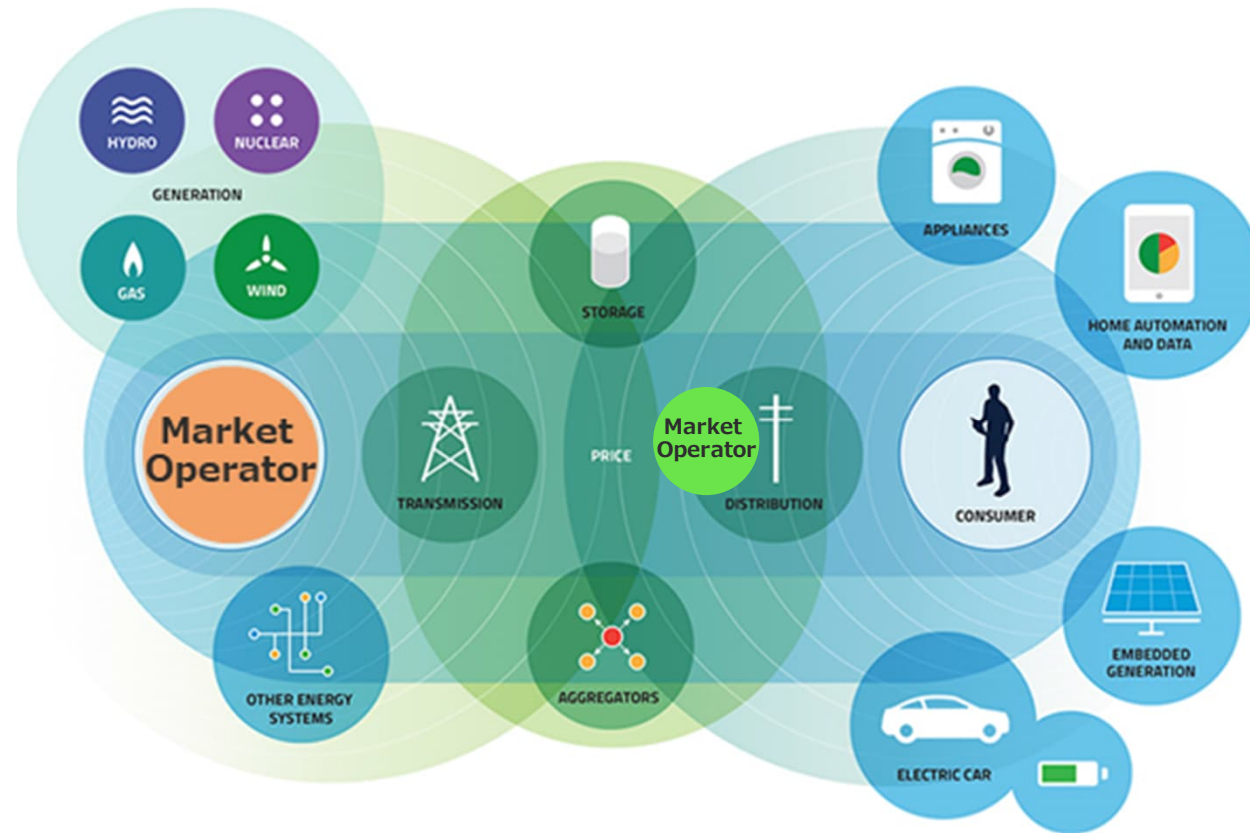




## APEX 2022 Dubrovnik Panel 3: New Technologies and Emerging Energy Forms

**Enabling new technologies to participate in electricity markets**

Mohit Saigal, Hitachi Energy

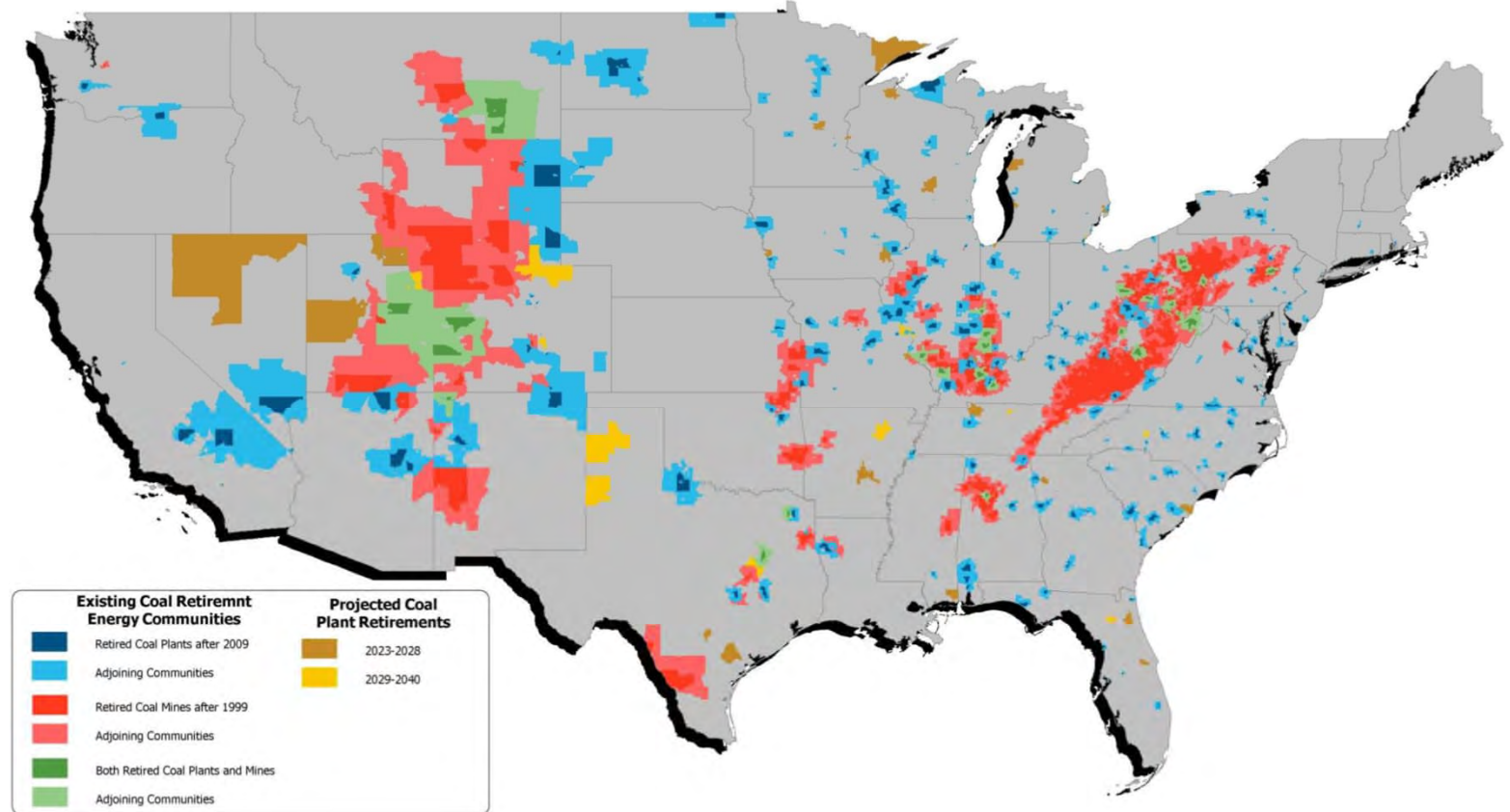


Source: IESO

## Inflation Reduction Act (IRA)

- Signed into law by U.S. President Biden on August 16, 2022
- The single largest investment in climate and energy in US history
- Delivers policy certainty
- Offers tax credits for low carbon and zero emission resources as well as tax credits for carbon capture
- Availability of bonus credits (e.g. brownfield sites, fossil fuel communities, low-income communities, domestic content)
- Extends tax credits for clean vehicles (electric vehicles, plug-in hybrids, hydrogen fuel cell vehicle) and offers rebates for electrification of buildings and energy efficiency related upgrades

## Hitachi Energy Velocity Suite Map





- By 2030: 50 % of new renewable installations in 16 countries of Continental Europe will be connected to the distribution network
- By 2030: Electricity demand across Europe increasing by almost 20% due to EVs and heat pumps, despite energy efficiency.
- Drivers: Self-generation, EVs, heat pumps, storage, electrification of the heat and transport sectors and sector coupling (example: power-to-gas, power-to-heat, power-to-hydrogen)
- Full transposition of Article 32 of the Clean Energy Package (Directive 2019/944) needed for deployment of flexibility markets.
- DSOs will need to actively manage more complex power flows and constraints
- Flexibility resources could deliver better value to resolve a network constraint than investing in traditional network reinforcement
- Need for greater coordination amongst DSOs and between DSOs and TSOs
- resources needed to manage the grid at all voltage levels are shared efficiently across the grid under a “one system approach”.



Source: ENTSO-E

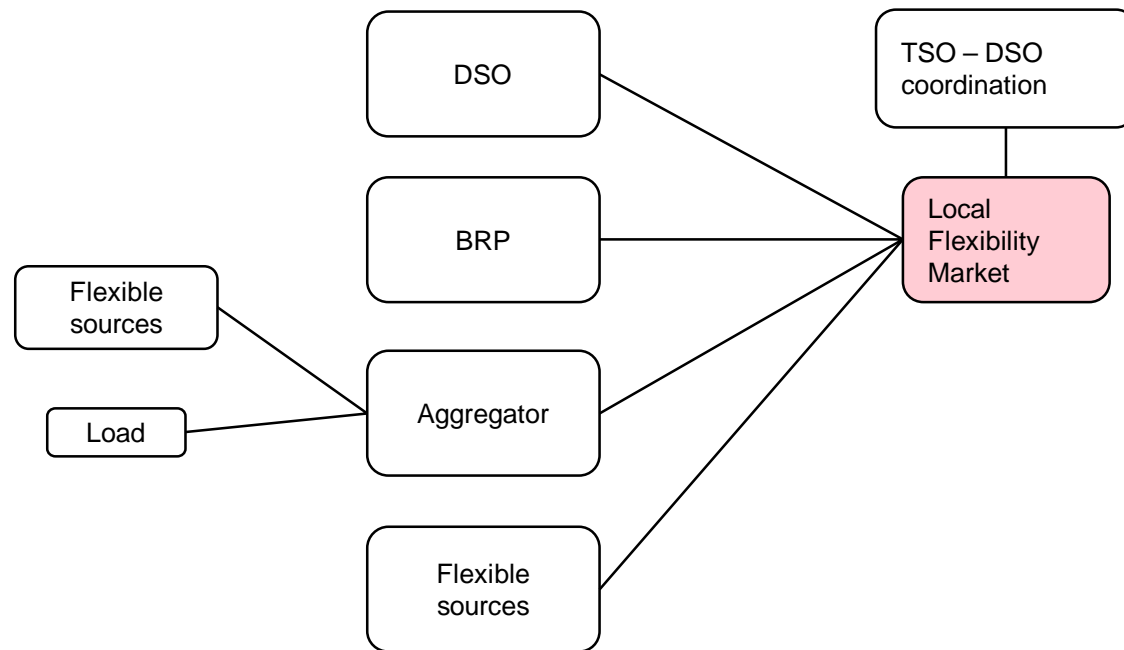
Source:

ENTSO-E. Vision on market design and system operation towards 2030. November 2019. Available at: [vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe\\_fp\\_vision\\_2030\\_web.pdf](https://vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe_fp_vision_2030_web.pdf)

Other studies foresee a sharp increase in electricity demand beyond 2030 and towards 2050: 53 % for the European Commission (A Clean Planet for all, 2018), 60 % for Eurelectric (Decarbonisation pathways for the European economy, 2018).

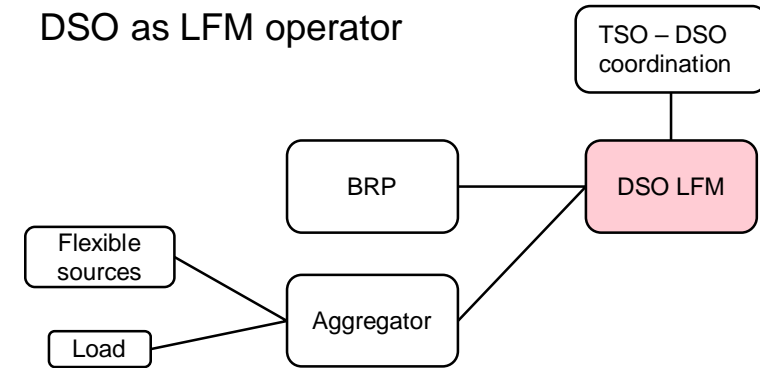
## Main model explored

LFM as independent operator

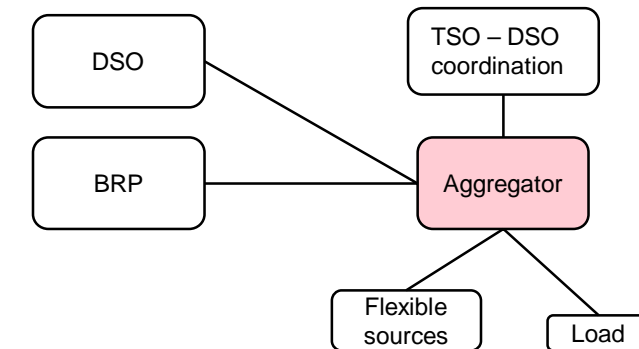


## Other models

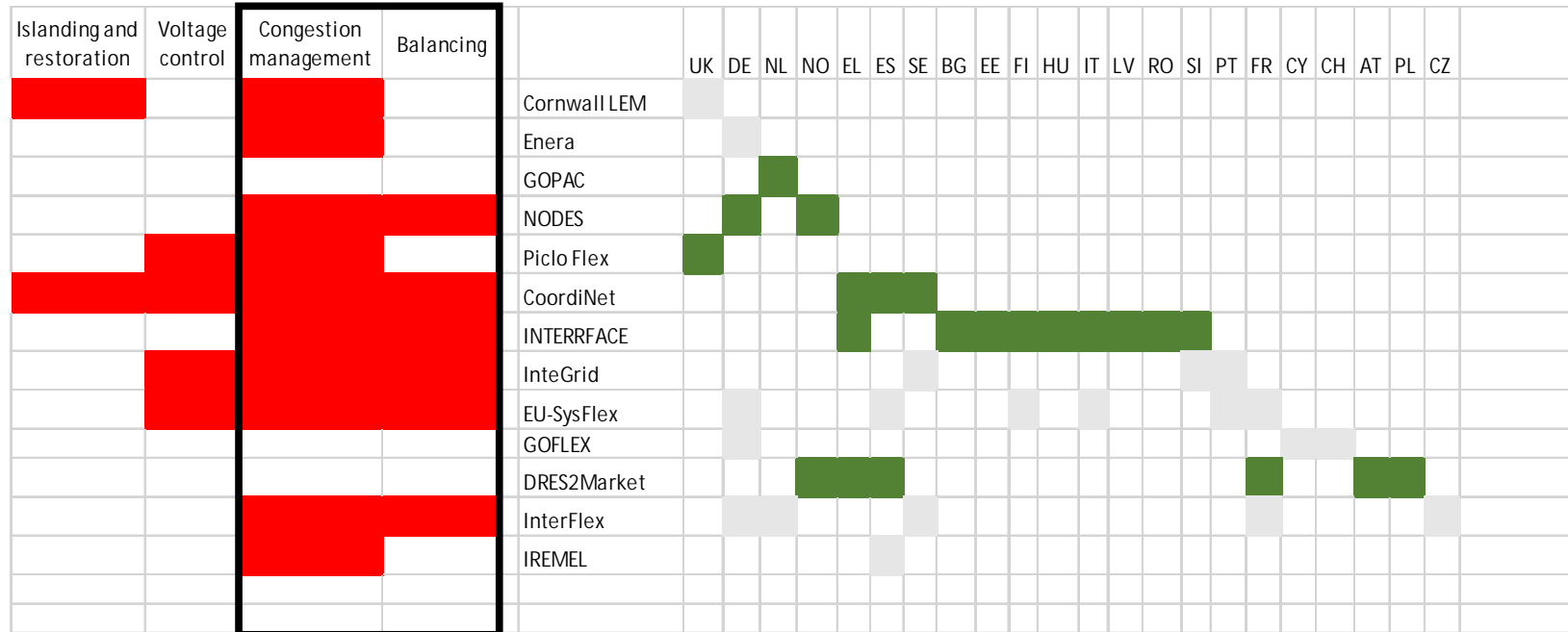
DSO as LFM operator



Aggregator as LFM



# Spread of local flexibility platform projects in Europe

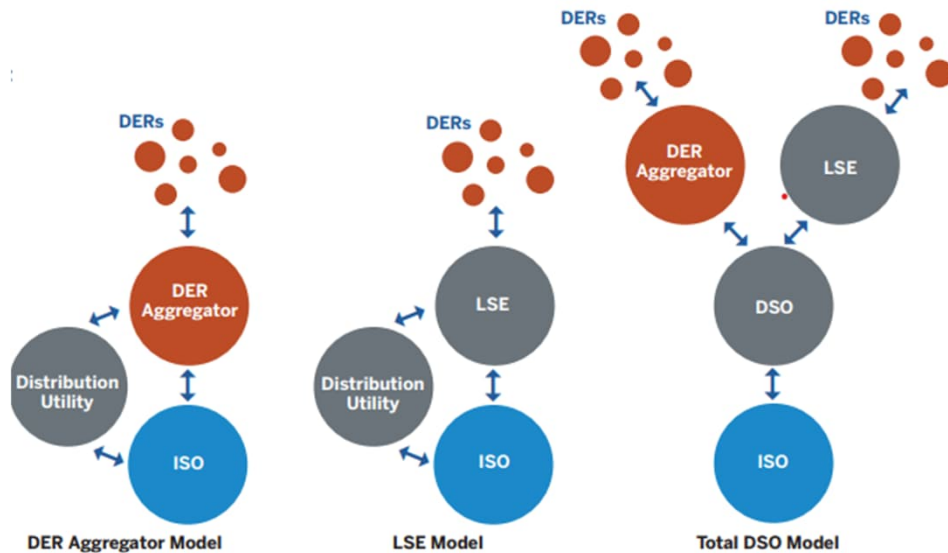


1. Most projects are looking at tackling the issue of congestion and balancing
2. Today, there still exist multiple pilot runs with some countries having multiple project in parallel
3. All projects are operating either as a link between TSO and DSO or working exclusively at a DSO level

Concluded  
 Running

## Models:

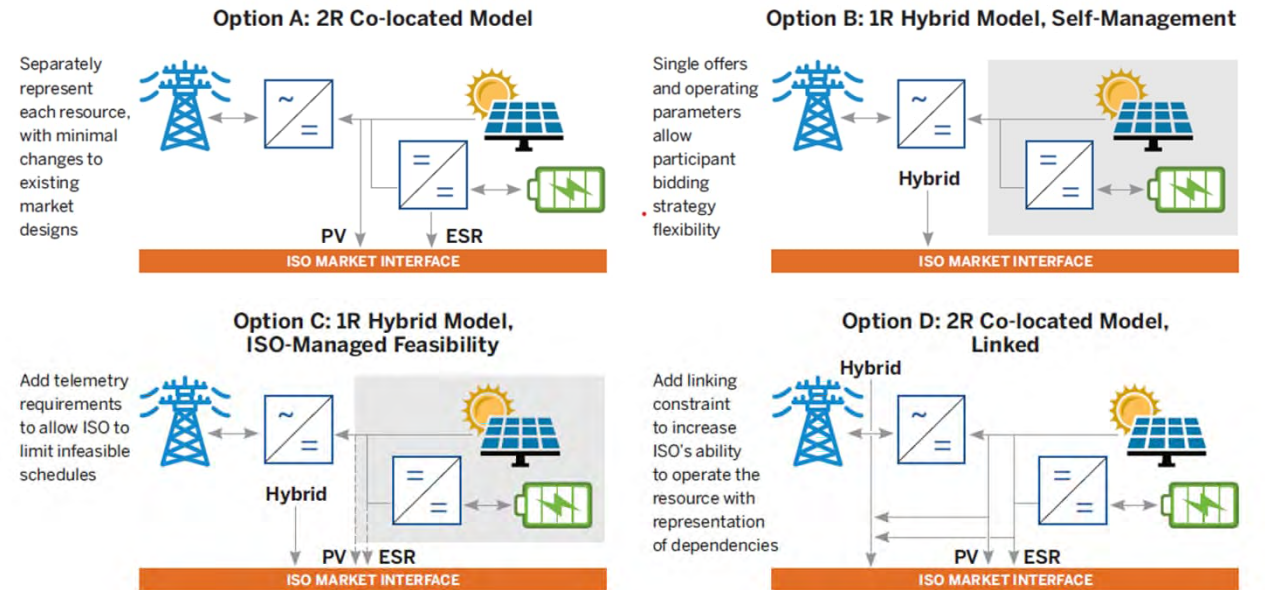
- DER aggregator model
- Load-serving entity (LSE) model
- Total distribution system operator (DSO) model



Source: ESIG

## Hybrid Resource Models:

- Co-located options
- Hybrid options

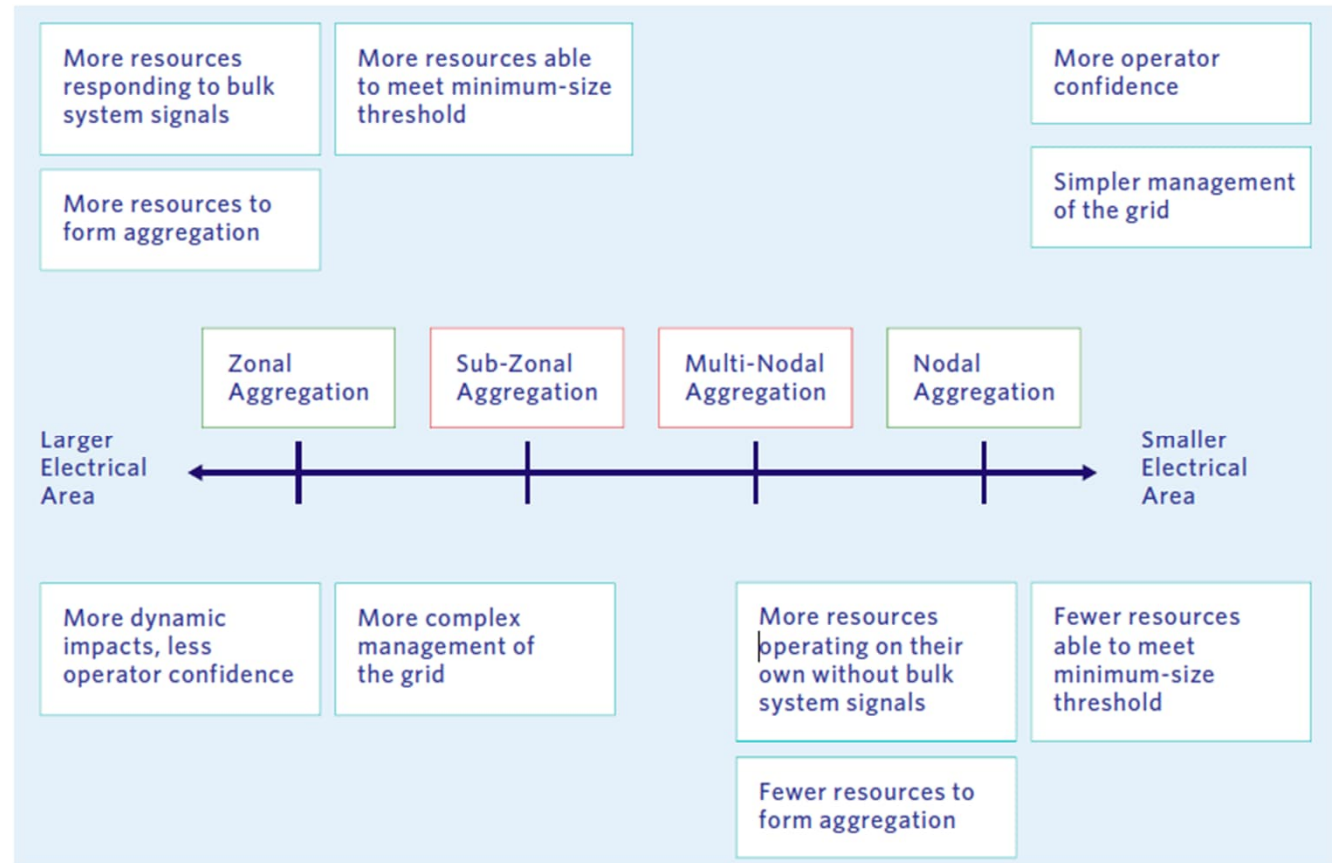


Source: ESIG



# Spectrum of Aggregation Boundaries and Outcomes

- Reducing minimum size threshold
- Modifying aggregation boundaries
- Aggregation for non-dispatchable generation
- Permitting alternative sources of telemetry
- Enhancing T-D interoperability
- System capabilities and needs

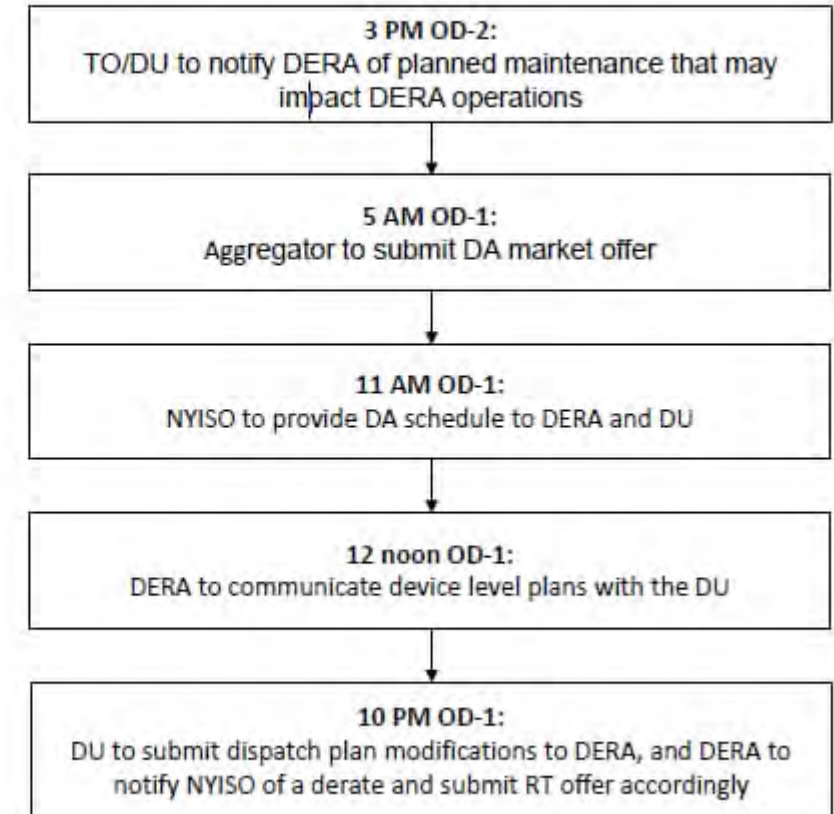


Source: Exploring Expanded DER Participation in the IESO-Administered Markets PART II: OPTIONS TO ENHANCE DER PARTICIPATION

## Future needs:

- Transmission and distribution planning coordination
- Distribution interconnection and aggregation review
- Communications and data-sharing
- Distribution operations
- Federal-state market regulation
- ISO market design
- Open access distribution tariffs
- Utility regulation and business models
- Transparency
- Data Visibility
- Value Stacking
- Incentives/renumerations
- - Regulatory framework
  - Article 32, Network Codes for flexibility, IRA, etc

## NYISO Model – Operational Coordination



OD: Operating Day, TO: Transmission Owner, DU: Distribution Utility, DERA: Distributed Energy Resource Aggregation, DA: Day-Ahead.

Source: EPRI

- DER 24/7 availability (CAISO) restricts services to other markets/programs (utility DRs, etc)
- Real time telemetry and metering (CAISO – over 10 MW aggregations requires this info from every DER device attached to the aggregation)
- Heterogenous aggregations - Measure load reduction and grid injection as a single value (NYISO)
- “Baselining” (ISO-NE/CAISO) - customer’s load profile would have been if an intervention hadn’t taken place.
  - “Baseline erosion” : If DER resource is dispatched multiple times per week, that baseline becomes normalized and becomes relatively useless. Not much or No credit received for DER performance (load reduction ,etc).
  - NYISO trying to tackle this issue by adding adjustments to baseline erosion.
- DERs acting as emergency capacity as of today – “doing little, earning little”
- Single “location pricing node” on its transmission network (NYISO, PJM)
  - CAISO is allowing for multi-node aggregations – increasing geographical area
- Double counting – ISO compensation and Utility retail compensation for the same DER action
- Banning Net Energy Metering DER resources in the retail sector to participate in ISO markets (CAISO)







# Supporting Renewable Energy Penetration In Expanding Markets



**Dr. Jeff Chapman**  
President, EnDimensions LLC  
Silicon Valley - California

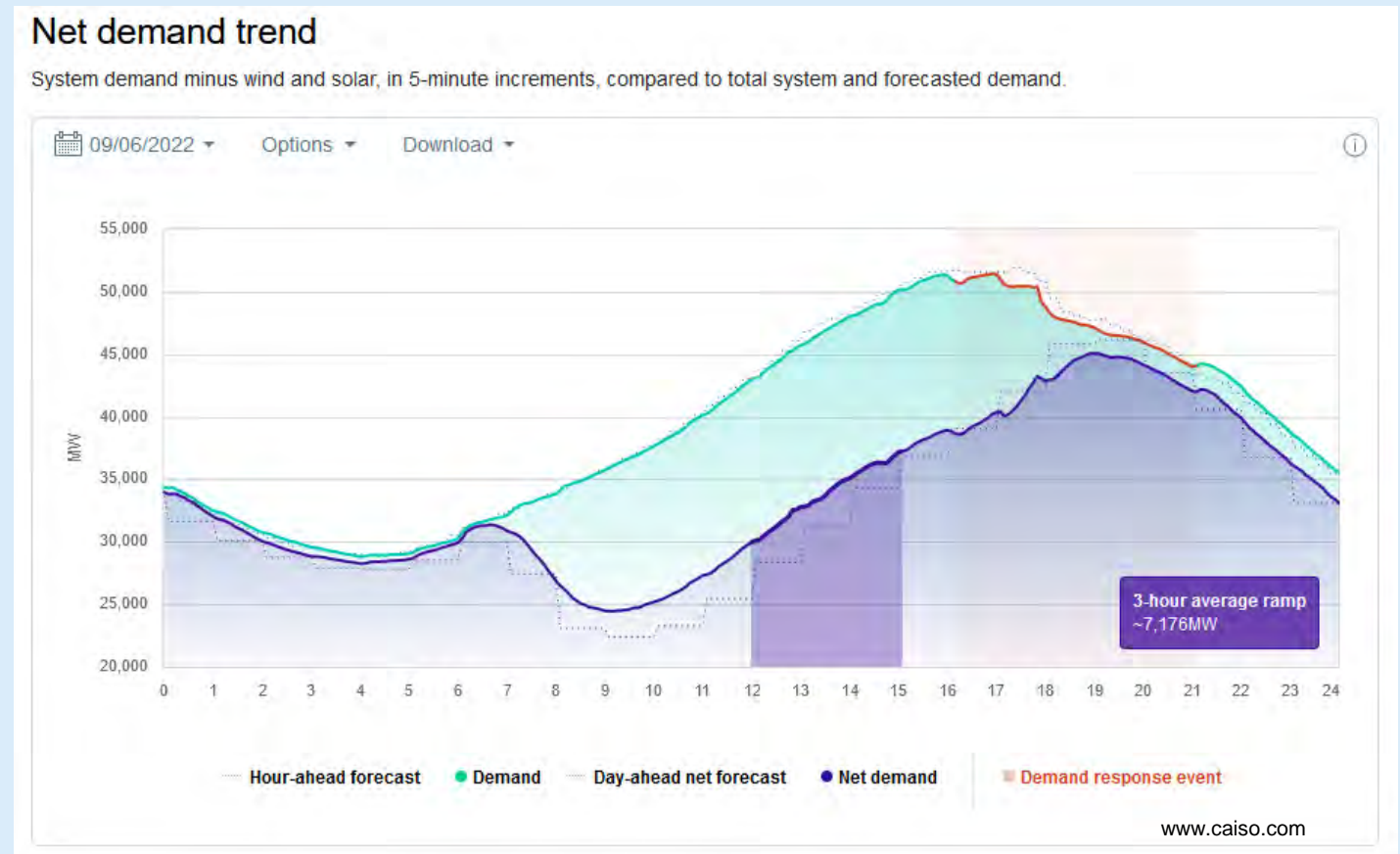
# About EnDimensions LLC

- EnDimensions LLC is a Silicon Valley based Company, Providing Energy Settlements and Market Operation Platforms for Energy Market Operators and Energy Utilities Worldwide.
- Our EnSuite<sup>®</sup> Financials Package leads the industry in performance, scalability and reliability.
- EnDimensions LLC provides implementation services including Market Design, Data Modeling, Integration, and Business Process Design
- Our clients include Large Investor Owned Utilities (IOUs), ISO/RTO Operators, Generation Owners and Transmission Owners
- Our focus is to provide visionary expertise and advanced software tools that enable the transformation of energy markets and market operations worldwide to support



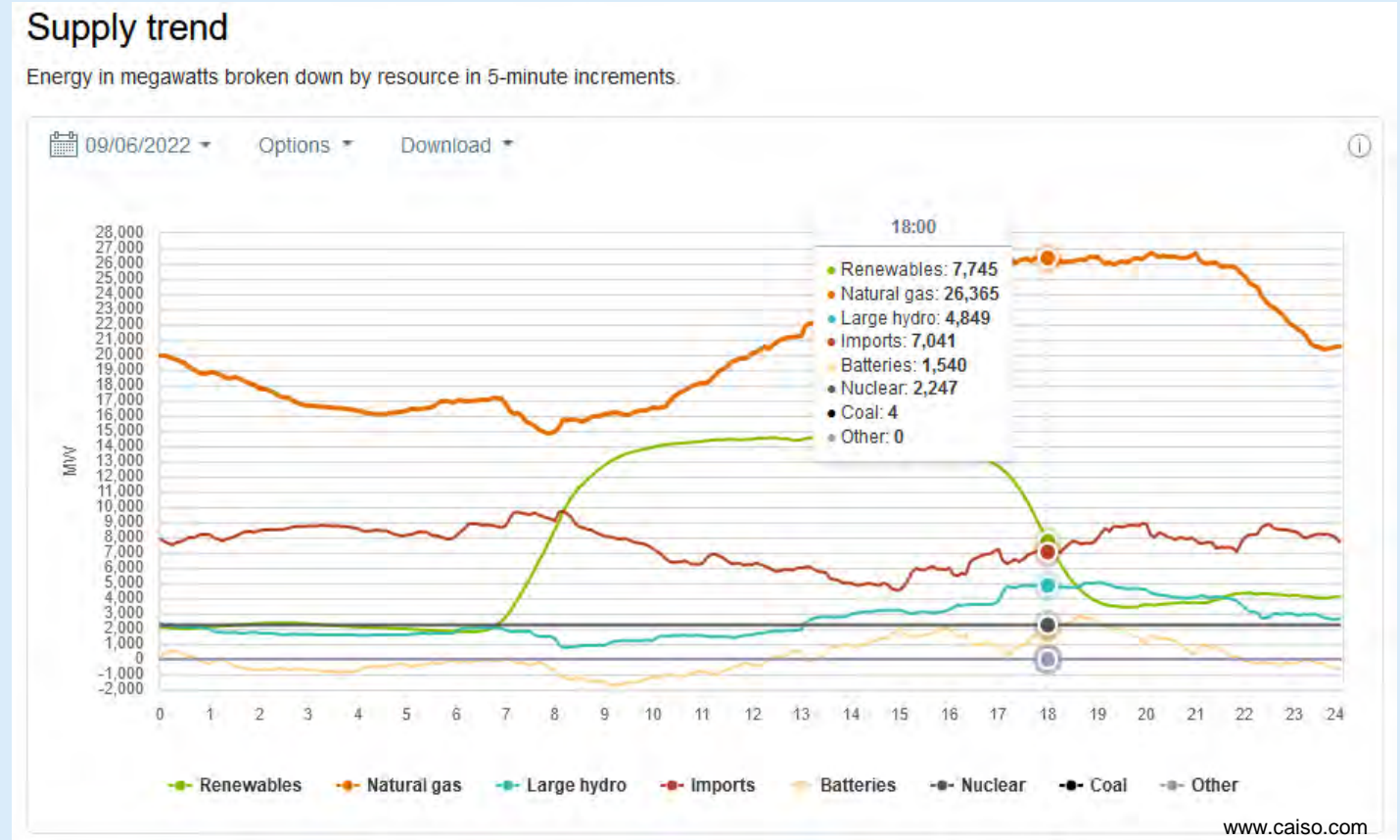
## A Difficult but Successful Day in the Life of California ISO

- Approx. 52,000 MW Peak Load, surpassing record from 2007
- Trough-to-peak ramp of 20,000 MW
- Demand Response starting at 16:00
- Call for voluntary reduction at 18:00
- No loss of load



# The Supporting Cast at the Critical Hour

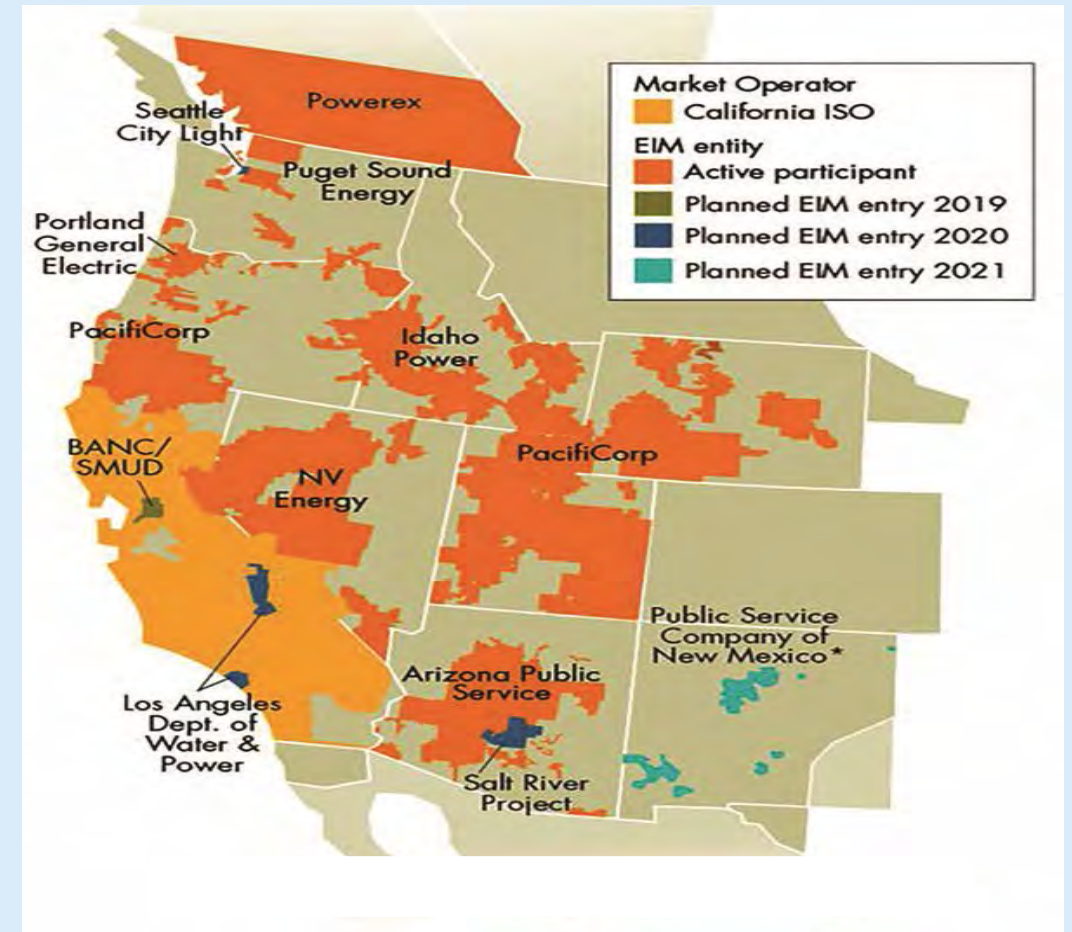
- Responsive Load
- Voluntary Reductions
- Battery output: 1580 MW, Ramping to 2,380 MW
- Solar Ramping Down from 12,500 MW at Peak, Wind 1179 MW Ramping Up to 2000MW at 19:00
- Hydro 4849 MW
- NatGas 26,365
- Imports 7041MW





## Market Mechanisms that Support Reliable Renewable Energy

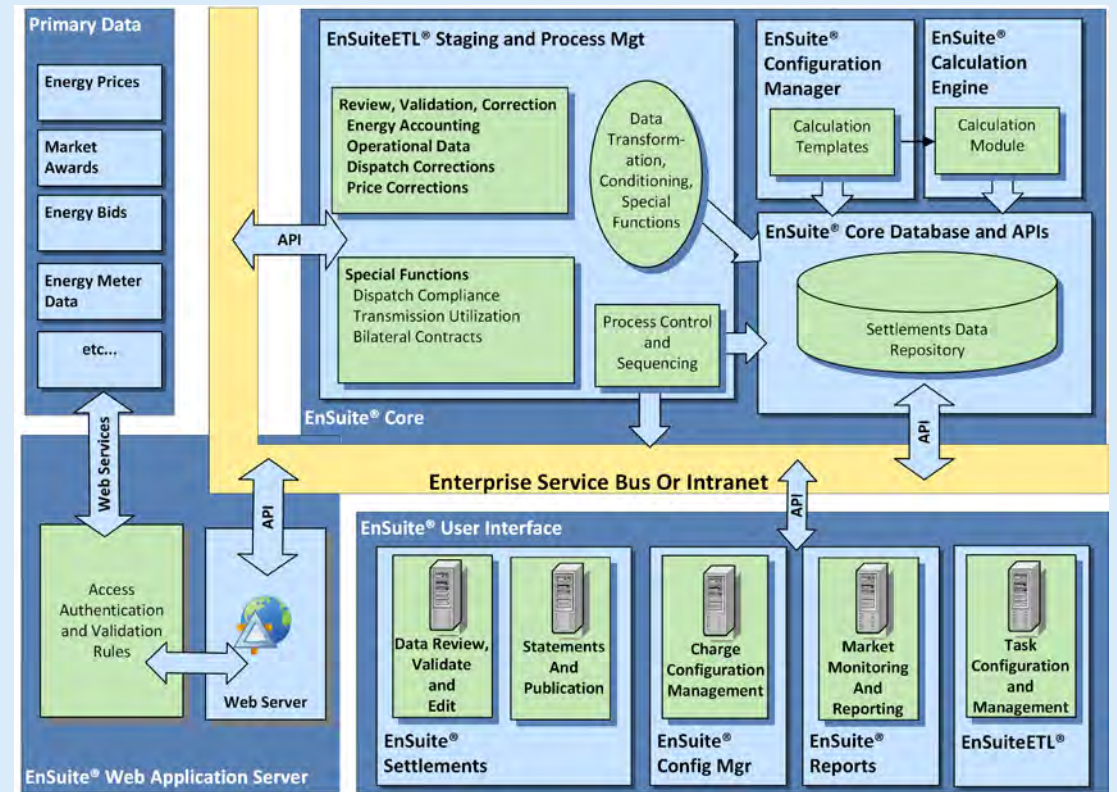
- Geographically expanded markets
  - Support for Near Real-Time Interchange
- New Market Products
  - Imbalance Energy
  - Energy Storage
  - Demand Response Products
  - Flexible Ramping Reserve
  - Reliability Reserves
- New Demands on Settlements
  - The Western Energy Imbalance Market added 35 New Settlements Codes!



# How Can An Expanding Market Manage the Growth of Renewable Energy?

## Position a Settlements System for Future Market Expansion

- A Settlements Product must satisfy the basic needs of the market, while providing capacity to absorb market expansion and changes
- Settlements products are extensively integrated – cheap to scale if properly designed, but expensive to replace
- Automate the business process, not just the application
- Modularity, Flexibility and Performance are key in supporting evolving markets
- Get Set for the Long Haul



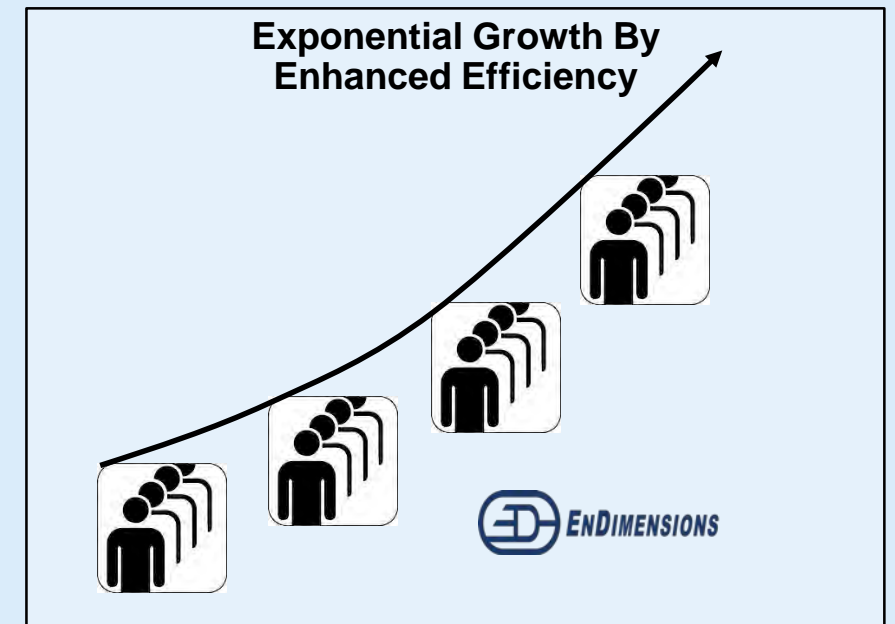
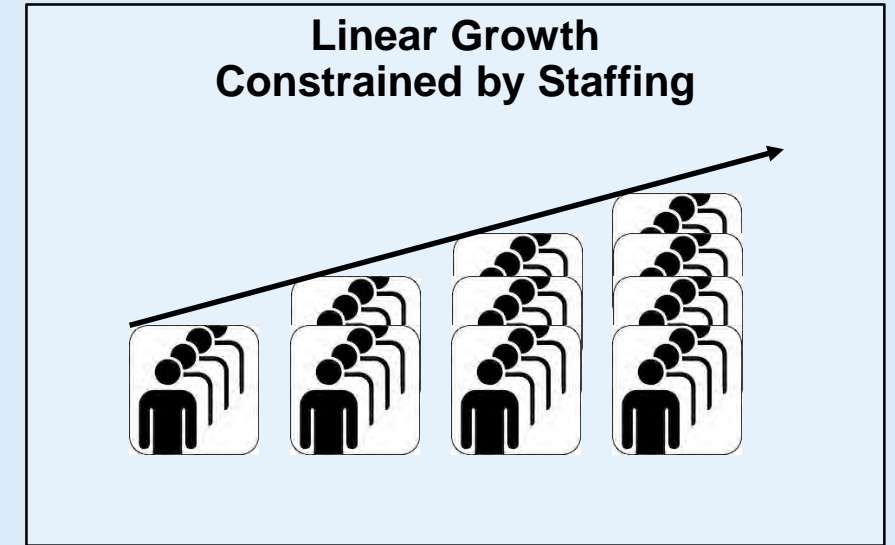
## The Five Pillars of Sound Design

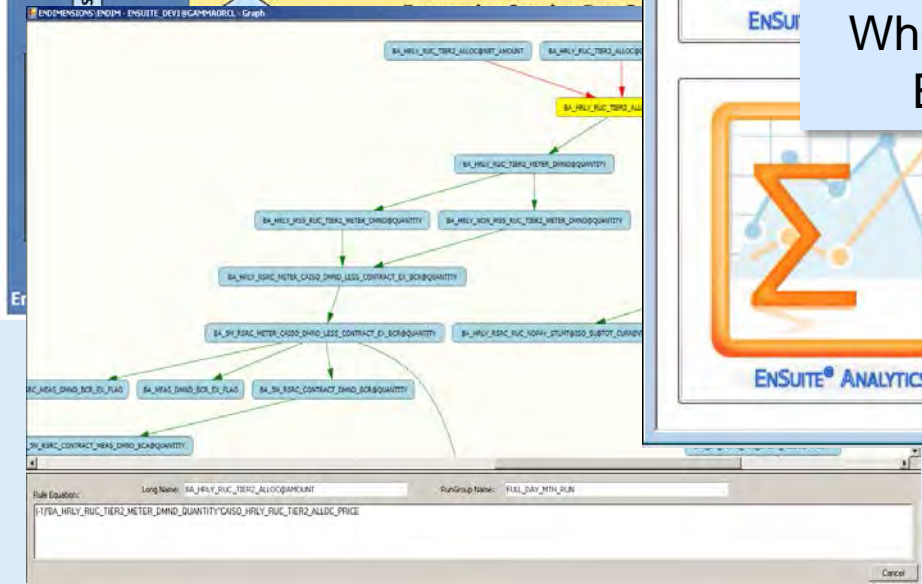
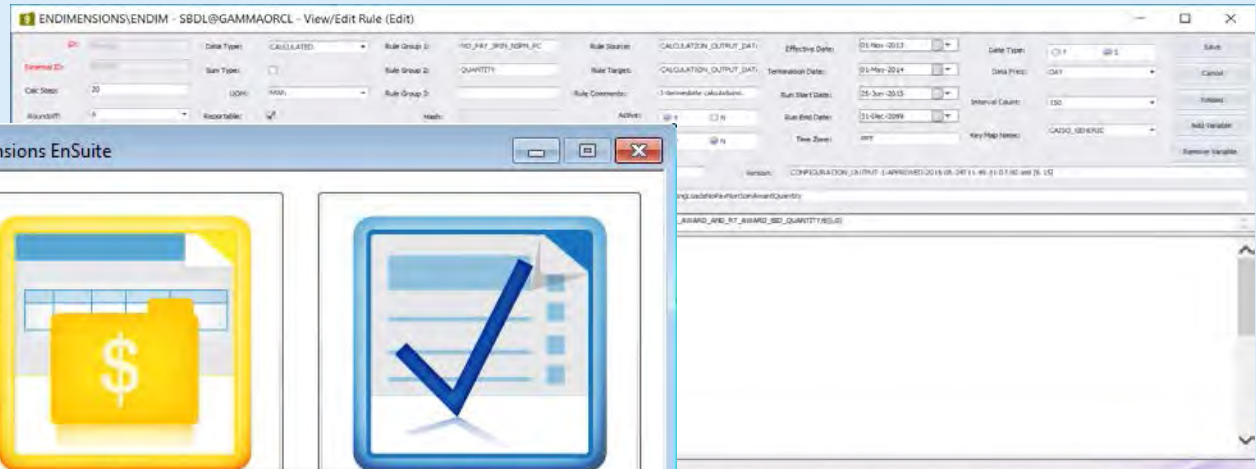
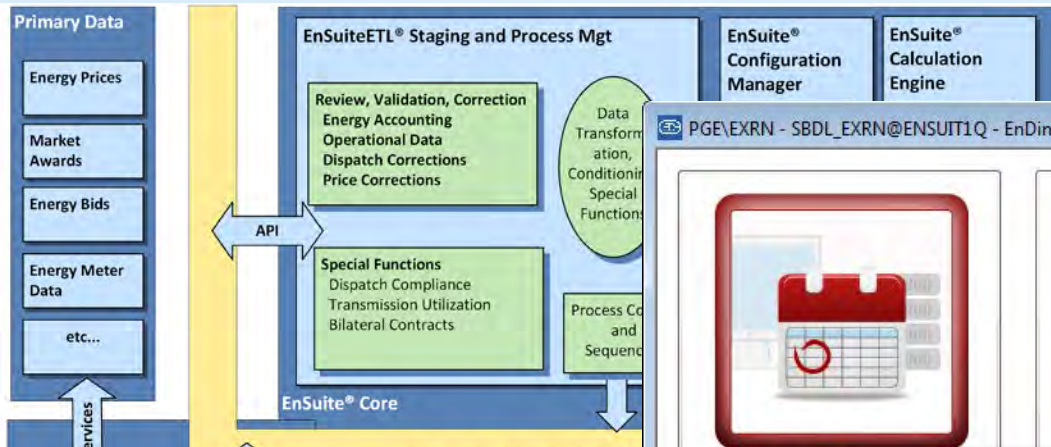
- 1. Flexibility**  
Architecture and Configuration support changes to market intervals, products and settlement rules
- 2. Scalability**  
Ability to support increasing market size and complexity
- 3. Auditability**  
Ability to fully reproduce any settlement calculation, including prior versions of market rules, data and calculations
- 4. Maintainability**  
Ability for staff to update and maintain configuration and calculation rule sets without disrupting day-to-day operations
- 5. Availability**  
Maintain online access to current and historical data, on a highly reliable hardware platform.



## Don't Get Behind the Curve

- Early transformation allows new system to easily adapt to market changes.
- Manual processes require increased staff in order to Support Heavier Market Demands
- Automated processes empower staff to handle more business with less effort.
  - More responsive to change
  - More responsive to opportunity
- Early adoption means
  - Easier, lower-cost transition of staff and systems
  - Earlier access to cost savings
  - Earlier support for growth without staffing constraints





**PGVEXRN - SBDL\_EXRN@ENSUIT1Q - EnDimensions EnSuite**



**ENSURE REPORTING**



**ENSURE CONTRACTS**



**ENSURE ADMINISTRATION**



**ENSURE ANALYTICS**

When it Comes to Settlements,  
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DATA Vector Data Move DAY INTEGRACION data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:04	18	18	0	0	0	0	10660006
DATA Vector Data Move DAY INTRASAM data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:03	18	18	0	0	0	0	10660121
DATA Vector Data Move DAY MIGRACION data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:02	18	18	0	0	0	0	10660224
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DATA Vector Data Move FACTOR INTRASAM data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:20	18	18	0	0	0	0	10780620
DATA Vector Data Move FACTOR MIGRACION data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:13	18	18	0	0	0	0	12132421
DATA Vector Data Move MTH INTEGRACION data from External API to XM_SAM schema	COMPLETED	2019-06-22 19:00:09	18	18	0	0	0	0	10930014

Panel 4:  
Regulatory Perspective



# Capping the price of gas in the EU

**Alberto Pototschnig and Ilaria Conti**

**APEX Congress 2022  
Dubrovnik, 21 October 2022**





# Preliminary considerations

- The EU gas market can be broadly split into two segments
  - The gas produced in the EU or imported into the EU via pipelines ('pipeline gas')
  - The gas imported into the EU as LNG
- There are limited opportunities for external pipeline exporters into the EU to redirect the gas destined to the EU or to liquefy and export it as LNG
- The EU has a limited ability to influence the international LNG market
- There might be regulatory tools to intervene on the price of pipeline gas in the EU

# A two-part strategy

**1. The adoption of measure(s) to contain the price of pipeline gas traded in the EU**

**1.a. The regulatory use of technical functionalities of gas exchanges, such as the Interval Price Limits (IPL) of ICE, to steer the price of gas traded on these exchanges downwards**

**1.b. A regulatory mandate to TSOs to sell/buy gas in the balancing mechanism at a predefined price or price range**

**2. The organisation of auctions for sourcing LNG for the EU on the global market**

# 1.a. Containing the price of pipeline gas in the EU Using technical functionalities of gas exchanges

Using gas exchanges' technical functionalities (e.g. Interval Price Limits) to guide the gas price down

Spot gas trading will clear at prices within the allowed range, which is gradually moved downwards

Long-term contracts indexed to the spot price would eventually align to the capped price

**If the limits apply only to gas traded on Organised Market Places, possible leakage to the OTC market**

# 1b. Containing the price of pipeline gas in the EU Using the balancing mechanism

## Cap on the price of balancing gas

TSOs to offer unlimited quantities of gas in the balancing market at a predefined price or price range

No market participant would buy/sell gas on the spot market above/below the predefined price or price range

The price of spot trading would therefore align to the predefined price or price range

Long-term contracts indexed to the spot price would eventually align to the predefined price or price range

However the imposition of a predefined price may reduce the supply of pipeline gas to the EU, leading to 'missing gas' volumes



### Dealing with possible 'missing gas' volumes

Energy saving measures are introduced to minimise the 'missing gas' volumes

A Single Buyer entity will procure any 'missing gas' volumes on the LNG market through auctions

LNG suppliers bid the price premium with respect to the predefined price or price range

The cost of the premia paid on LNG is recovered through regulation

FSR Policy Brief 2022/49 September 2022

## Capping the European price of gas

by Alberto Pototschnig and Ilaria Conti

<https://fsr.eui.eu/publications/?handle=1814/74868>

FSR Policy Brief 2022/51 October 2022

## Securing gas for Europe

(a follow up to the policy brief on Capping the European price of gas)

by Alberto Pototschnig and Ilaria Conti

<https://fsr.eui.eu/publications/?handle=1814/74941>



**Thank you for your attention!**



# APEX 2022 Dubrovnik

## Regulatory perspective

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PANEL MODERATOR LINA MASIULIENE, NORD POOL





# Regulatory panel

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- 1. Christophe Gence-Creux**, Head of Energy department. ACER (EU Agency for the Cooperation of the Energy Regulators).
- 2. Commissioner Mark C. Christie**. FERC (Federal Energy Regulatory Commission).
- 3. Alberto Pototschnig**. Executive Deputy Director, FSR ( Florence School of Regulation).
- 4. Kevin Ly**. Group Manager, AEMO (Australian Energy Market Operator)
- 5. Hans Randen**, Director - Governments and External Affairs, Nord Pool AS.

# Turbulent times in the Energy sector

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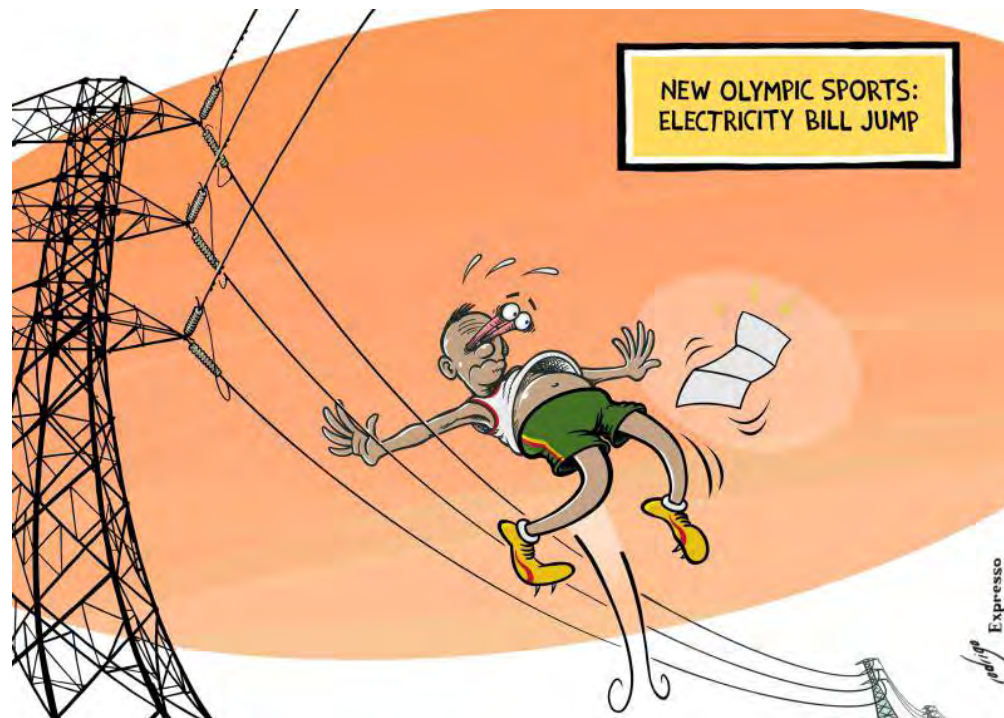
- Unprecedented dishonoring of Gas contracts in Europe
- Extremely high energy price level
- Dry weather affecting hydro power production
- Lack of nuclear production
- New policies & short-term interventions
- Supply diversification
- Discussions regarding market design



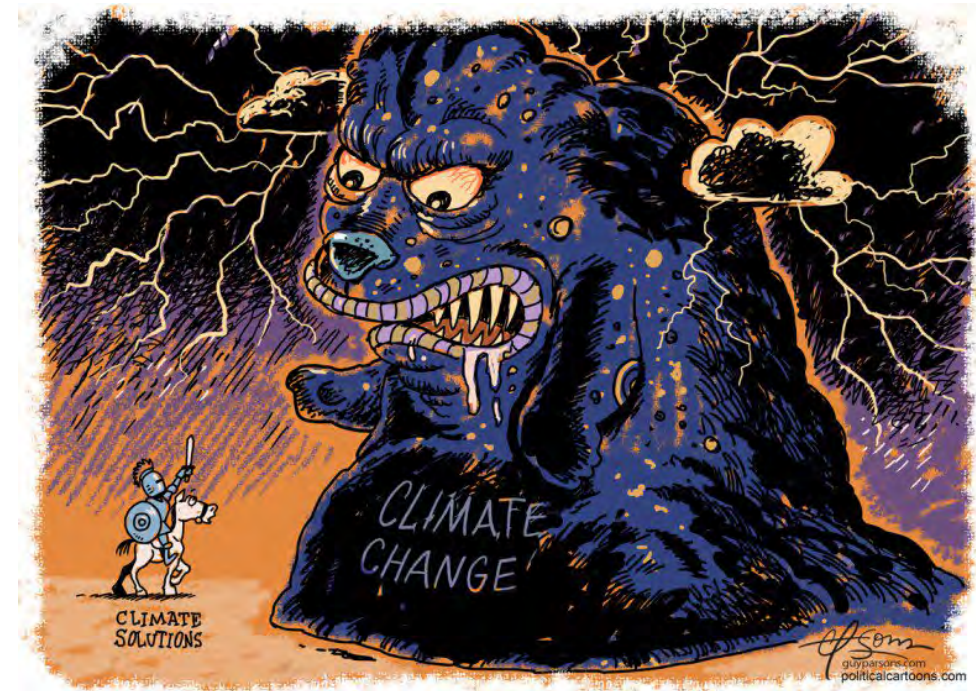


# Situation in Europe : short term interventions vs long term goals

ENERGY CRISIS: HIGH PRICES, INTERVENTIONS  
NEW REGULATIONS AND POLICIES



LONG TERM GOALS: HOW TO ACHIEVE  
CLIMATE CHANGE COMMITMENTS?



# U.S. Response to the Global Energy Crisis

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How global energy crisis, new policies and interventions in continental Europe affect U.S. energy agenda?

What is the internal discussion within U.S. on energy exports vs increase in local energy prices?



# Opportunities for Australia ?

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How global energy crises will shape future of Australian energy sector: coal & gas (LNG)? Will it postpone green agenda?

Market suspension in Australia (July 2022): local challenges related to price surge and lessons learned.

# Short term action vs future market design

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## SHORT TERM ACTIONS

Measures established on political level

All agree on the need for demand reduction/flexibility

No clear guidance for how to do implementation of several of the other measures

## FUTURE MARKET DESIGN

UK have started a broad consultation on future market design

EU have stated the need for a change

Green shift requires huge investment in new green production

How to improve the market design without destroying what has been established in the last decades

Panel 5:  
Flexibility and Resilience

# EWEC: Managing the Energy Transition In Abu Dhabi and the Northern Emirates

Dubrovnik

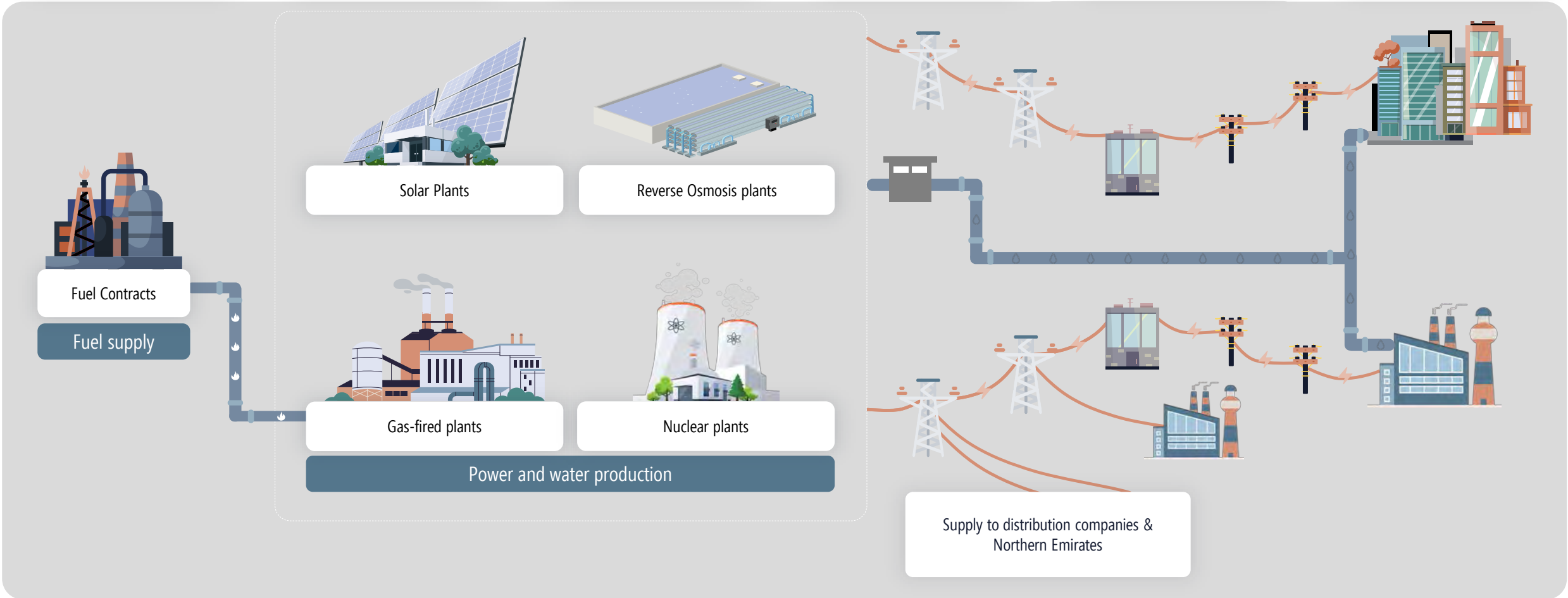
21 October 2022



# EWEC's role has evolved to be an Independent System Operator (ISO+) since January 2022



- Demand forecasting
- System and operational planning
- Capacity Procurement
- Fuel Procurement
- Contract management, payment & settlement
- Scheduling, dispatch & transmission system operation



# EWEC partners with 15 plants for the supply of water and electricity across the UAE



Shuweihat S1  
101 MGD  
1,615 MW



Mirfa  
53 MGD  
1,702 MW



Taweelah A1  
84 MGD  
1,671 MW



Fujairah F1  
131 MGD  
861 MW



Noor AD  
935 MW



Future  
Al Dhafra PV  
1,584 MW  
(2,101 MW DC)



Shams Solar  
100 MW



Masdar PV  
10MW

Shuweihat S2  
101 MGD  
1,627 MW

Shuweihat S3  
1,627 MW

Barakah 1 and 2  
2 x 1,390 MW

Future:  
Barakah 3 and 4  
2 x 1,390 MW



Um Al Nar  
95 MGD  
2,290 MW

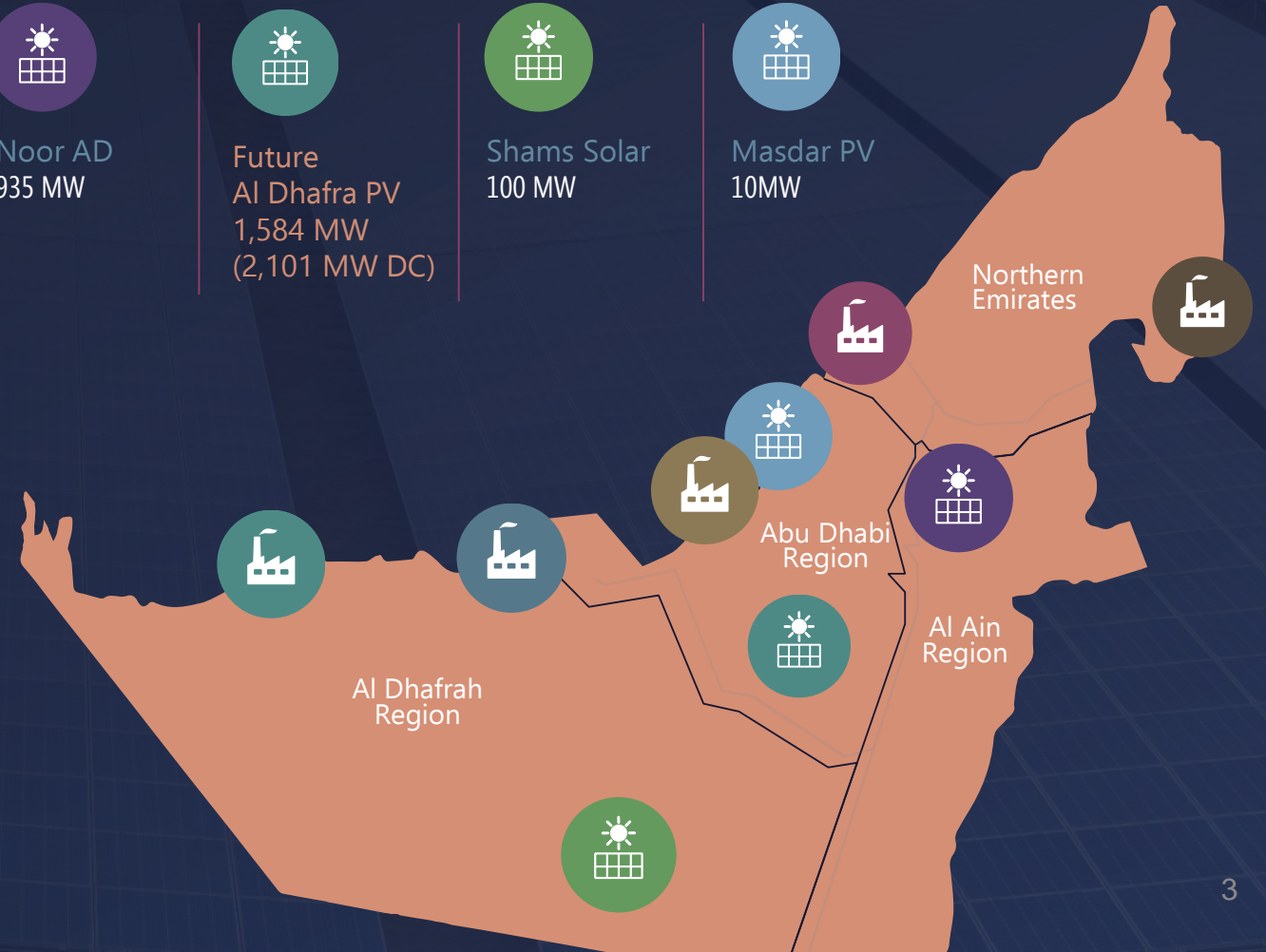
Taweelah RO  
(early)  
100 MGD

Taweelah B  
162 MGD  
2,220 MW

Future:  
Taweelah RO  
(Full)  
200 MGD

Fujairah F2  
132 MGD  
2,114 MW

Future:  
Fujairah F3  
2,457 MW





## Competition for the Market but not in it

- Capacity auctions for 20 – 30-year supply contracts
- Payment made for availability and energy supplied (with fuel supplied as a pass-through)
- Technology, size and location of new plants specified
- EWEC's payment default risk underwritten by Abu Dhabi government

Combination of these factors results in low risk for project developers and world record low-cost tariffs offered to EWEC



## EWEC Sells to its Bulk Customers

- EWEC is a “not for profit”
- Objective to minimize the cost of supply
- Net Zero by 2050; 60% “Clean” energy by 2035
- Principle customers are the distribution companies
- They pay a “bulk supply” tariff that recovers full cost of supply
- Overseen by an independent Regulator
- EWEC can supply other customers if this results in a reduction in the Bulk supply tariff

With UAE's commitment to Net-Zero, the market structure is evolving



### Net-Zero commitment requires:



Greater Interconnection



Solar or Nuclear

- If Solar: A lot of land + a lot of storage
- If nuclear: A lot more \$\$



Both solar or nuclear will require additional grid stability services



Enhancement of Operability Planning capability and integration into Techno-economic planning



Potential UAE Market Evolution





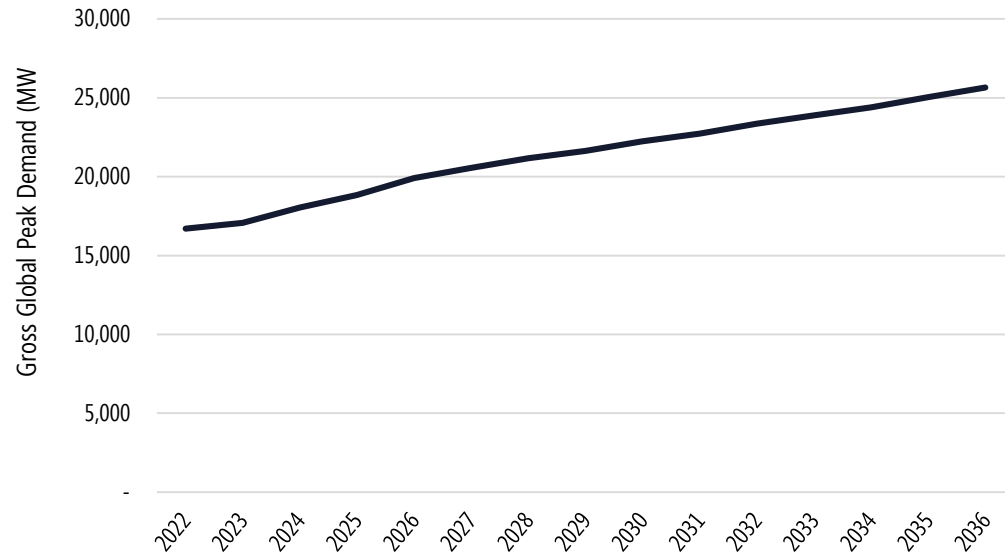
# Peak power demand is expected to increase by 30% between 2022 and 2029 requiring additional generation capacity



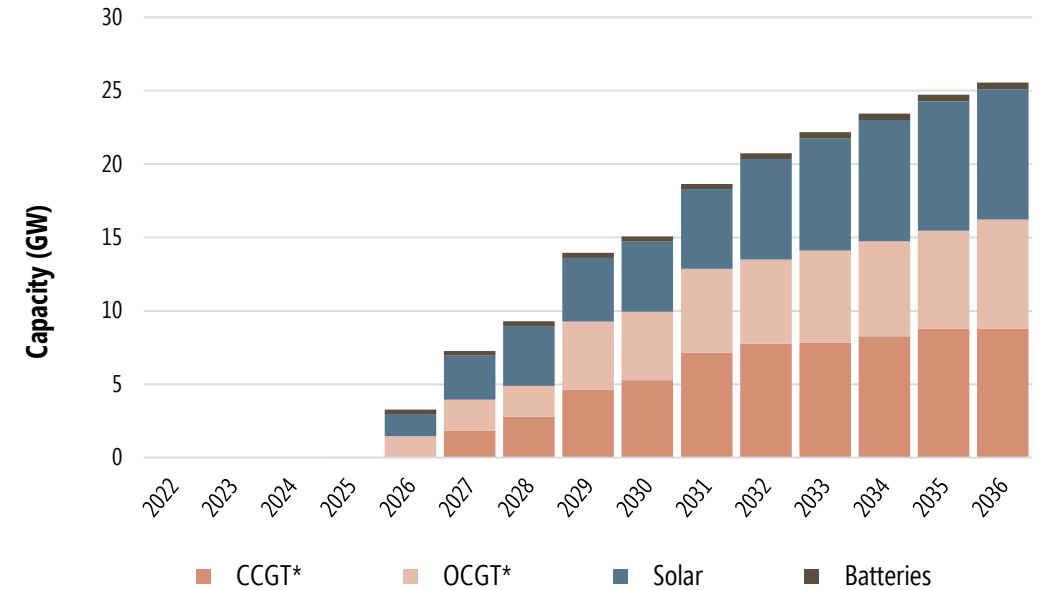
Higher peak demand requires additional thermal and solar generation capacity along with batteries to enhance system reliability

- Thermal: Significant gas capacity (3.9GW) needed in 2026 and 2027 to replace expired PPAs
- Solar: An additional ~5GW of solar PV is recommended by 2030 (Total 7.3GW installed)
- Batteries: 300MW of batteries configured for reserve provision needed by 2026 to enhance system reliability

### Peak demand forecast 2022 - 2036



### Base Case<sup>1</sup> Capacity Projection, EWEC + EWE (GW – Gross Capacity)

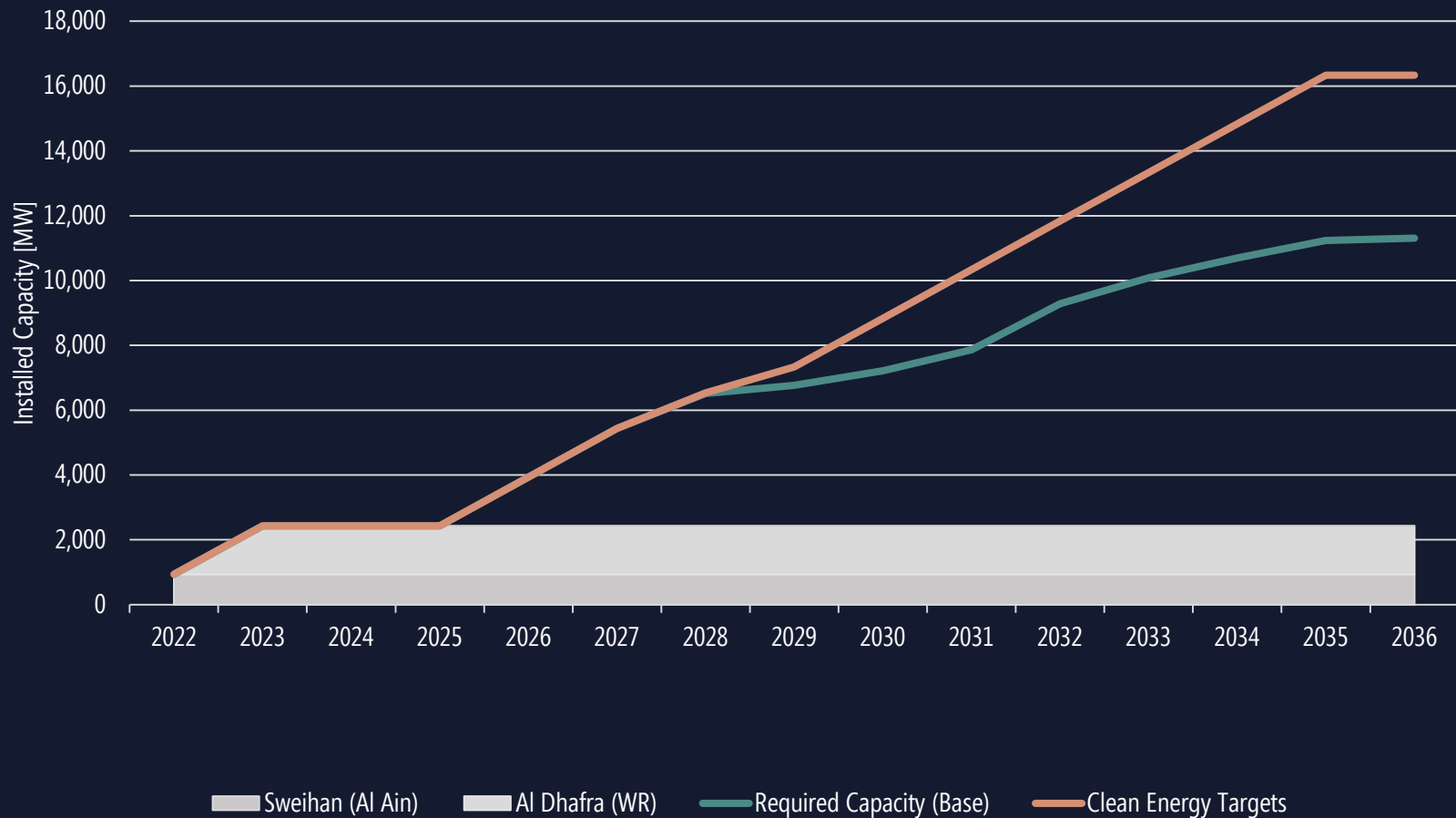


<sup>1</sup>The base case excludes committed capacity (Al Dhafra at 1,500MW and F3 at 2,457MW).

\* CCGT and OCGT could be new build or contract extension

# A significant amount of solar PV capacity is recommended from 2025 onwards

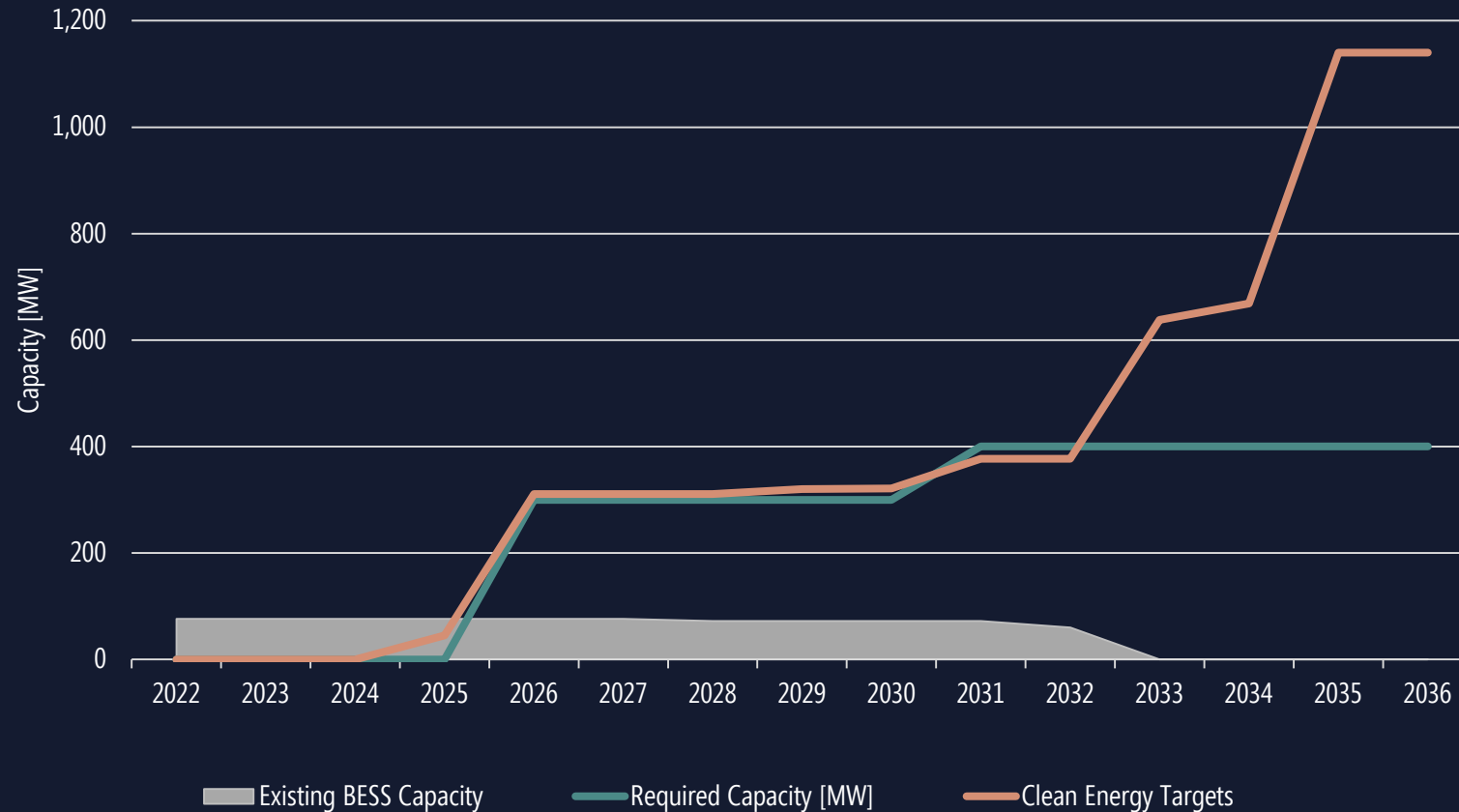
### Optimal Development of Solar-PV Capacity for Base , EGA Integration Cases and Clean Energy Targets (2022 - 2036)



- By 2030, the recommended optimal new solar-PV capacity is between c.4.5 - 6GW. Including the two committed projects at Sweihan PV and PV2 (Al Dhafra) the total solar-PV capacity will reach 7.2 - 8.5GW
- By 2036, following recent commitment to new Clean Energy Targets significantly more Solar-PV capacity is recommended bringing the total to between 16-20 GW
- New Solar-PV capacity is recommended as soon as possible (assumed by 2026), with further additional Solar-PV capacity entering service in subsequent years

# Over 300 MW of batteries are required from 2026 to enhance system reliability

### BESS Capacity and New BESS Capacity Requirement with Clean Energy Targets (2022 - 2036)



- Battery Energy Storage Systems (BESS) are recommended to provide **primary and secondary reserves**. They provide system cost savings by enabling a higher penetration of low-cost solar PV
- Batteries become **essential for system security** following the commissioning of all 4 nuclear reactors at Barakah and the resulting decline in dispatch of gas generation
- Analysis of a proposal to reconfigure the existing NGK sodium-sulphur battery capacity for reserve provision has indicated that this option is significantly more costly than replacing it with new Li-ion based batteries
- **4 new BESS projects** of a total size 575 MW is recommended between 2026 – 2033
- **Lead to build** new BESS – 3 Years

## Increased Operability Requirements



Curtailment of 17% of total solar energy expected with 16 GW of solar in a 25 GW system



Active dispatch of solar capacity including the provision of grid flexibility services will be essential



Specification, delivery and management of grid flexibility services needed



Increased interconnection – larger systems. Dubai, Oman, Saudi / GCCIA



Getting from low carbon to no carbon will require the integration of lower cost storage + control solutions with solar that are not currently available:

- People
- Systems
- Technology / cost



# EWEC's ISO+ market model provides a flexible framework for managing changes in portfolio composition and identifying operability challenges



## Flexible market model

EWEC's ISO+ market model provides a flexible framework for:

- Managing a rapid change in portfolio composition
- Identification of Operability Challenges and specification, delivery and management of grid flexibility services needed



## Clean energy targets

60% clean energy by 2035 will require the system to produce ~60% of energy from solar during daylight hours in addition to the nuclear baseload contribution



## Increased interconnection

Increased interconnection will be needed— larger systems (Dubai, Oman, Saudi / GCCIA)



## Transition to "no" carbon

Transition from 'low carbon' to 'no carbon' will require a major transformation in the portfolio composition, human capabilities, systems and processes



## Technological challenges

The integration of lower cost storage + control solutions with solar that are not yet available



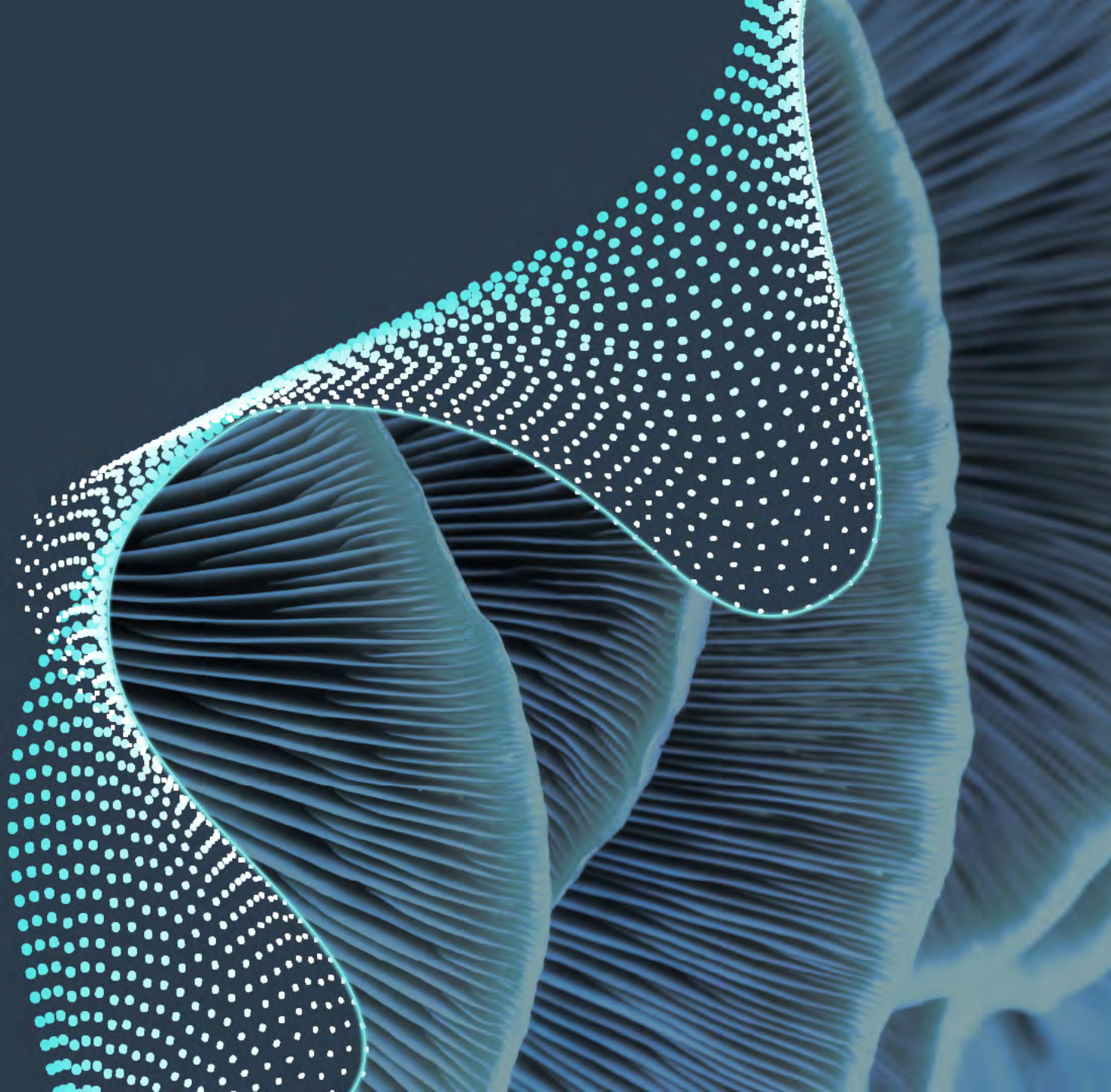
[www.ewec.ae](http://www.ewec.ae)

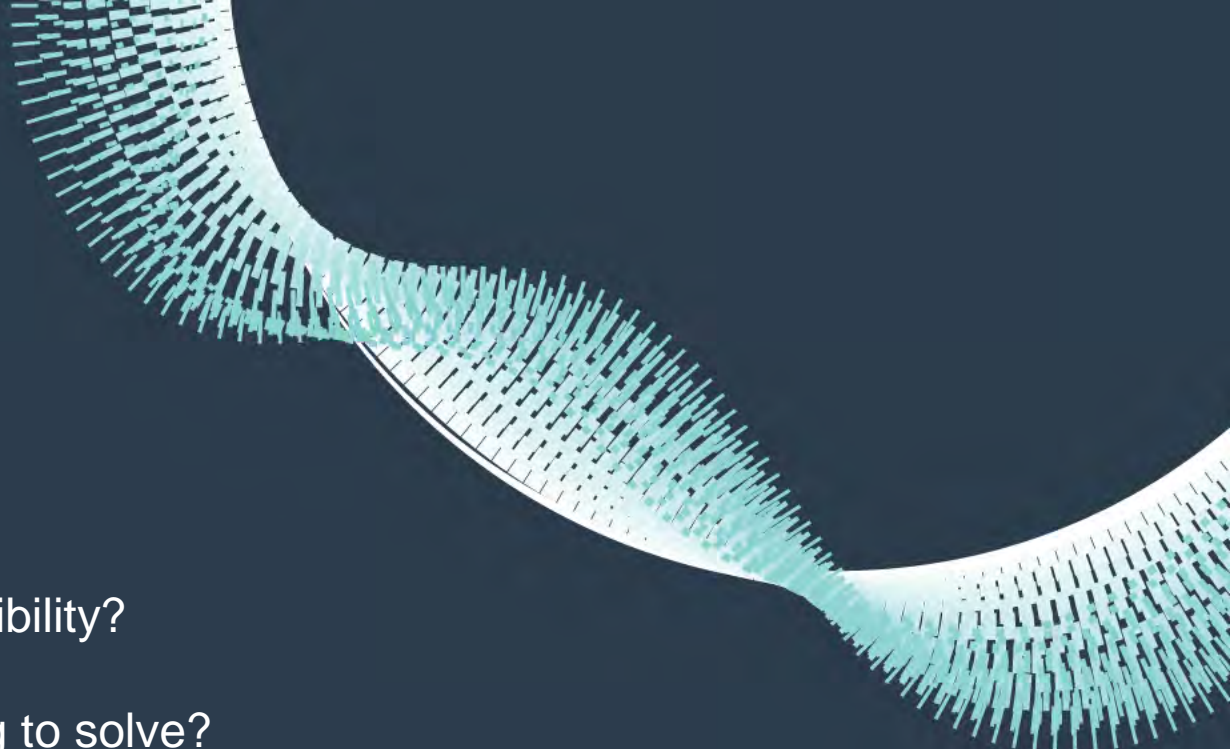


NEOM ENERGY AND WATER

# INTRODUCTION TO ENERGY FLEXIBILITY

OCTOBER 2022



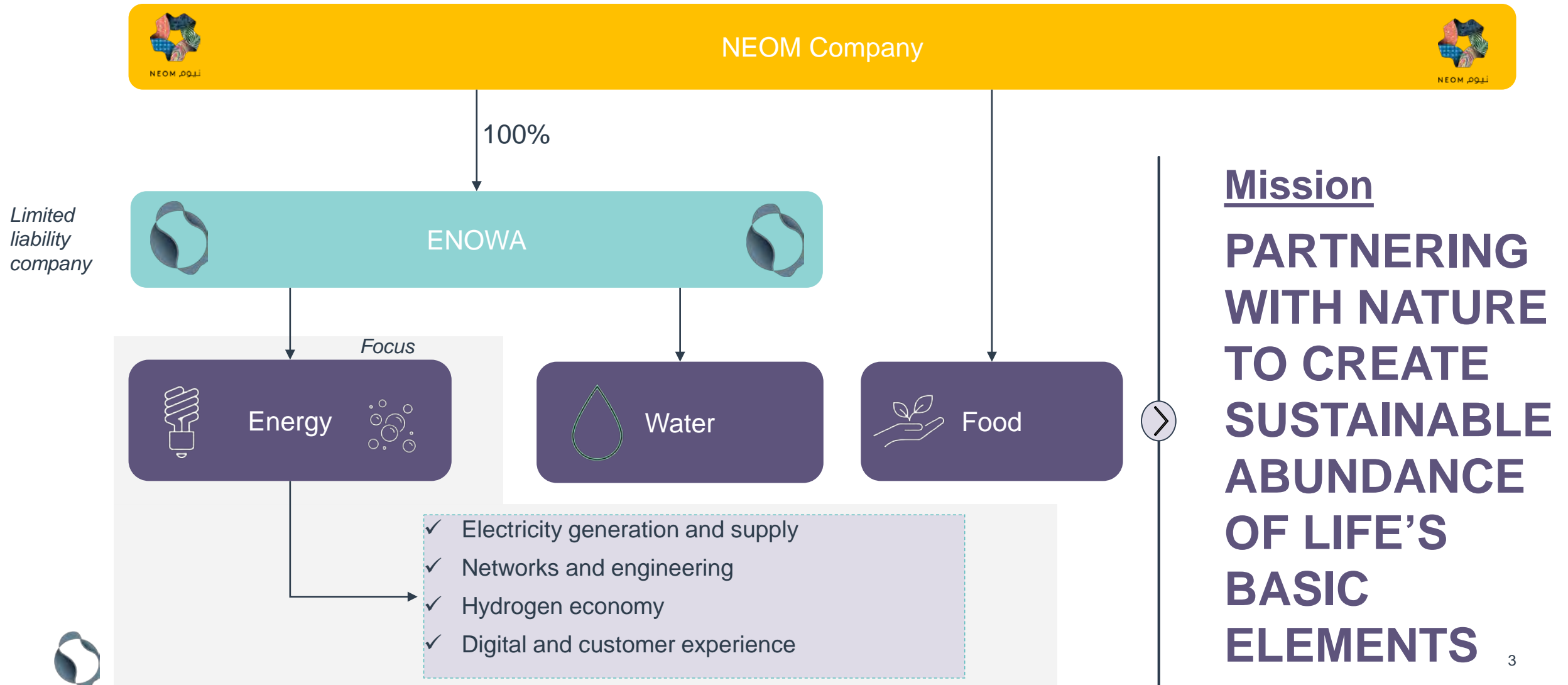
- 
- Who is ENOWA Energy Flexibility?
  - What challenge are we trying to solve?
  - What is flexibility and how does it help?
  - What are the sources of flexibility?
  - What is the value of flexibility?
  - How is NEOM planning to enable?





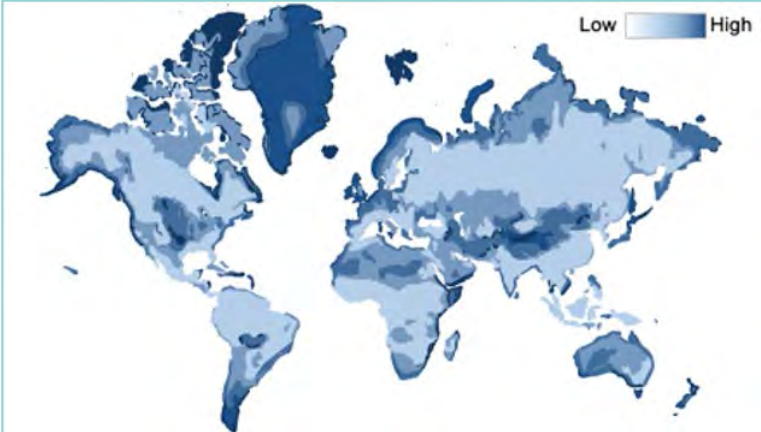
# ENOWA – NEOM ENERGY AND WATER COMPANY

INCORPORATED IN DECEMBER-21 AS A 100% SUBSIDIARY OF NEOM COMPANY WITH ITS OWN BOARD AND STRATEGY

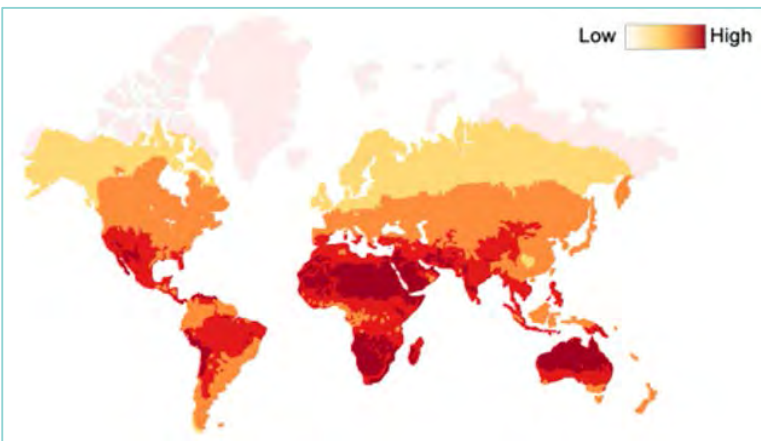


# NEOM HOSTS AN UNRIVALED COMPLEMENTARY WIND & SOLAR PROFILE

Highest wind speed regions, m/s



Highest solar radiation regions, kWh/m<sup>2</sup>



## Regions with high joint wind speed and solar radiation<sup>1</sup>

★ Exemplary regions with favourable wind and solar PV conditions



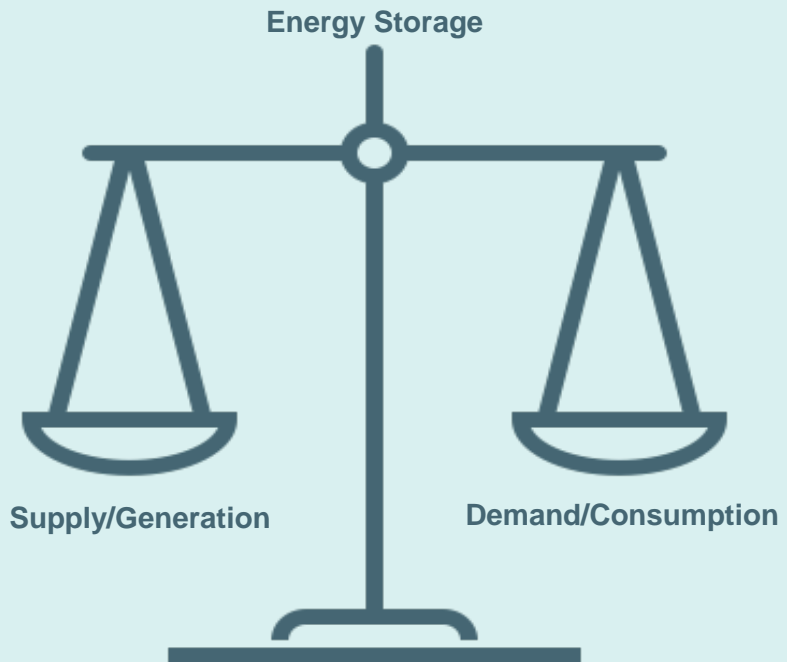
NEOM's complimentary solar and wind profile enables a value proposition of low cost 100% renewable power

<sup>1</sup> Map is a graphical combination of the two maps on the left  
SOURCE: NEOM Energy and Water Team, IRENA, Meteornorm



# THE FUNDAMENTALS OF POWER SYSTEM ECONOMICS AND AVAILABLE CLEAN TECHNOLOGIES MAKES ACHIEVING LOW TOTAL SYSTEM COST IN A 100% RENEWABLE SYSTEM A CHALLENGE

## The Power Balancing Law



Electricity generation must equal demand for every second to maintain system stability



Supply/Generation

- **Intermittency:** Wind and solar are variable and weather dependent
- **Profile:** Times of available generation does not match times of peak consumption



Demand/Consumption

- **Behaviour/Comfort:** Use energy when and how they want.
- **Opportunity cost:** Need for business to plan for core value propositions

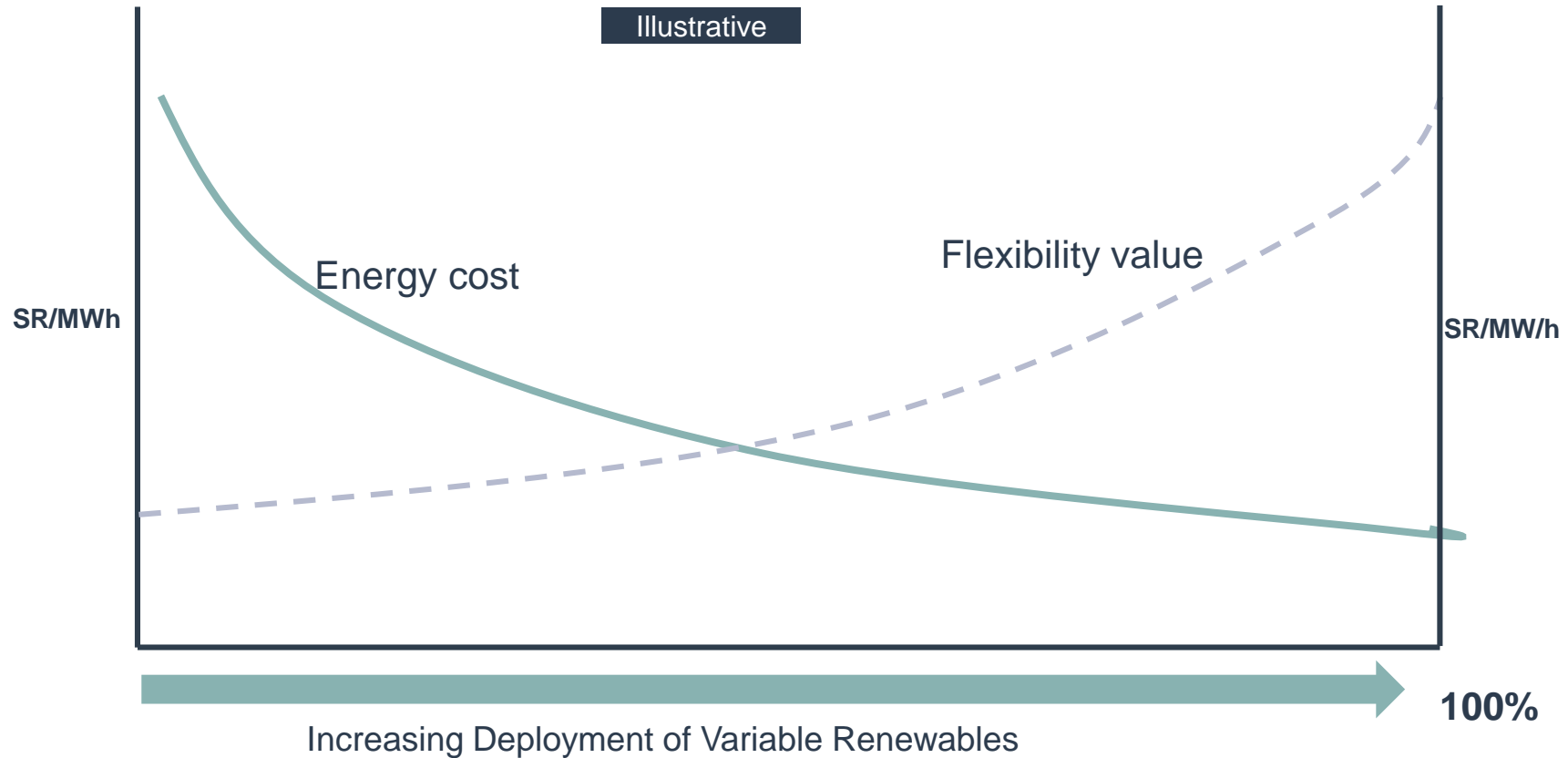


Energy Storage

- **Cost:** Storing energy for long periods is difficult and still expensive
- **Resource:** Geographic, and resource constraints make some proven technologies challenging



# THE MAIN IMPLICATION OF THE POWER BALANCING LAW GIVEN THE OPPORTUNITIES AND CHALLENGES OF A 100% RENEWABLE GRID IS THE HIGH COST OF “FLEXIBILITY”



**Energy** relates to generation costs and excludes additional cost for transport, distribution and losses.

**Flexibility** is inclusive of short-term balancing, ancillary services and energy profiling/shifting costs.



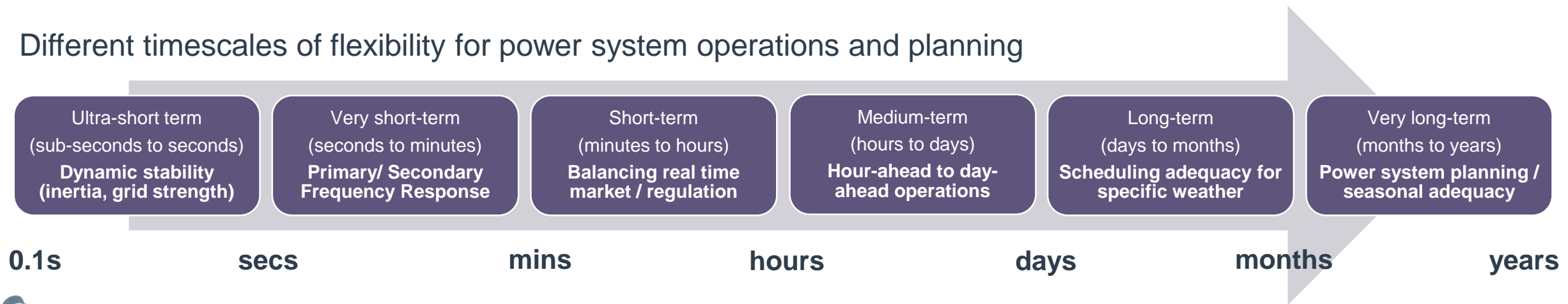


# WHAT IS POWER SYSTEM FLEXIBILITY?





International Energy Agency

‘Power system flexibility is one aspect of power system transformation (PST). It is the ability of a power system to **reliably** and **cost-effectively** manage the variability and uncertainty of **supply** and **demand** across **all relevant timescales.**’

Different timescales of flexibility for power system operations and planning



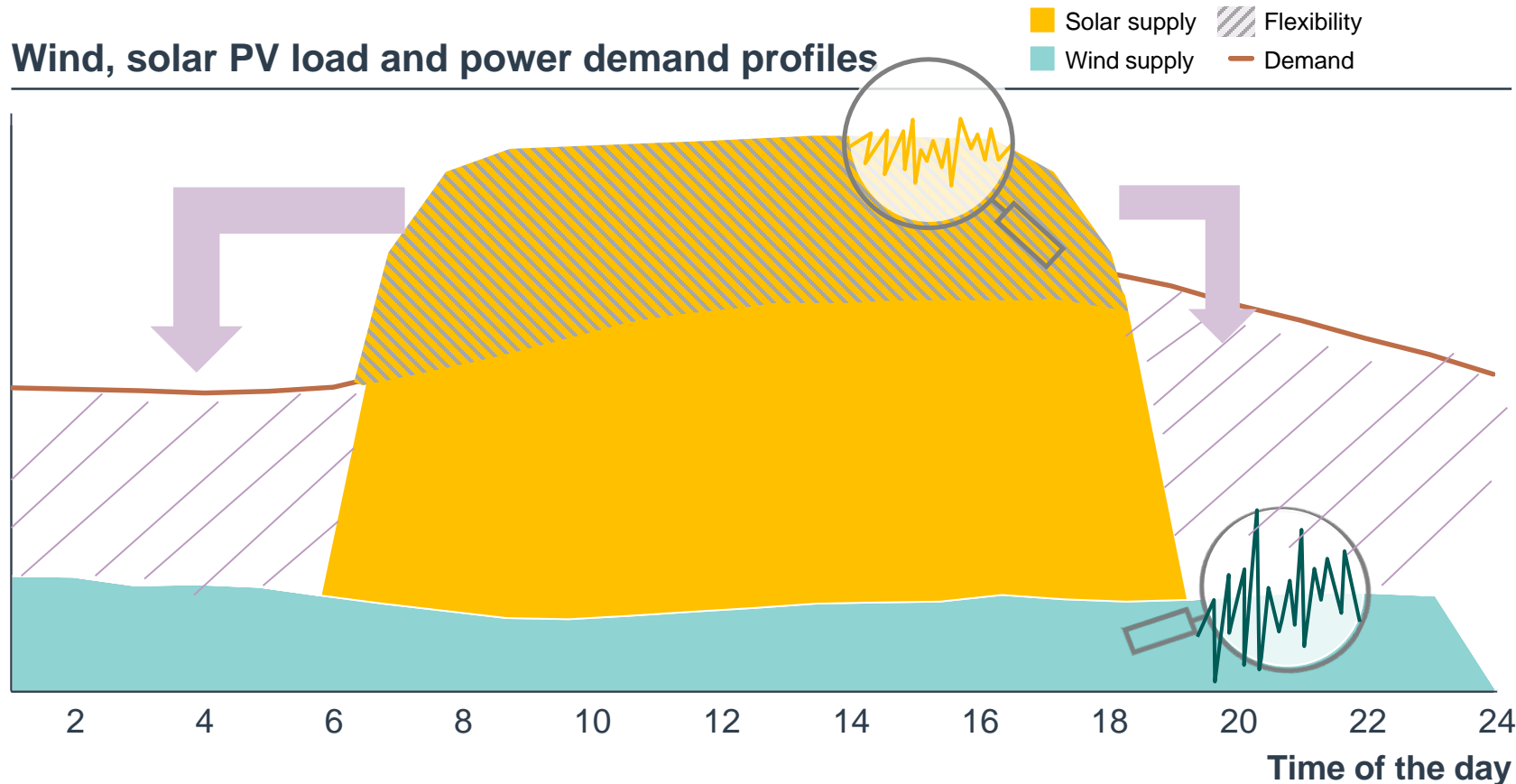
# FLEXIBILITY IS INTRINSIC TO THE MANAGEMENT OF ENERGY SYSTEMS AND HAS A VARIETY OF APPLICATIONS

	APPLICATION	PURPOSE
	Frequency and Voltage Regulation	Maintaining system frequency (50/60Hz) and voltage in safe operating conditions
	Energy Shifting	Deferring consumption and/or generation to optimal period for energy balancing , price arbitrage and/or avoiding curtailment
	Congestion and Constraints	Deferring significant investments in grid infrastructure and/or offering short term relief to overloaded grid systems
	Stability and Other Ancillary services	Ensuring resilience and stability of the grid system by maintaining inertia and planning for the underlying physics of the grid



# SUPPLY / DEMAND BALANCING

RENEWABLE BASED SUPPLY FLUCTUATE ACROSS TIMESCALES AND CHANGES IN WEATHER MAKING IT DIFFICULT TO MATCH DEMAND WHEN IT IS NEEDED AND REQUIRES STORAGE AND SYSTEM FLEXIBILITY



Even though load profiles and power demand are generally presented as average, actual load and demand includes continuous fluctuation

**Solar PV capacity only available during the day, while wind capacity is more stable and is available continuously throughout the 24h**

During the day, power consumption peaks are driven in part by

- **Temperature differential** increasing **cooling load** and,
- Increased **economic and social activity**

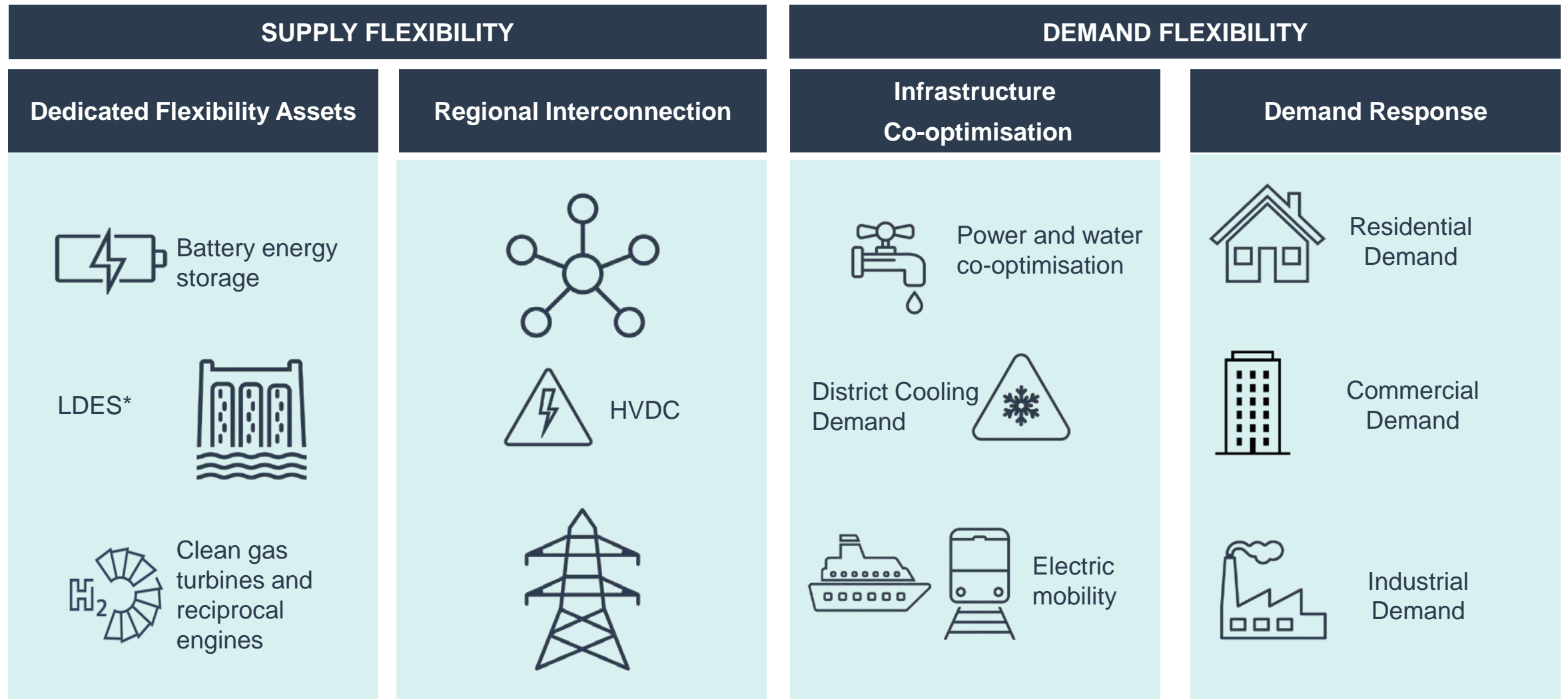
Additionally, **seasonal temperature changes drive different consumption profiles**

Solar-Charged Li/PHS can provide Off-peak supply at >2-3X cost of wind

**Customers carry the responsibility of optimizing the trade-off of cost & time-of-use objective with min intrusion from utility**



# NEOM EXPECTS TO INVEST IN FLEXIBILITY FROM MULTIPLE SOURCES TO DIVERSIFY RISK AND KEEP COST DOWN FOR THE CONSUMER



\*Long duration energy storage (including pumped hydro storage)

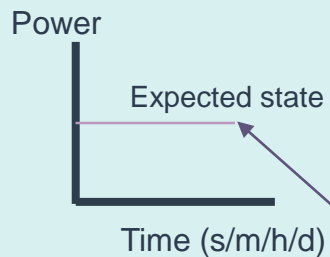




# HOW DOES FLEXIBILITY APPLY IN ENERGY SYSTEMS

‘The ability of an energy asset to effect a change in active/reactive power at a unique measurable point in the grid and sustain this for a predefined period based on a trigger’

## EXISTING STATE



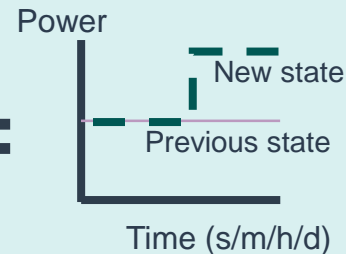
+

## TRIGGER

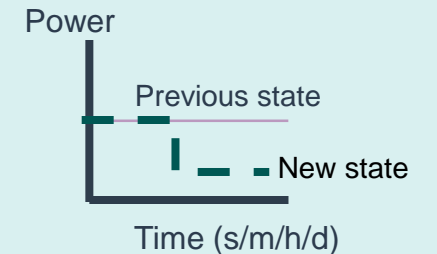


Technical and/or commercial trigger

=



OR



Baseline assumptions for existing/expected states are used to measure flexibility response. Baselining can be challenging with possible market gaming



# FLEXIBILITY IS CHARACTERIZED BY KEY DRIVERS THAT HELP DETERMINE VALUE TO THE POWER SYSTEM WHICH WILL ENABLE NEOM TO ASSESS THE OPTIMAL MERIT ORDER OF INVESTMENTS

## Flexibility Characteristic

## Value Driver



Speed of Response

The faster the better



Depth of Response

The bigger the better



Duration of Response

The longer the better



Location of Response

The nearer the better



Opportunity Cost

The lower the better



## Flexibility Investment vs Value Merit Order

*Investment*

Illustrative

Interconnection

Energy Storage

Industry

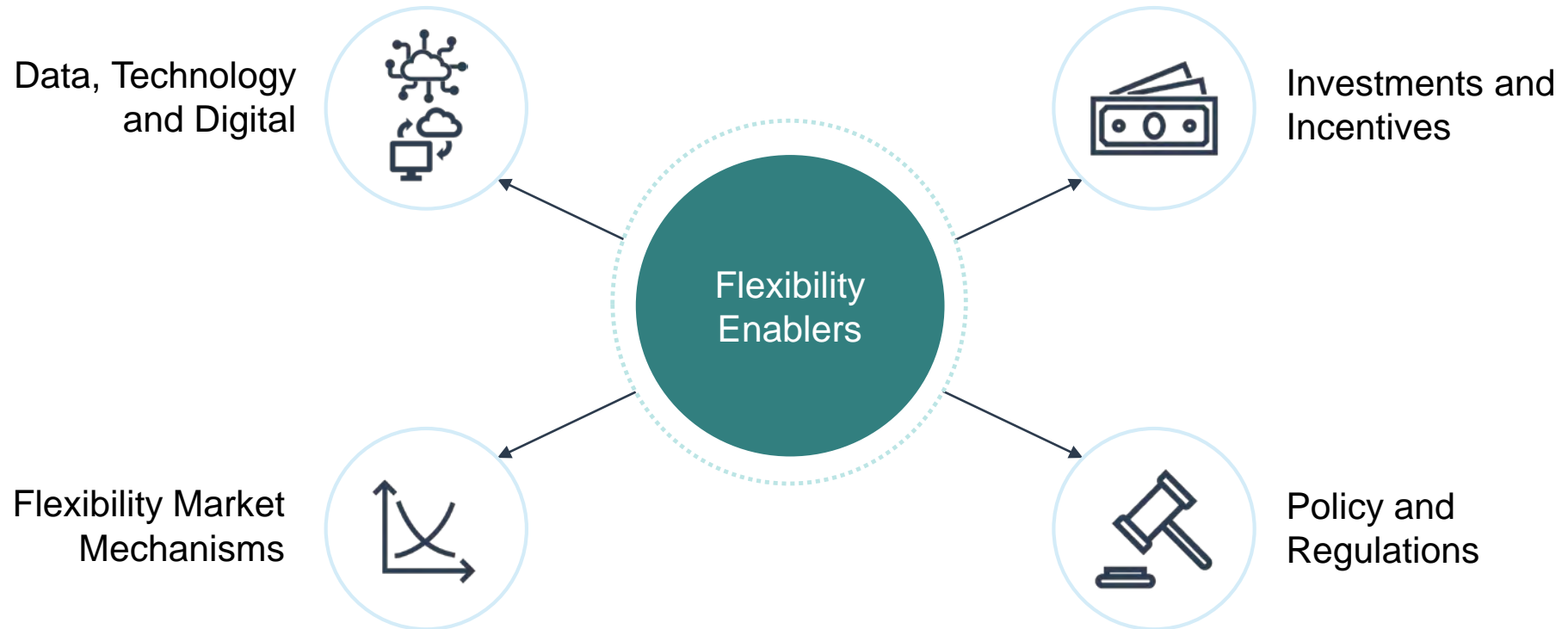
Building (Cooling, smart appliances)

Water

*Value*



# NEOM INTENDS TO UTILIZE A VARIETY OF LEVERS TO ENABLE FLEXIBILITY IN ITS GRID FOR THE LONG TERM

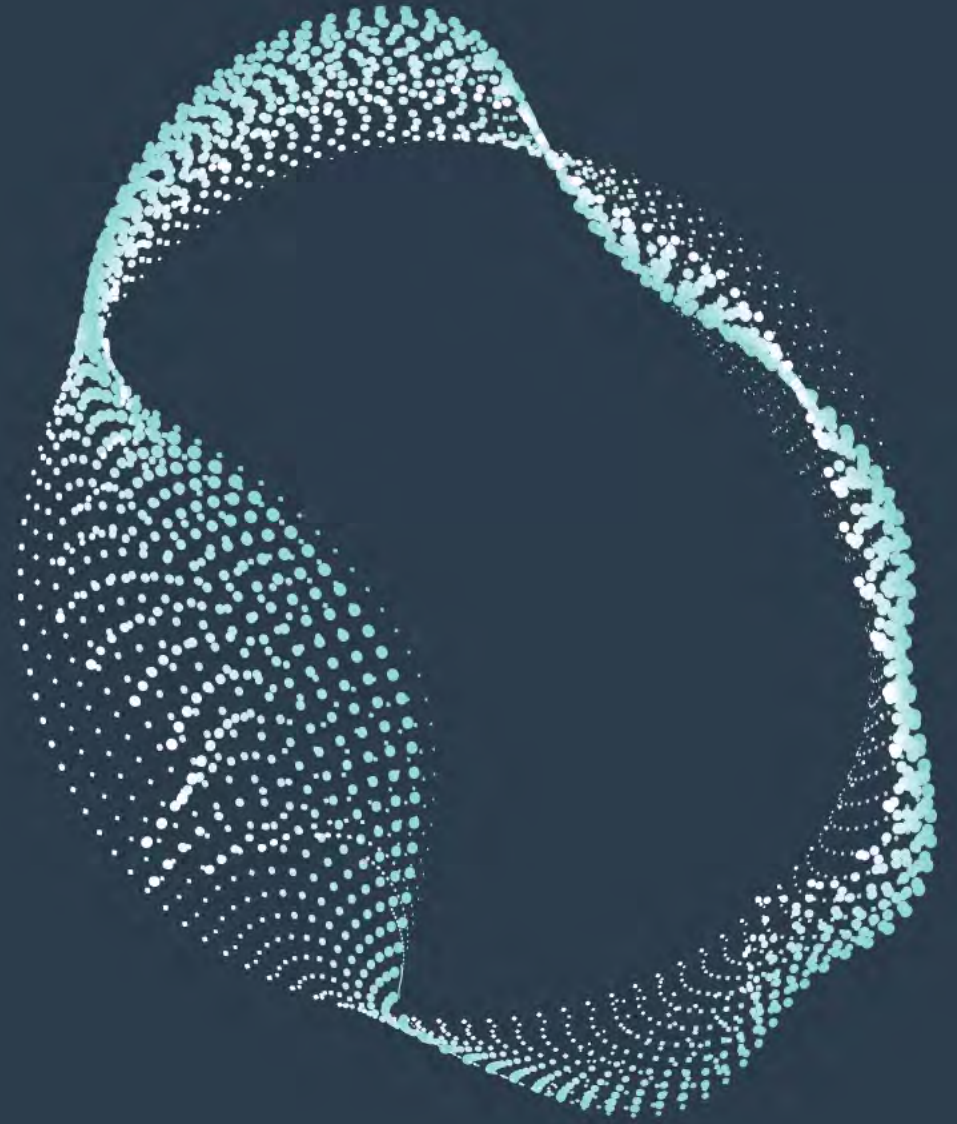


# THANK YOU

FRANCK BERNARD

DIRECTOR FLEXIBILITY  
CERTIFICATES – NEOM

[franck.bernard@neom.com](mailto:franck.bernard@neom.com)





# Flexibility and Resilience

## Overview of Recent Issues

Aidan Tuohy, PhD, Senior Program Manager

APEX Annual Conference

Oct 21, 2022

Dubrovnik, Croatia

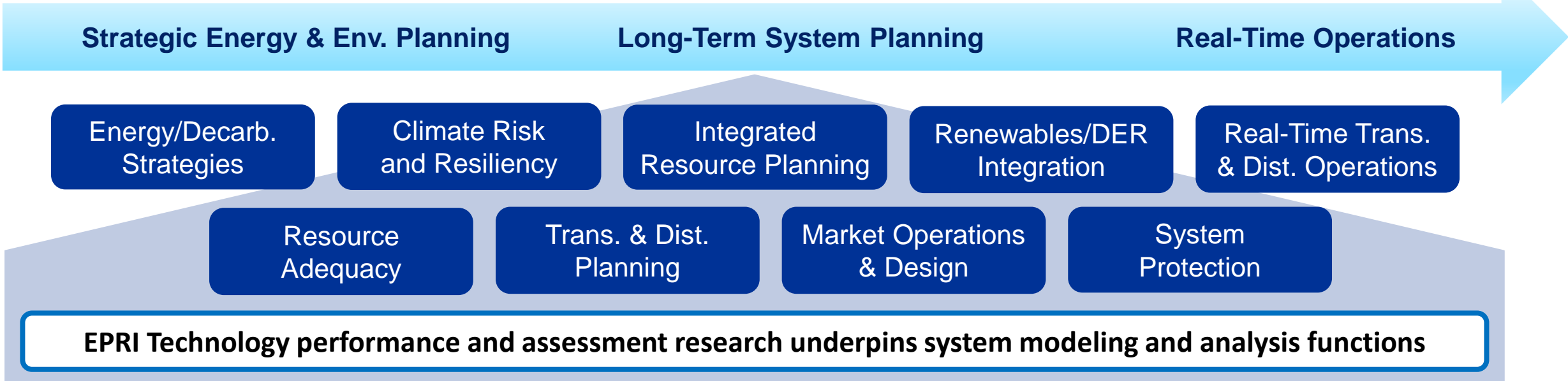


[www.epri.com](http://www.epri.com)


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# Integrated Grid & Energy Systems Planning/Analysis Scope




**Staff Expertise**




**145**  
Modeling & Grid Systems SMEs

**R&D Collaboration**



**90**  
Utility/ISO R&D Partners

**Applied Support**



**120**  
Utility Specific Applications (2021)

# Requirements for a Reliable, Resilient Decarbonized Grid

## New Grid Operation Capabilities

New protection, control, and other technologies to reliably and resiliently operate the grid



## Revised Market Designs

Markets must incent investment and properly compensate resources for grid services provided



## Grid Investment and Development

Adequate investment, supply chain, and workforce to develop extensive new supply, demand, and T&D resources

## Efficient Regulation and Collaboration

Faster timelines for siting, permitting, and building new infrastructure and developing and deploying new technology



## Integrated Planning for Reliability and Resiliency

Tools and processes for regional investment plans across electric and other energy systems in context of changing climate and other hazards

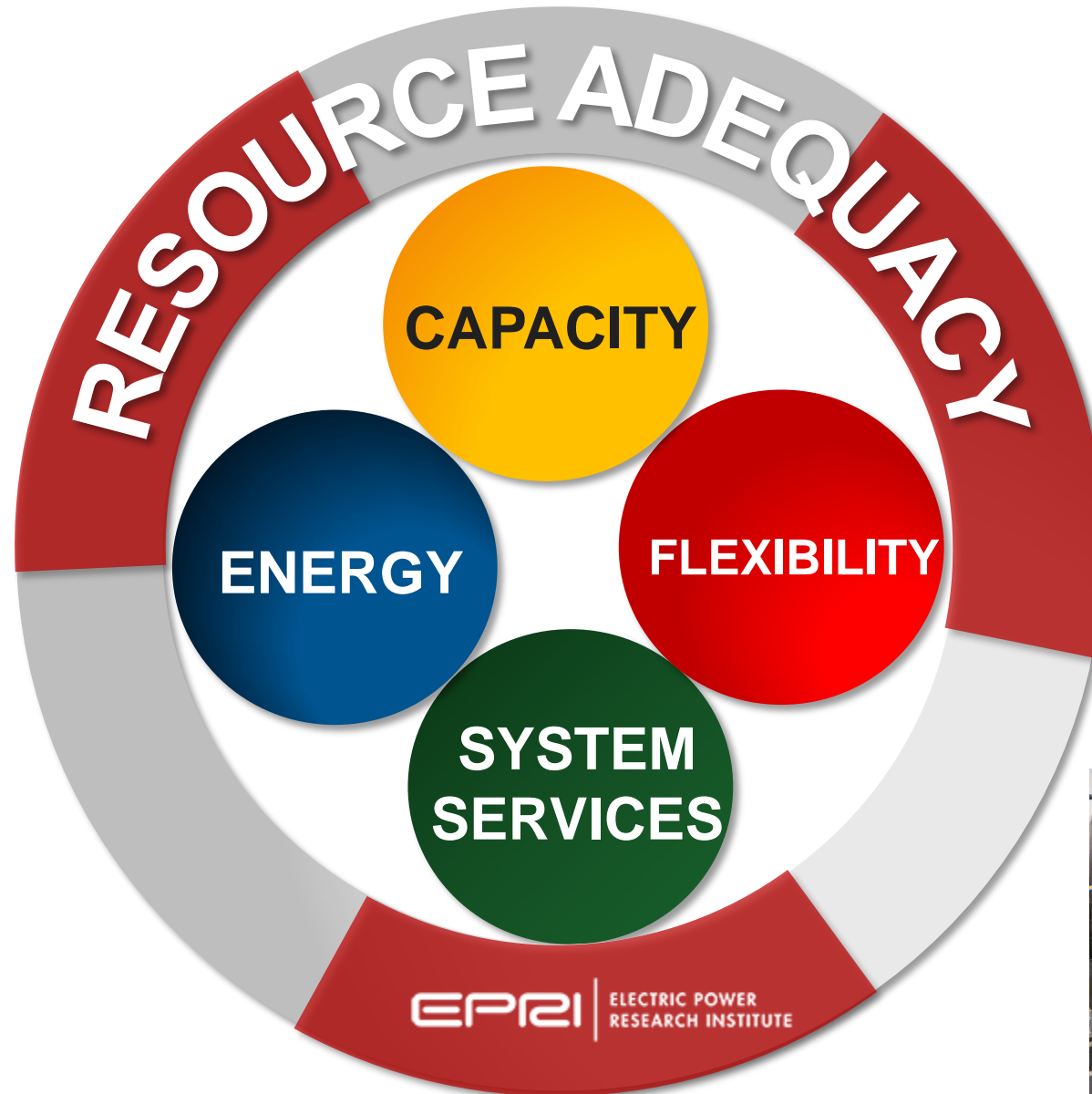


See EPRI, *Enhancing Energy System Reliability and Resiliency in a Net-Zero Economy*, 2022 ([link](#)) for more details

# What does it mean to have adequate resources?



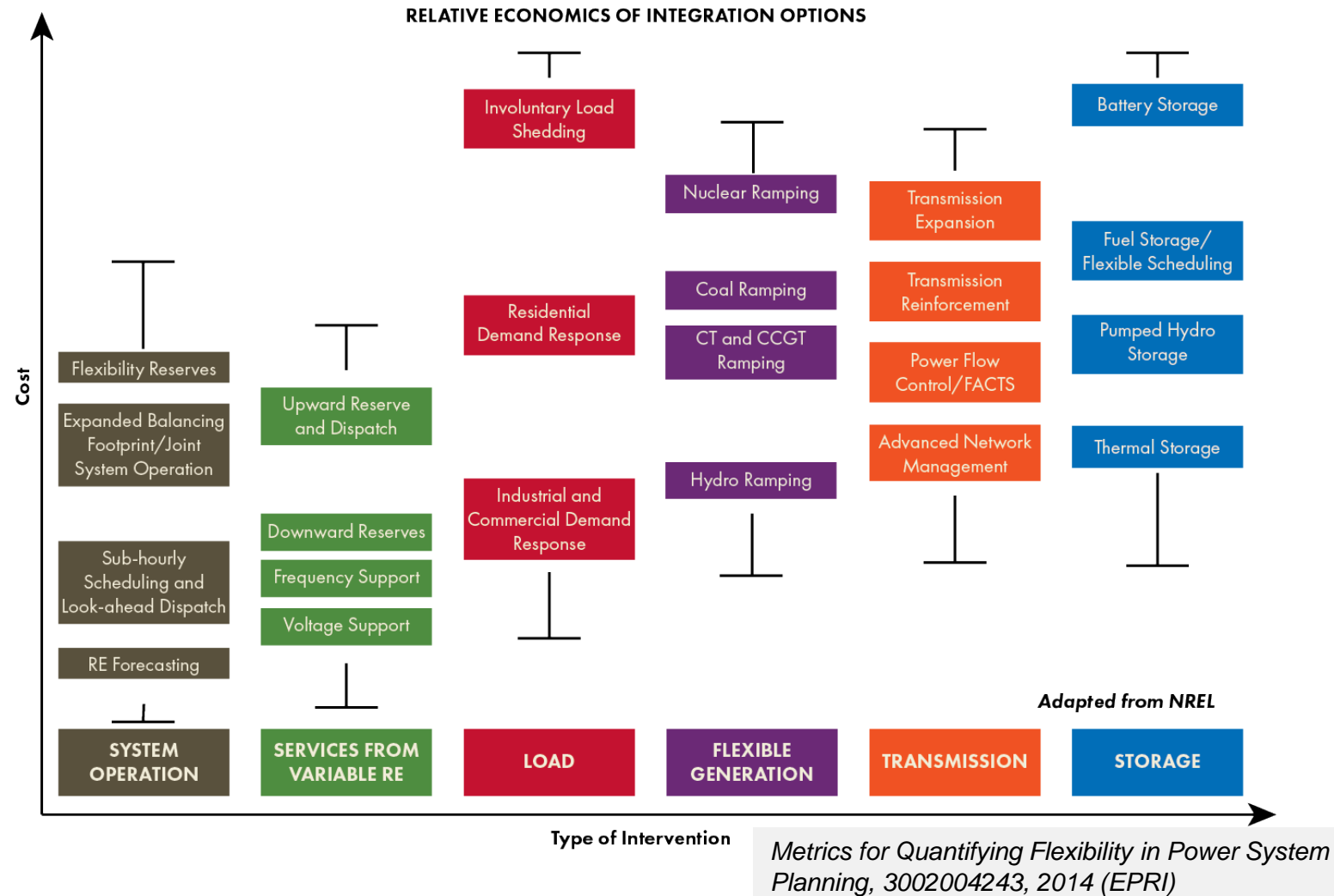
*An adequate supply fleet is not just the installed MW in the ground. The capacity must have energy to sustain during critical time periods, flexibility to accommodate condition changes, and sufficient reliability services to provide when necessary*





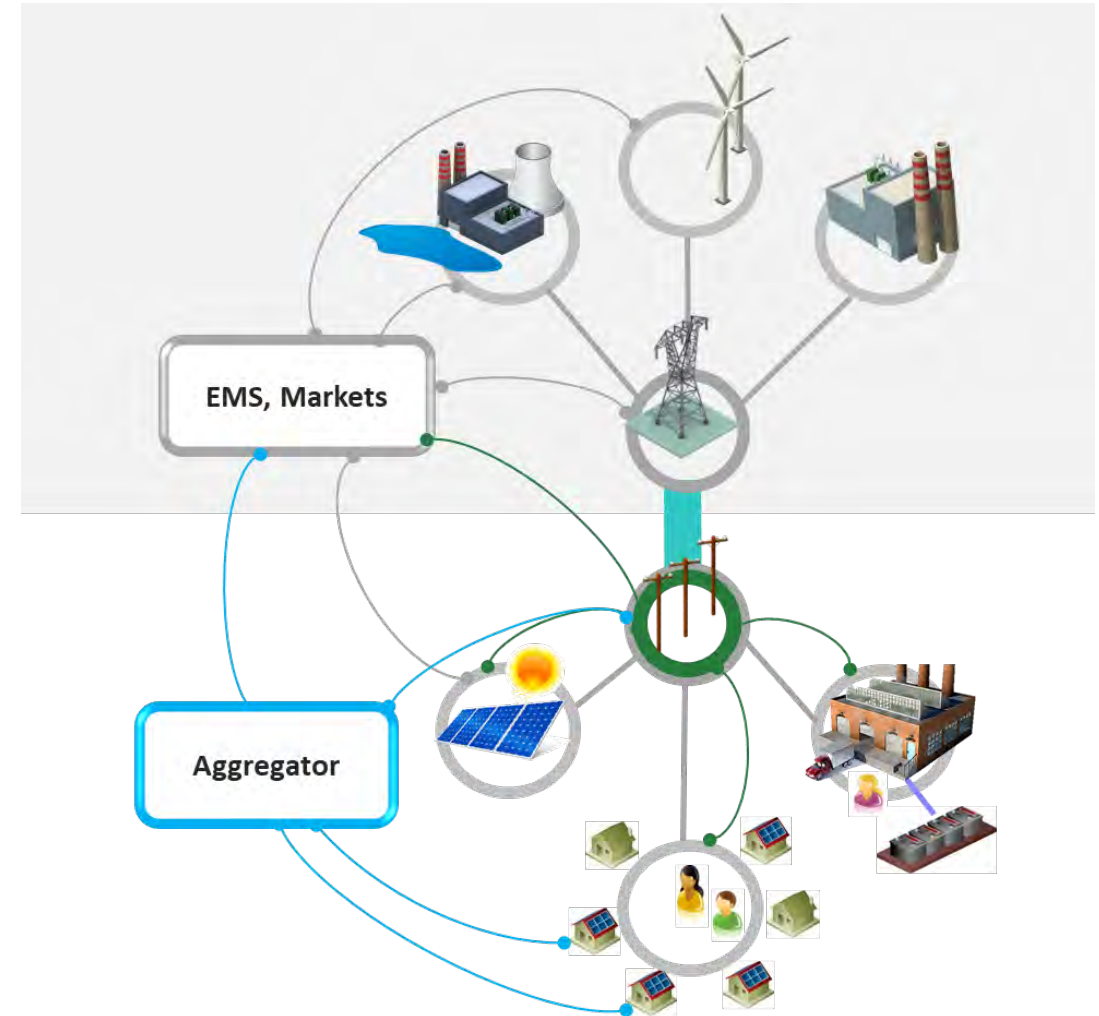
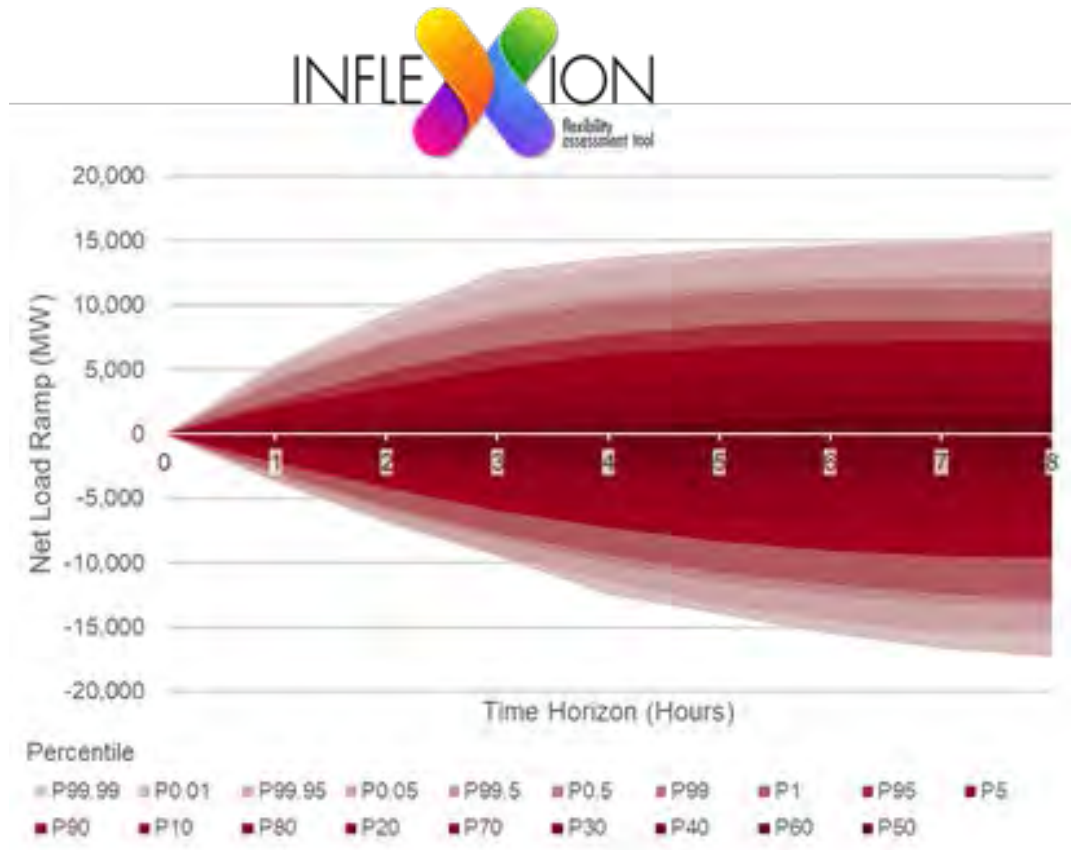
# Flexibility Will Become More Valuable

- Increasing variability and uncertainty will require flexibility on all time scales and at different spatial scales
- Different resources may contribute
  - DER, storage and inverter-based resources may provide some of the needed flexibility services
  - Retrofits and altered operational practices
- Wind/PV flexibility (with or without storage) increasingly important



EPRI working on flexibility tools and metrics to assess long term resource adequacy impacts

# Flexibility – measuring needs and obtaining services

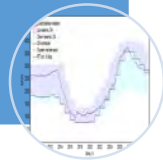


Need to be able to assess what is needed, and then get it from emerging resources

# Mechanisms to Incentivize Flexibility

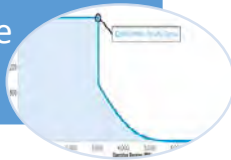
- Reduce costs and improve reliability with intelligence

Forecasted Reserve Requirements



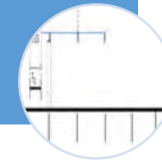
- Value reserve above minimum requirements

Operating Reserve Demand Curve



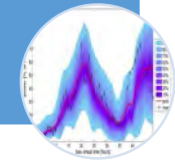
- Price opportunity costs of ramp

Multi-interval settlement



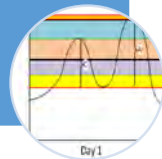
- Represent uncertainty explicitly

Stochastic models, smart reserve



- Make sure flexibility is built in the first place

Forward Flexible Capacity Attribute Procurement



- Let demand provide flexibility

Real-time pricing, retail alignment and automation



- Transparency leads to innovation

Price Formation

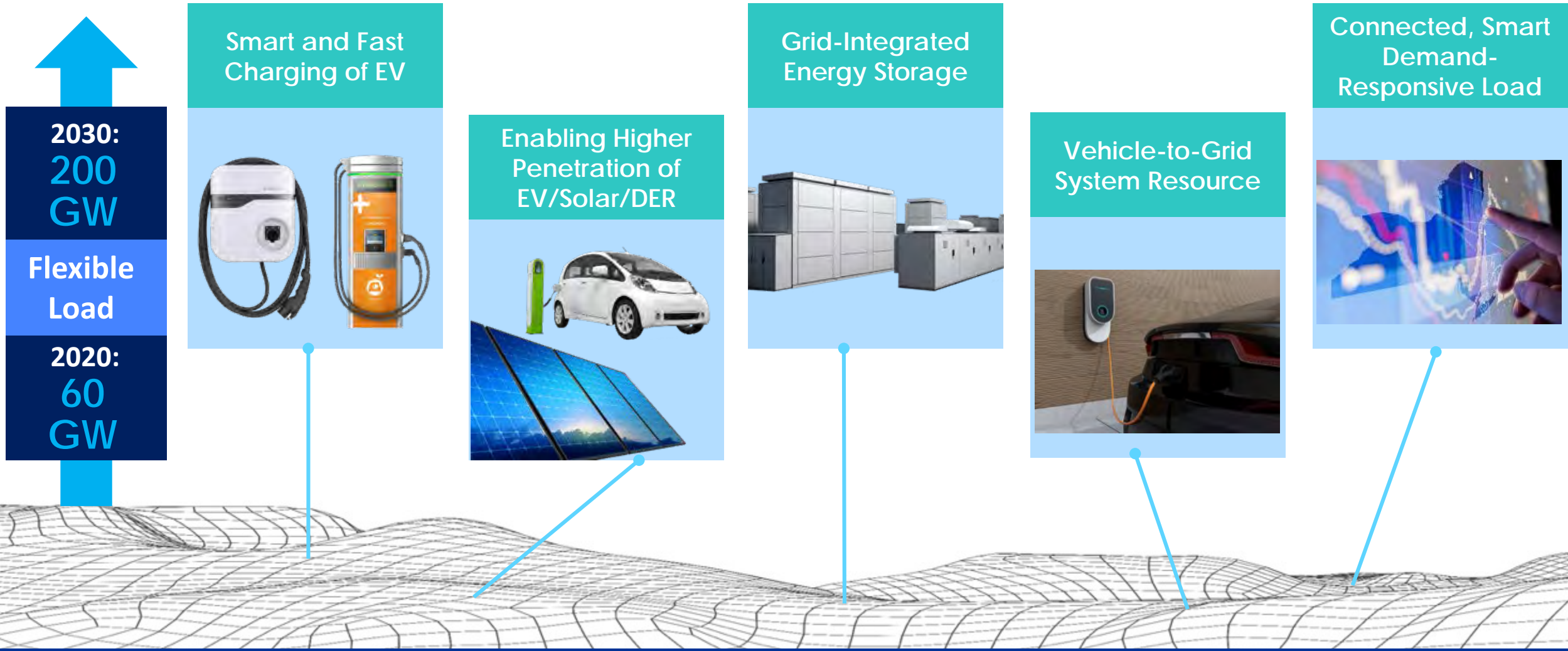


- Reduce uncertainty directly

Enhanced Forecasting



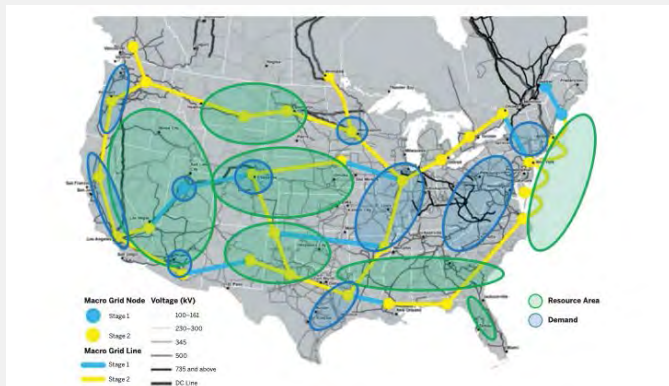
# Distributed Resources for Grid Flexibility



**2020 Brattle study estimates potential U.S 2030 load flexibility at 200 GW – 20% of peak load.**



# Role of Interconnections



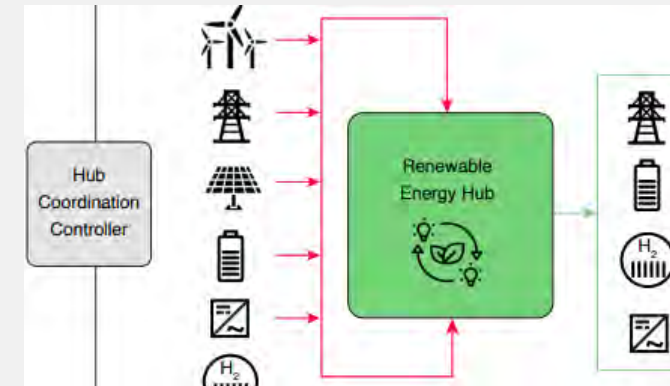
## Macrogrid ideas

- Allow for broad sharing of clean energy sources
- Diversity of demand and production
- Resilience to extremes



## Build out of HVDC

- Need to determine which lines provide most benefit for reliability/resilience
- Links to local and regional networks



## Energy hubs

- Very different electrical requirements
- Interoperability and standards can support

Potential for significant benefits to linking different regional grids



EPRI 50<sup>th</sup>

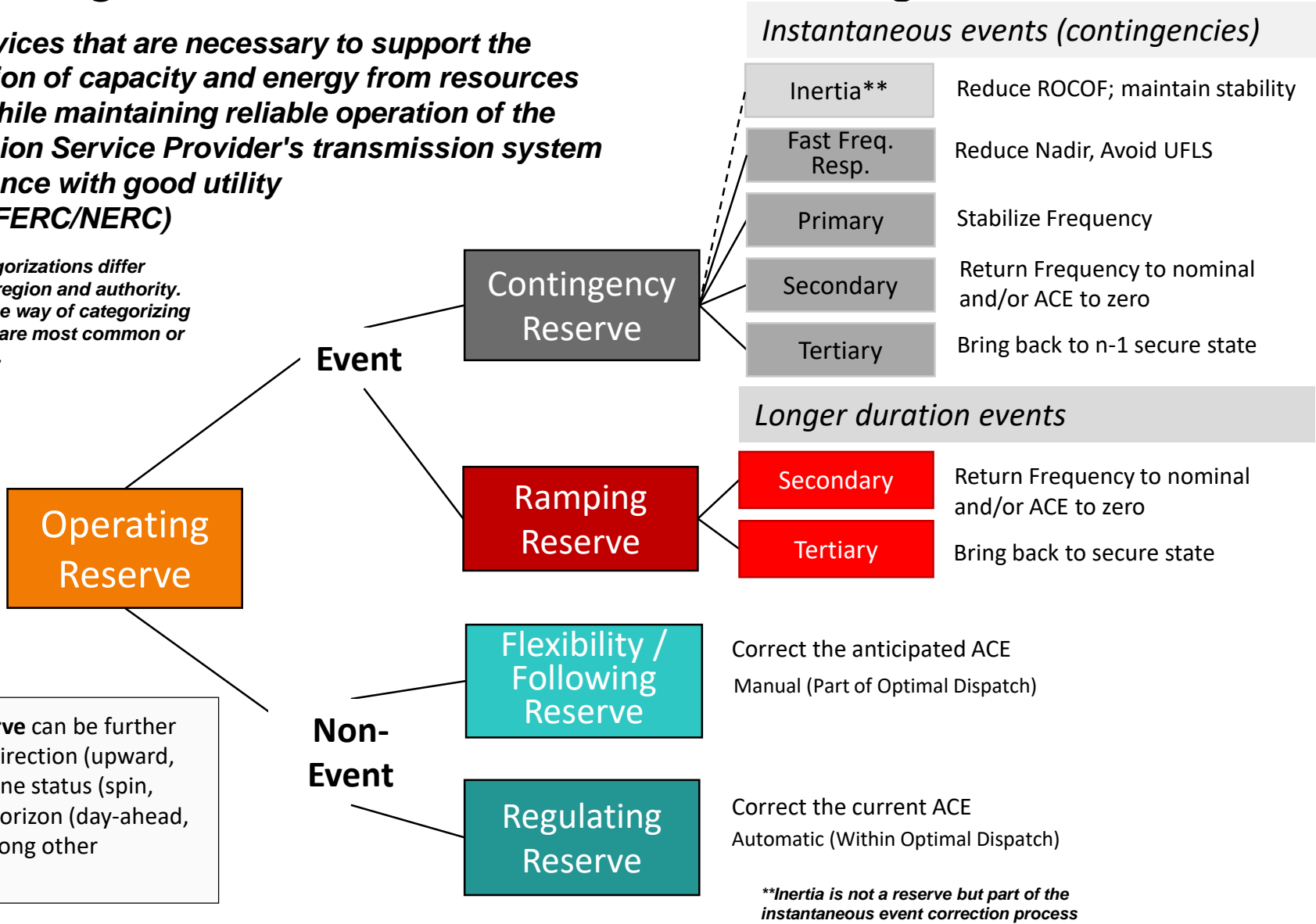
ANNIVERSARY

Together...Shaping the Future of Energy<sup>®</sup>

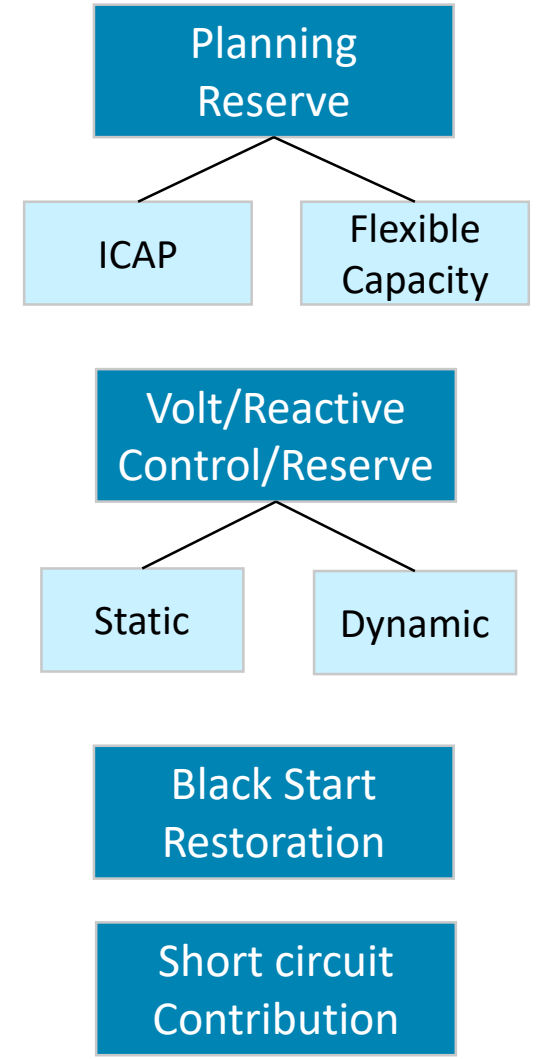
# Ancillary Services\* (Bulk Power System)

Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice. (FERC/NERC)

\*Terms and categorizations differ substantially by region and authority. This is simply one way of categorizing using terms that are most common or most descriptive.



Operating Reserve can be further categorized by direction (upward, downward), online status (spin, non-spin), and horizon (day-ahead, hour-ahead) among other characteristics.

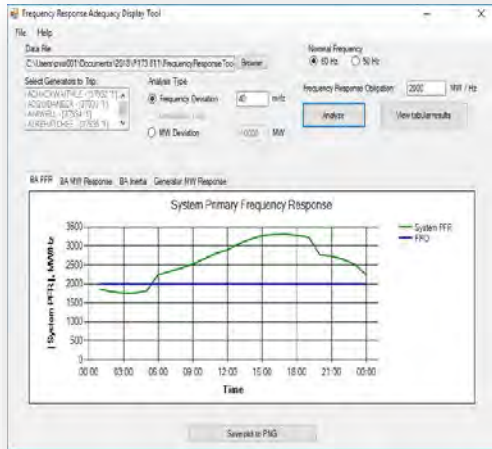


\*\*Inertia is not a reserve but part of the instantaneous event correction process

# Renewable Integration Reliability Assessment

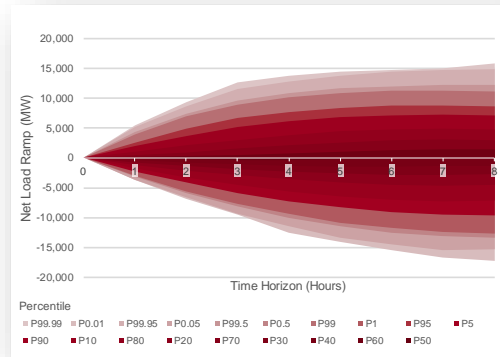
*How much \_\_\_ is needed?*

## Frequency Response

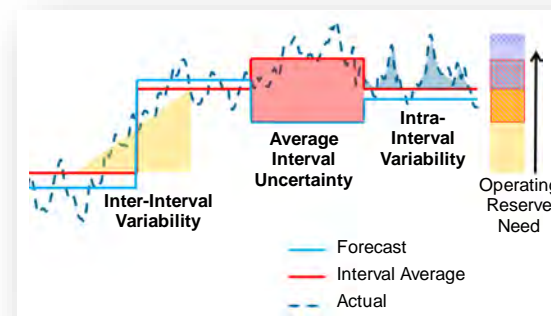


FRADT

## System Flexibility



## Operating Reserve



DynADOR

## System Strength

Simple SCR		
Thevenin Impedance Magnitude (pu)	SCC MVA	SCR
0.653507	155.6983	6.227933
1.129373	90.31558	11.28945
0.649164	157.1251	6.285003
0.326675	306.1143	2.448914
0.348464	286.9736	2.452766
0.22936	435.9957	2.62648

GSAT

These tools can support both planning and operations applications

- Study future scenarios and reliability and economic impacts with utilities
- Input or output of operational simulation tools
- How much is needed? How much will I have?





# Importance of Flexibility in a Changing Resource Environment

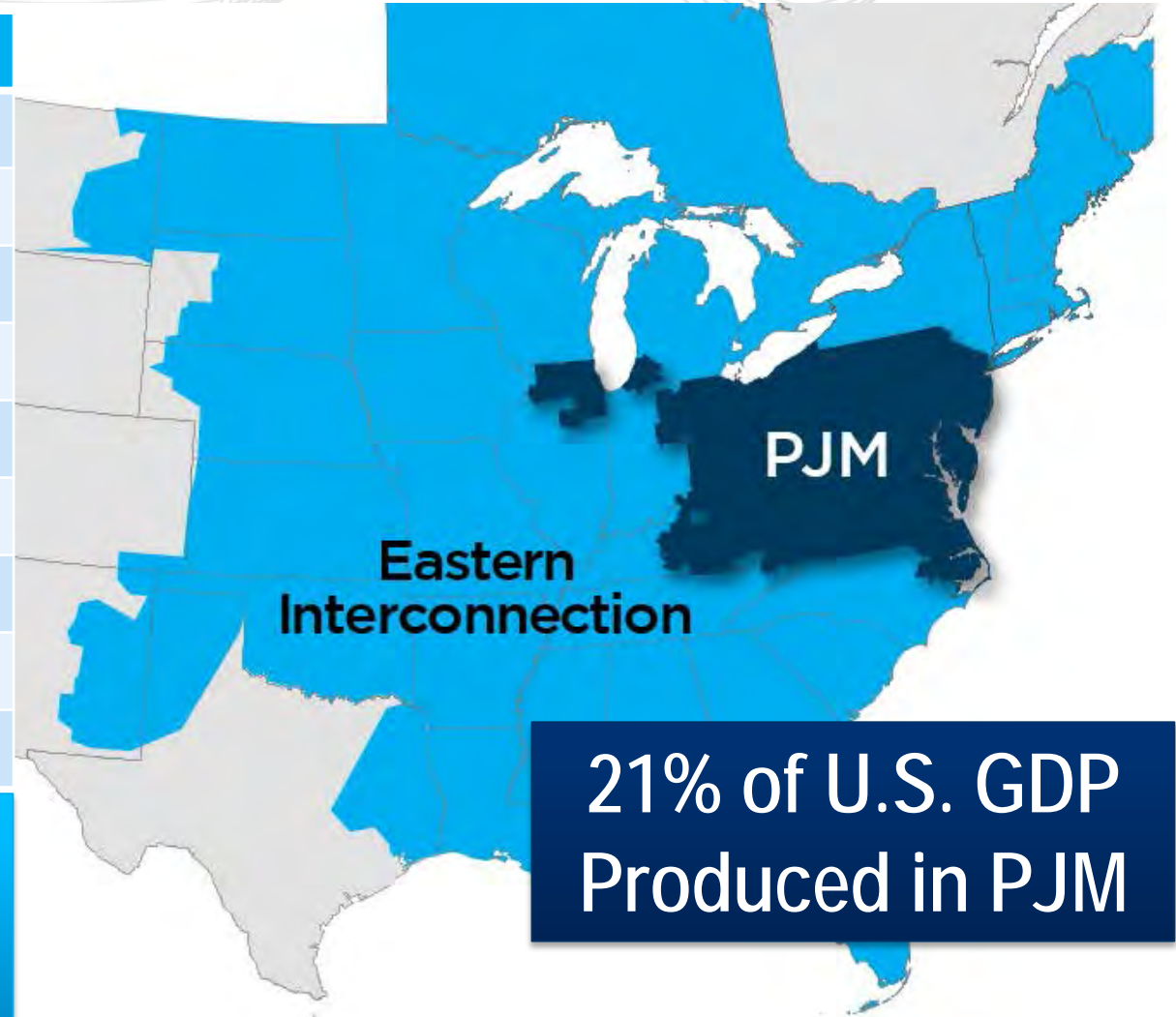
APEX October 2022

Tim Horgner  
PJM Interconnection L.L.C.  
Senior Director, Forward Market Operations &  
Performance Compliance

## Key Statistics

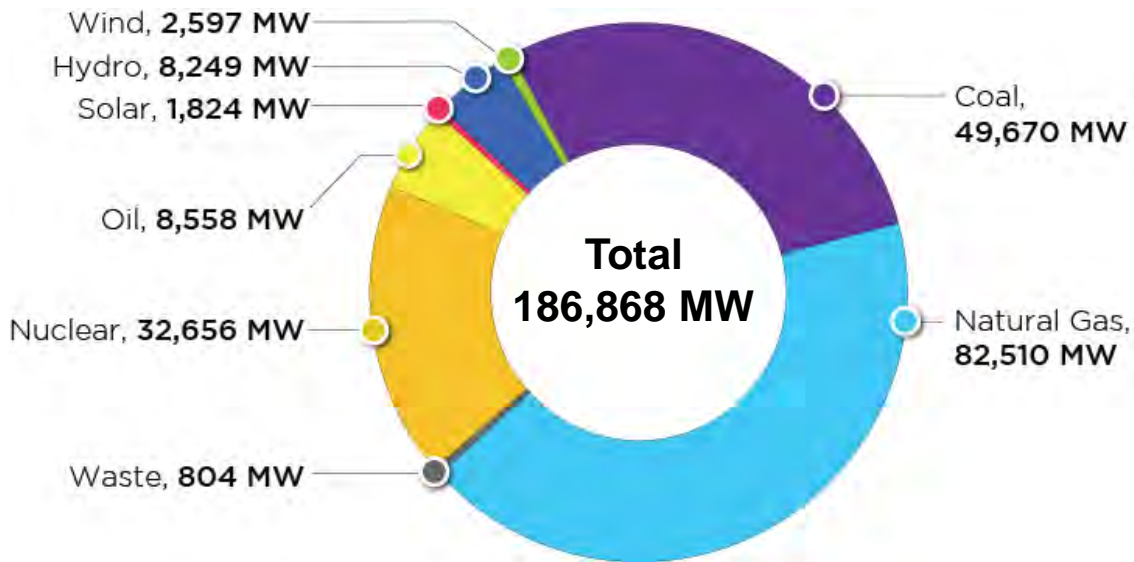
Member companies	1,060+
Millions of people served	65
Peak load in megawatts	165,563
Megawatts of generating capacity	185,442
Miles of transmission lines	85,103
2020 gigawatt hours of annual energy	782,683
Generation sources	1,436
Square miles of territory	368,906
States served	13 + DC

- 26% of generation in Eastern Interconnection
- 25% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection

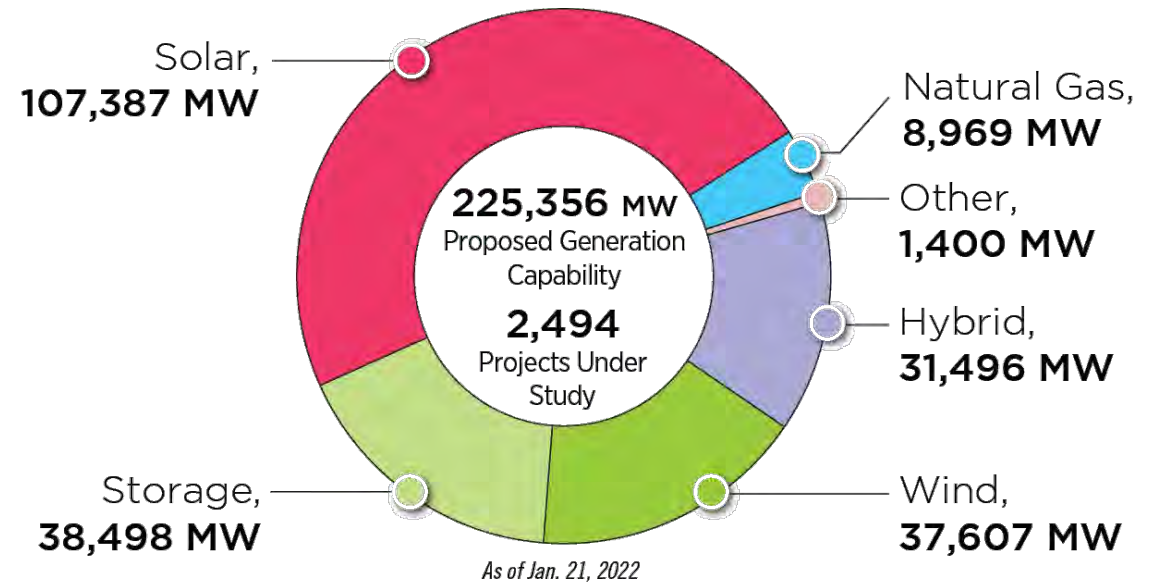


As of 2/2022

## PJM Existing Installed Capacity Mix

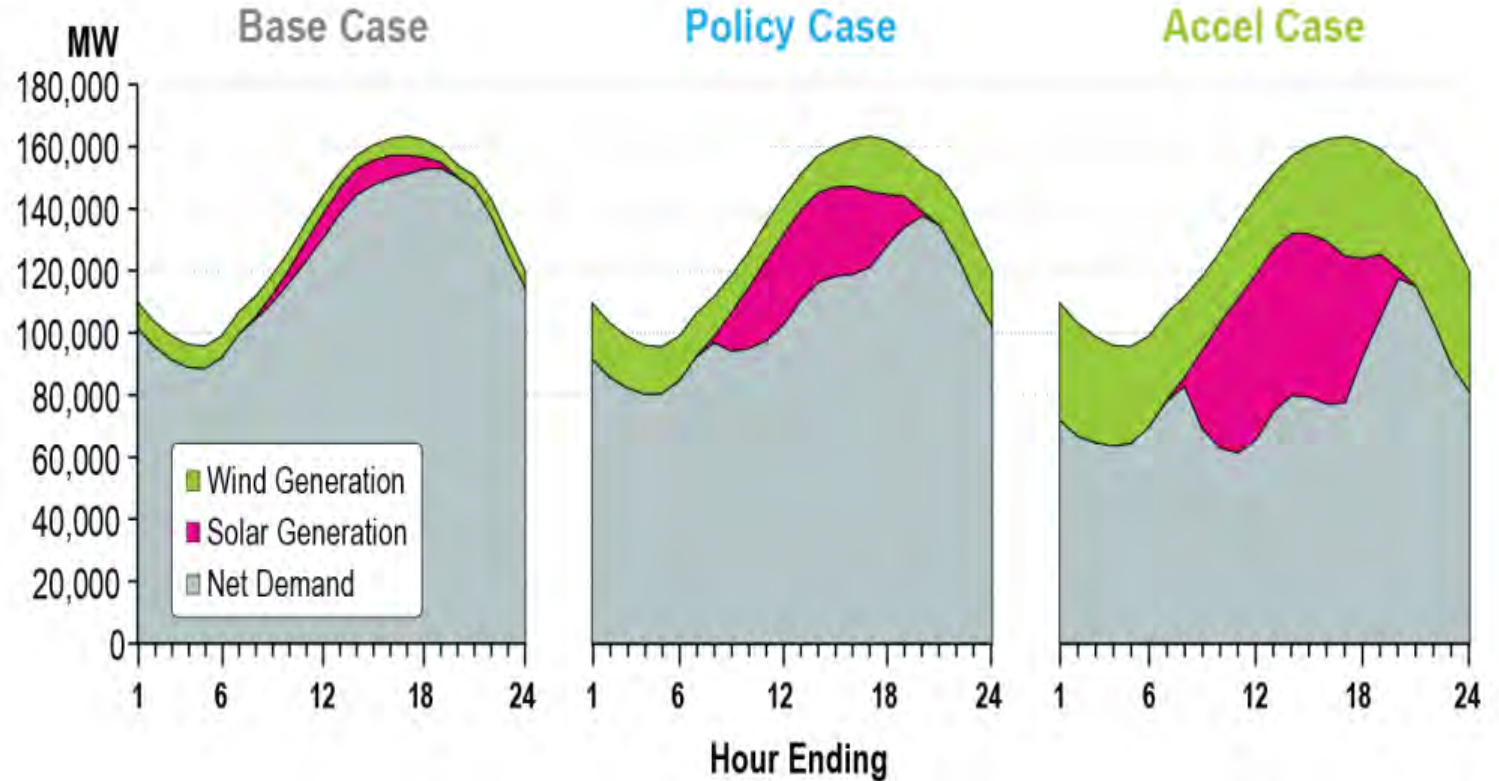
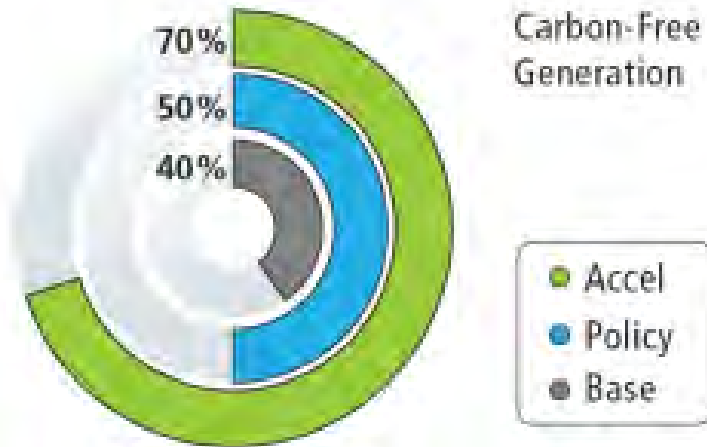


## Current Interconnection Queue



**Key Point: Significant shift to cleaner resources is expected in PJM Region.**

## Annual Assumption of PJM Energy from Carbon-Free Resources



**Key Point: The peak load level and ramping needs shifts with an increase in renewables.**



**Flexibility is the ability for a resource to quickly, accurately and predictably:**

- change output/consumption in response to a signal, and/or
- come online/offline in response to a signal.

## Flexible Resources

- Thermal
- Pumped Hydro
- Demand Response
- Storage/Hybrid

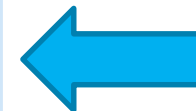
## Inflexible Resources

- Solar
- Wind

*Important for Reliability*



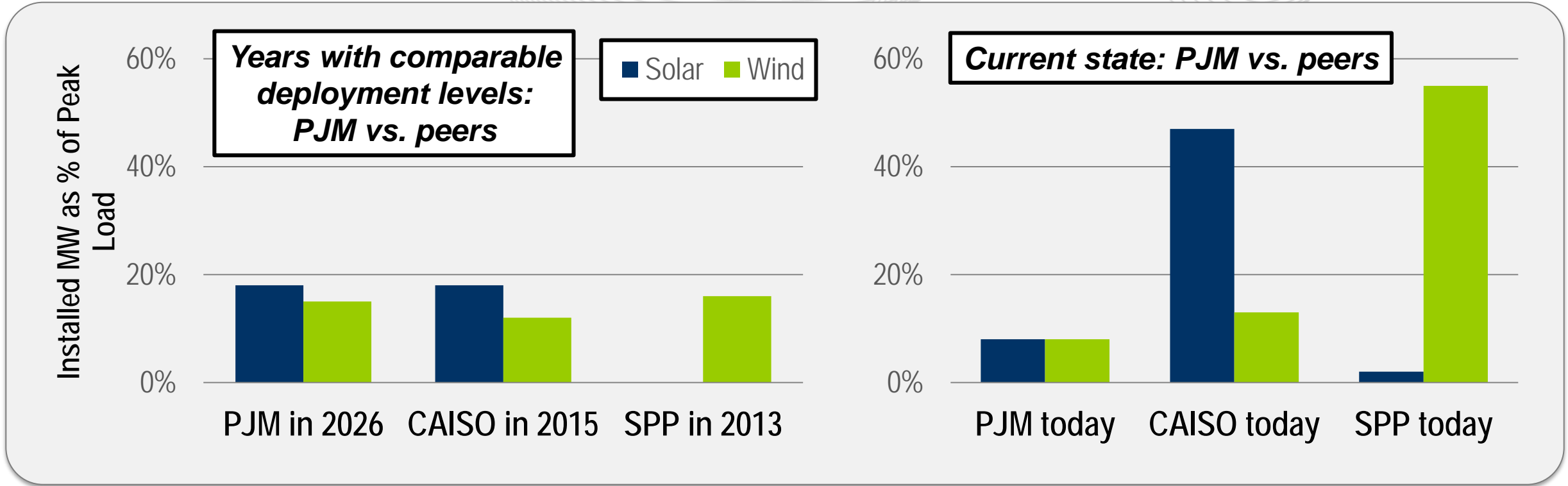
*Important for Environment*



*Lower Costs*

**Key Point: Maintaining Incentives for Flexibility is critical as resource mix shifts**

# Where is PJM compared to peers?



**Key Point: PJM has time for preparing for the resource shift and can learn from others**

Up and Down  
Regulation signals  
(minimizes min gen  
impacts)

Optimization of  
storage schedules

Resource flexibility  
requirements

Demand Response



Sloped Reserve  
Demand Curves

Enhance interaction of  
wind and solar  
forecast/bids/curtailment  
with constraint  
management

Regulation for  
wind/solar

Intraday unit  
commitment: more  
frequent updates,  
more granular

Other Ideas?

New  
Technologies

Research

Enhance forecasting

Derate renewables with  
higher deployment



# Flexibility & Resilience

APEX

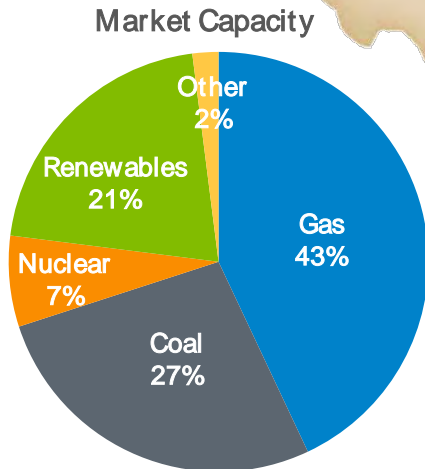
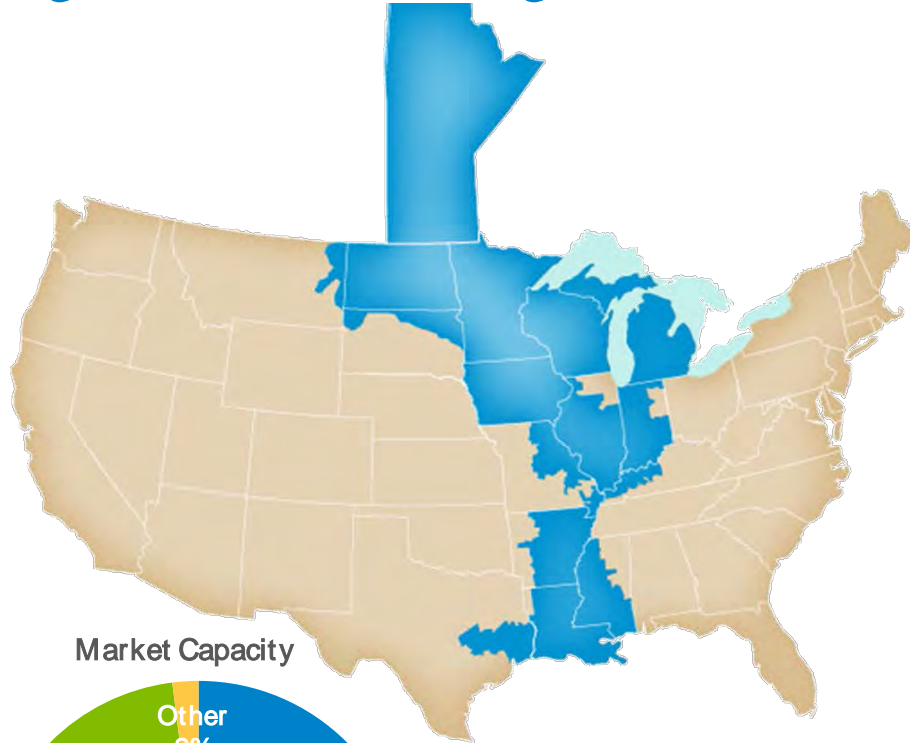
Wayne Schug

MISO

October 21, 2022



# MISO is an independent, not-for-profit Regional Transmission Organization serving 15 U.S. states and one Canadian province



## What we do

- ❖ Provide independent transmission system access
- ❖ Deliver improved reliability coordination through efficient market operations
- ❖ Coordinate regional planning
- ❖ Provide a platform for wholesale energy markets

## MISO by the numbers\*

High Voltage Transmission	65,800 miles**
Generation Capacity	205,177 MW
Peak Summer System Demand	130,917 MW
Customers Served	42 Million

# Executive Summary



- Aggressive decarbonization strategies and accelerated policies are driving rapid change in our region
- As the evolution of the resource fleet accelerates, variability is increasing, and attributes required to reliably operate the system are diminishing
- Traditional methods (e.g., static reserve margins) used to ensure resource adequacy do not capture the emerging dynamic fleet risks
- Policymakers and the financial community are not supporting the required investment in controllable resources to manage the transition
- We must develop a coordinated transition plan to reliably navigate from the present to the future

# The MISO Region's accelerated resource transformation is creating a future that is both more complex and less predictable

## Past

- Primarily controllable resources
- Ample reserve margins
- Predictable resource outages
- Relatively predictable weather
- Focus on providing energy in *the worst peak load hour* during the summer

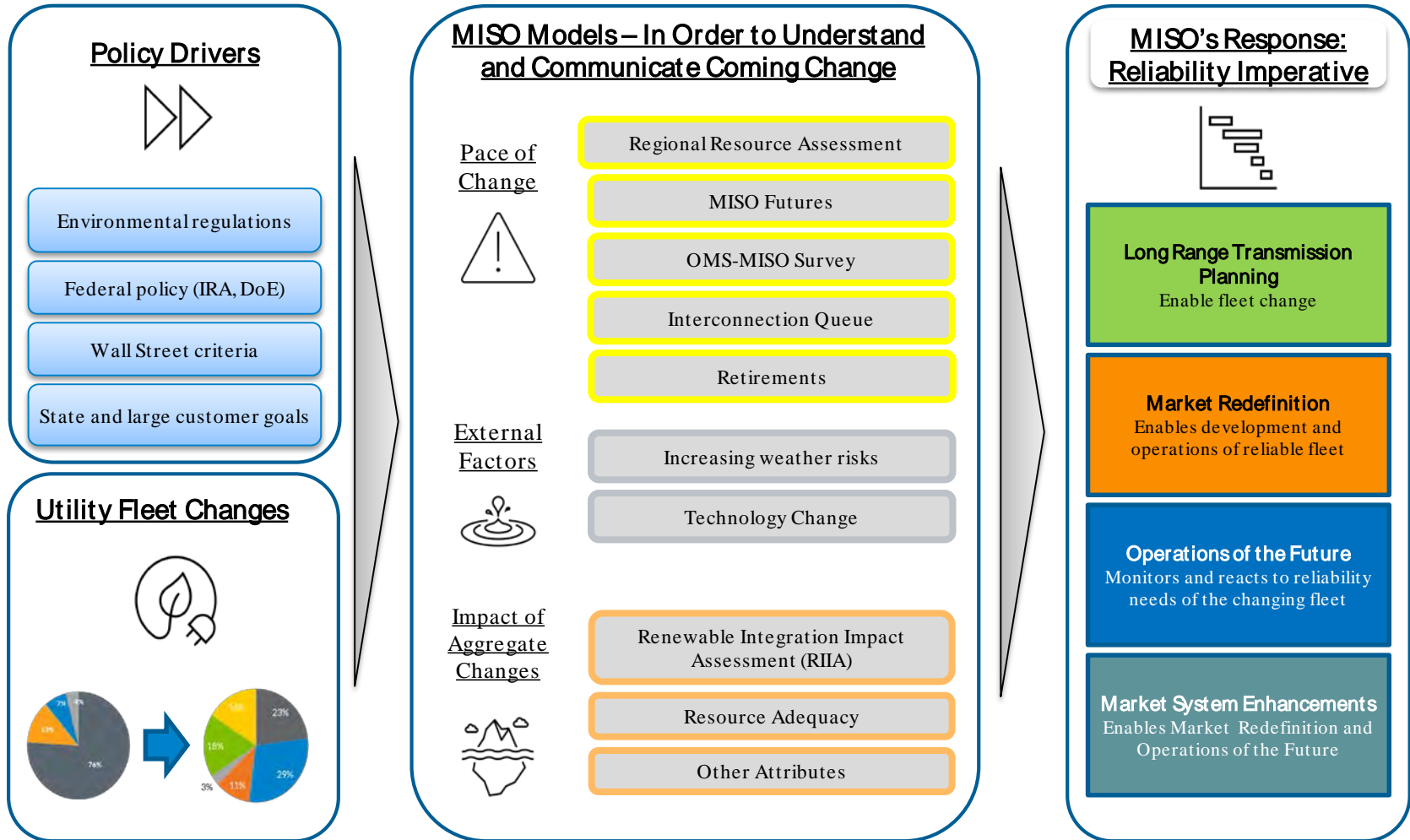
## Present

- Transitioning resource mix
- Tightening reserve margins
- Less predictable resource outages or unavailability
- Growing uncertainty in weather conditions
- Greater inter-dependence between utilities, states, and RTOs
- Focus on providing energy on *the worst day in each season*

## Future

- Primarily weather-dependent resources
- Risk-adjusted reserve margin requirements
- Less predictable resource outages or unavailability
- Less predictable weather
- Increasing scarcity of essential reliability attributes
- Increasing electric load
- Increasing importance of accurate load and renewable forecasting
- Focus on providing energy for *the worst week in each season*

# To maintain reliability during the energy transition, MISO must understand and what changes are coming (and when), understand the implications of the changes and prioritize work to both influence and prepare for the changes



## Policy Drivers



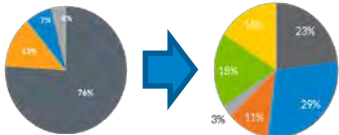
Environmental regulations

Federal policy (IRA, DoE)

Wall Street criteria

State and large customer goals

## Utility Fleet Changes



## MISO Models – In Order to Understand and Communicate Coming Change

Pace of Change



Regional Resource Assessment

MISO Futures

OMS-MISO Survey

Interconnection Queue

Retirements

External Factors



Increasing weather risks

Technology Change

Impact of Aggregate Changes



Renewable Integration Impact Assessment (RIIA)

Resource Adequacy

Other Attributes

## MISO's Response: Reliability Imperative



**Long Range Transmission Planning**  
Enable fleet change

**Market Redefinition**  
Enables development and operations of reliable fleet

**Operations of the Future**  
Monitors and reacts to reliability needs of the changing fleet

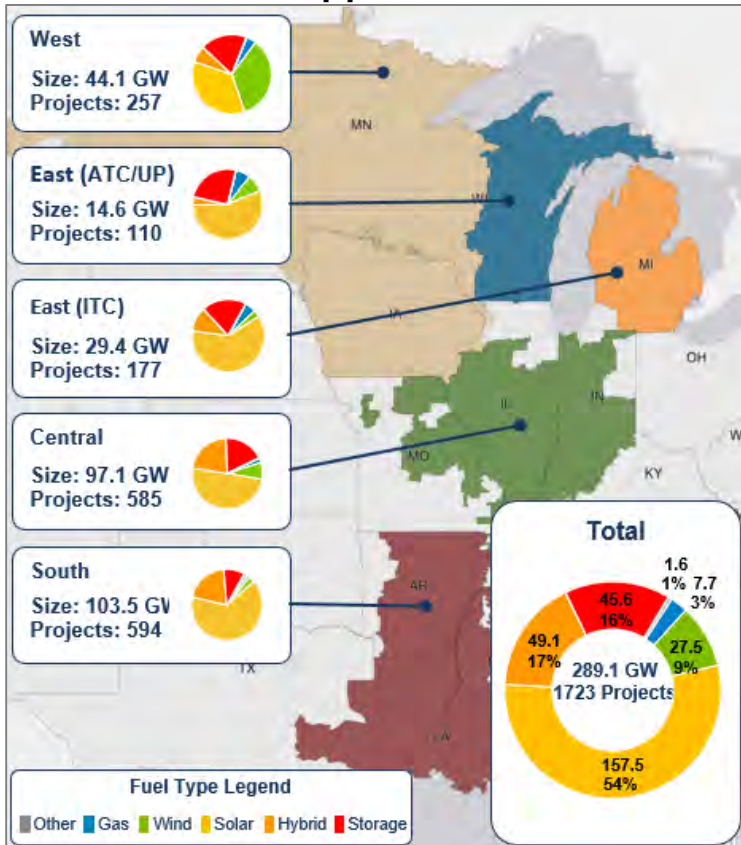
**Market System Enhancements**  
Enables Market Redefinition and Operations of the Future



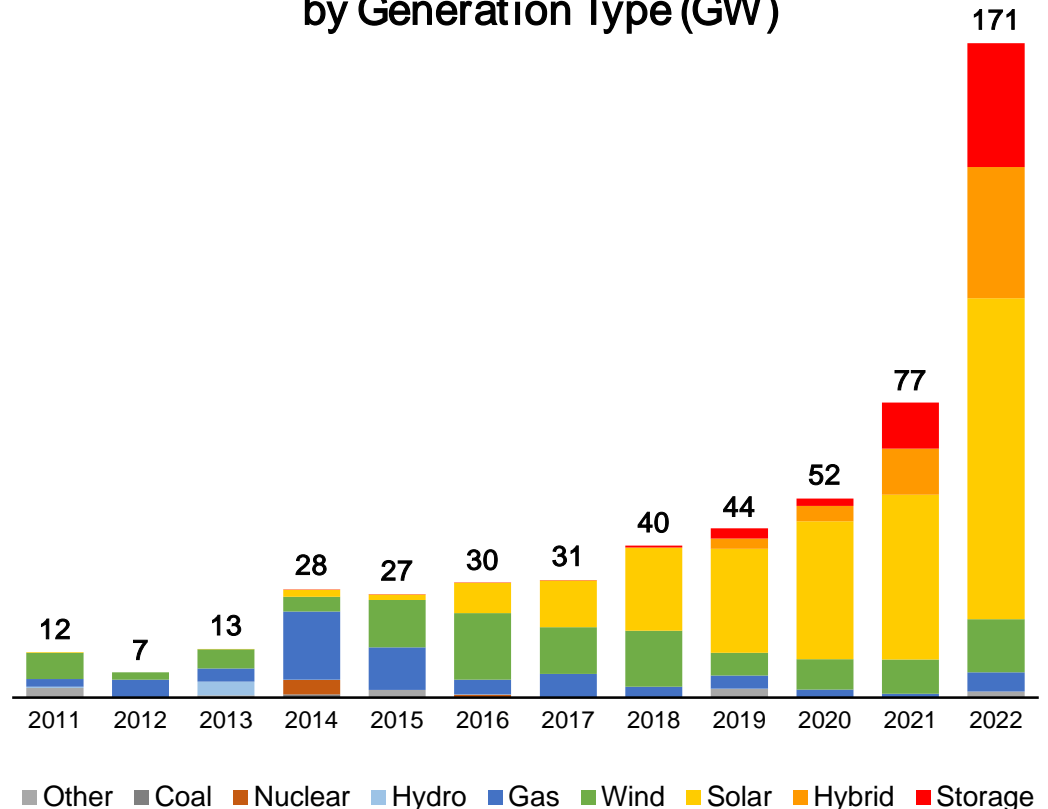
# MISO's 2022 interconnection queue reveals continued growth in renewable resources, growth in limited duration storage resources, and relatively few resources with long duration dispatchability

NOTE – All values shown in Nameplate Capacity

## MISO Active Queue plus 2022 Applications\*



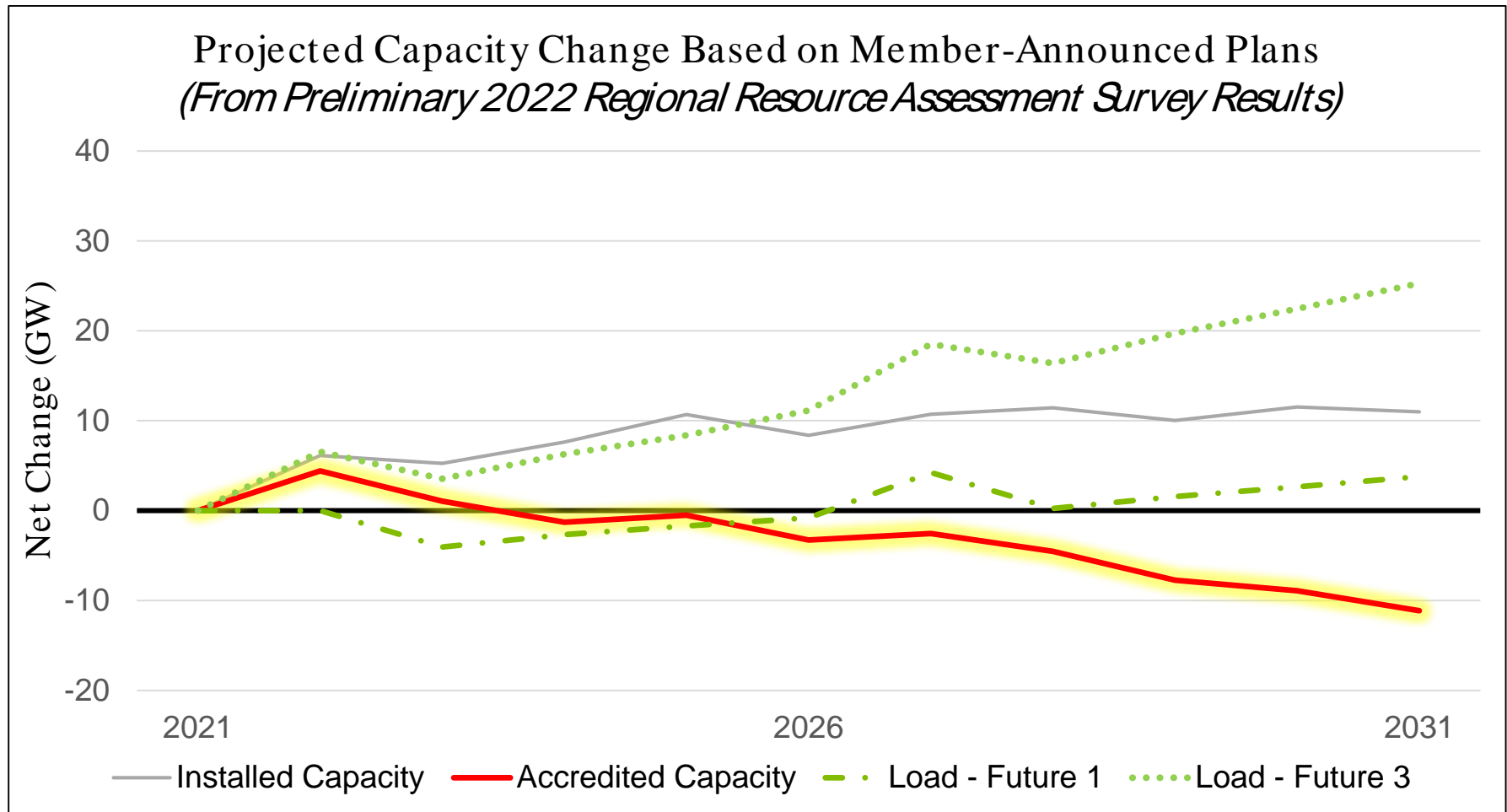
## MISO Queue Applications\* by Generation Type (GW)



9/13/2022

\*Not all project applications will enter the active queue. Historically, 10% to 30% have been withdrawn/removed during the application review phase.

# Our current member plans indicates accredited capacity will continue to decline, combined with increasing intermittent resources and demand

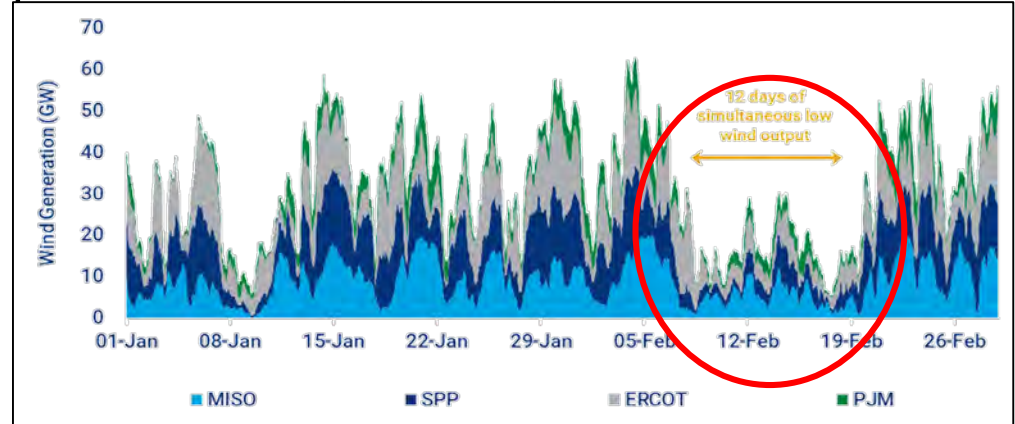


\*Future projections calculated as change from Future 1 2022 load assumption

Estimated accredited capacity: 16.6% for wind; 35% for solar, 87.5% for battery, 90% for coal, 90% for gas, and 95% for nuclear

# Traditional reserve margin calculations are no longer sufficient to address the growing system level risks

During Winter Storm Uri, wind output was low for a 12-day period across MISO, SPP, ERCOT, and PJM...



Source: Wood Mackenzie

.. concurrently, all resource types in MISO South, SPP, and ERCOT experienced increased outages

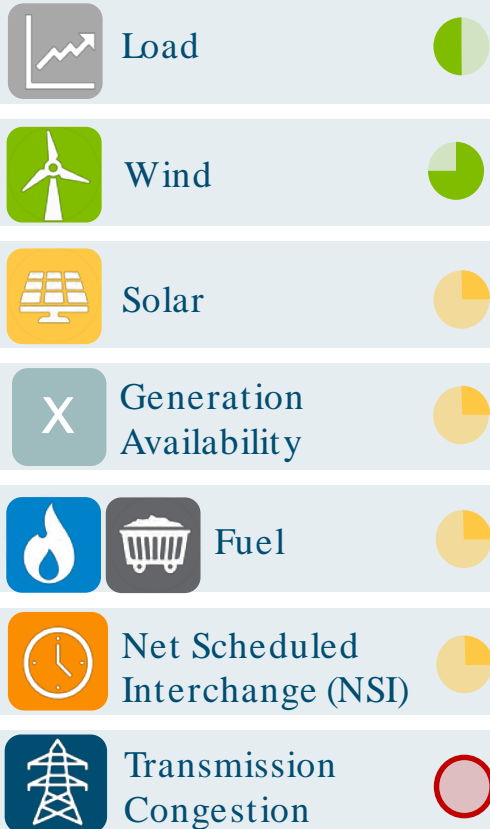


Source: FERC Report on The February 2021 Cold Weather Outages in Texas and the South Central United States

## PROBABILISTIC FORECASTS AND RISK ASSESSMENT

PROGRESS TOWARD QUANTIFYING UNCERTAINTY

SOURCE



RISK PORTAL INPUTS

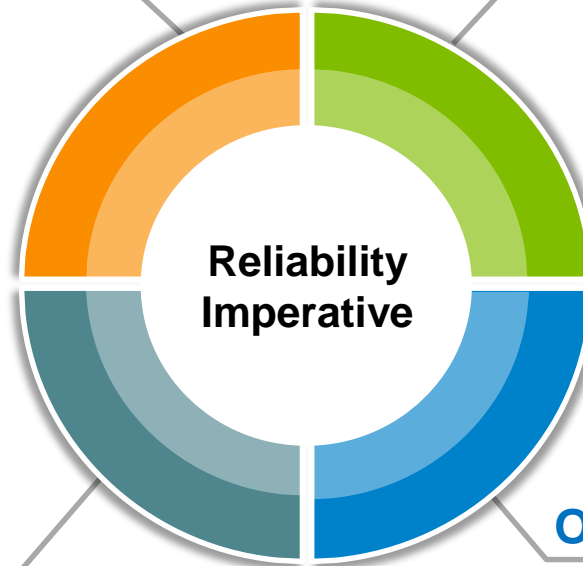
# MISO's Reliability Imperative defines the changes necessary to reliably manage the changing resource portfolio and system risks

## Market Redefinition

*Aims to ensure that resources with needed capabilities and attributes will be available in the highest risk periods across the year*

## Long Range Transmission Planning (LRTP)

*Assesses future transmission needs holistically, reflecting utility/state plans for new generation; will also consider potential cost-allocation changes*



## Market System Enhancements (MSE)

*Transforms MISO's legacy platform into a flexible, upgradeable, and secure system that can evolve for years to come; will also integrate advanced technologies to process increasingly complex information*

## Operations of the Future

*Focuses on the skills, processes, and technologies needed to ensure MISO Operations can effectively manage the grid into the future under increased complexity*



# Appendix

# MISO's Market Redefinition is working on reforms to enhance alignment of fleet capability with system needs

## Recently Approved by FERC

### Resource Adequacy Construct

- Moves from annual to seasonal model, improves accreditation, and updates planned outage thresholds

## Ongoing Activities

### Improved Resource Accreditation

- Renewable and Load Modifying Resources are the focus in 2022

### Resource Adequacy Construct

- Potential improvements to the Planning Resource Auction, including reevaluation of a reliability-based demand curve

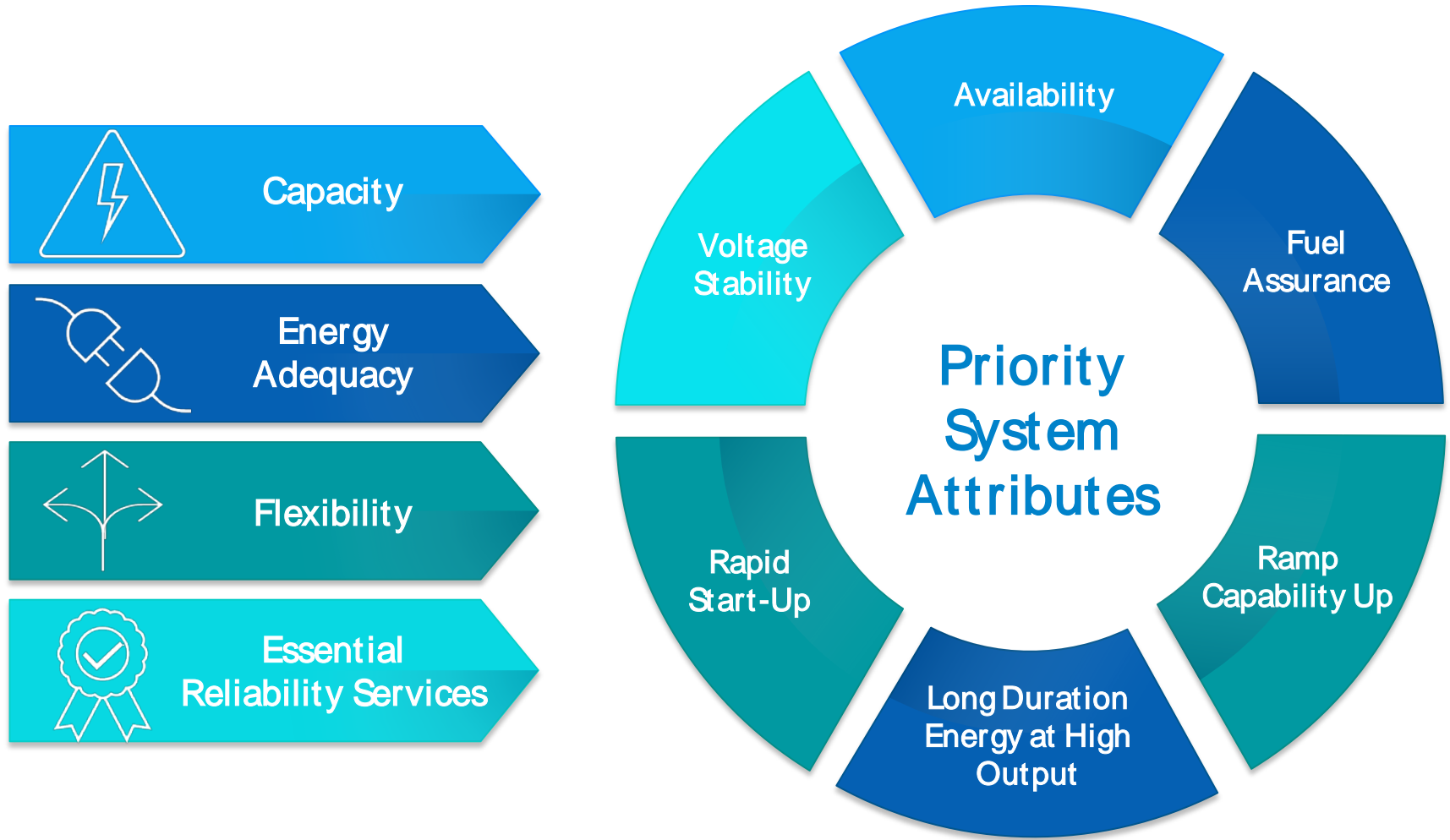
### Pricing

- Continued refinement of scarcity price reforms
- Improved modeling to achieve more efficient market outcomes and price signals

### Resource Attributes

- Evaluating approaches to value resource attributes critical to reliably operating the evolving portfolio

Maintaining reliability with the changing resource portfolio and evolving risks requires a better understanding of system attributes that were “included” in the historic fleet



Nordpool



**APEX Conference 2022**

**Energy Markets in Uncharted Territory**

Tom Darell, CEO

20 October 2022

**NORD  
POOL**

# AT A GLANCE

- Nord Pool offers day-ahead and intraday trading, clearing and settlement services
- ~ 400 customers from 20 countries trade on Nord Pool's markets
- Power exchange in 16 European countries (NEMO)
- 2 Serviced markets
- ~140 employees, 35 nationalities, offices in Oslo, Stockholm, Helsinki, London, Brussels and Tallinn



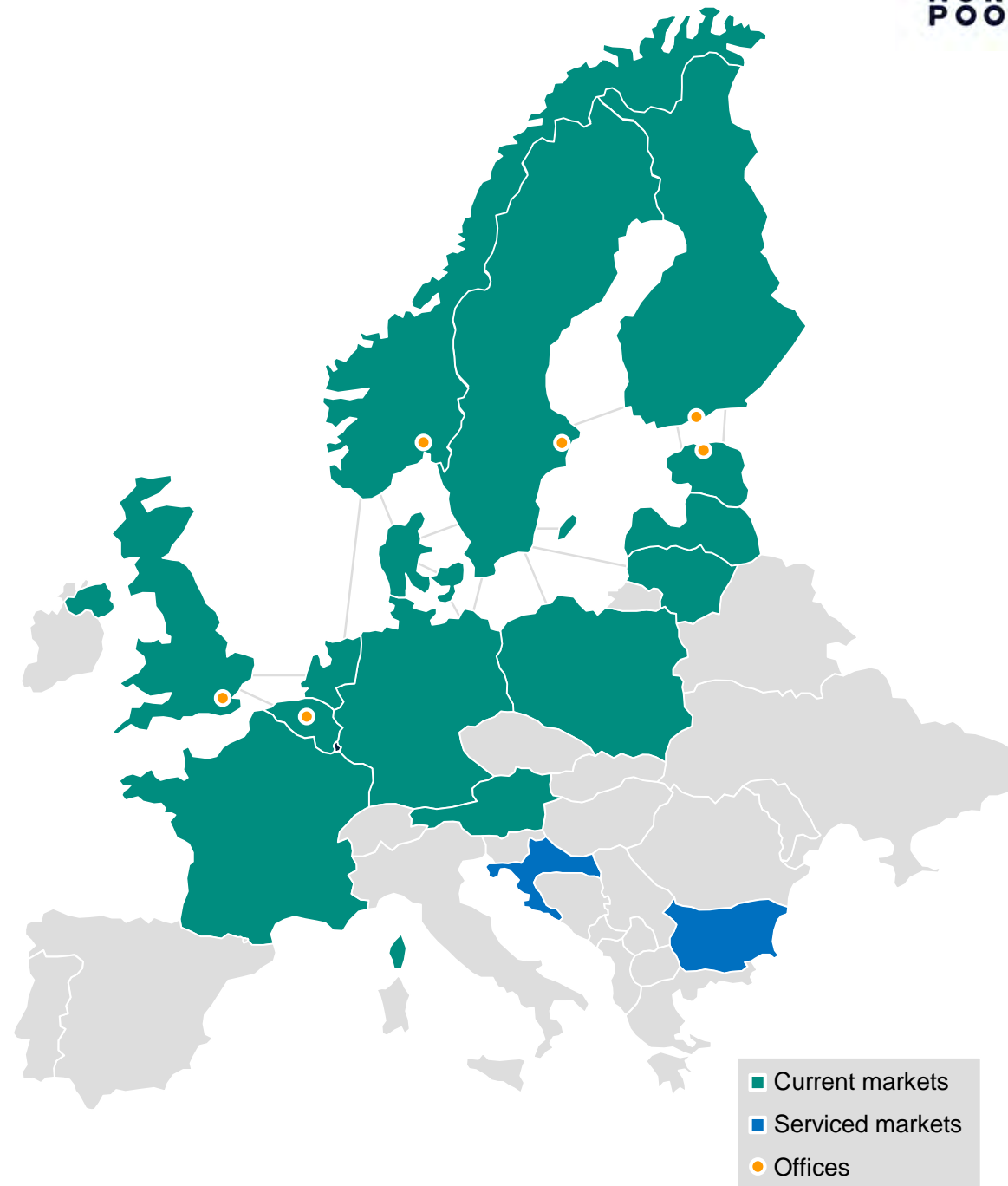
1000 TWh  
day-ahead



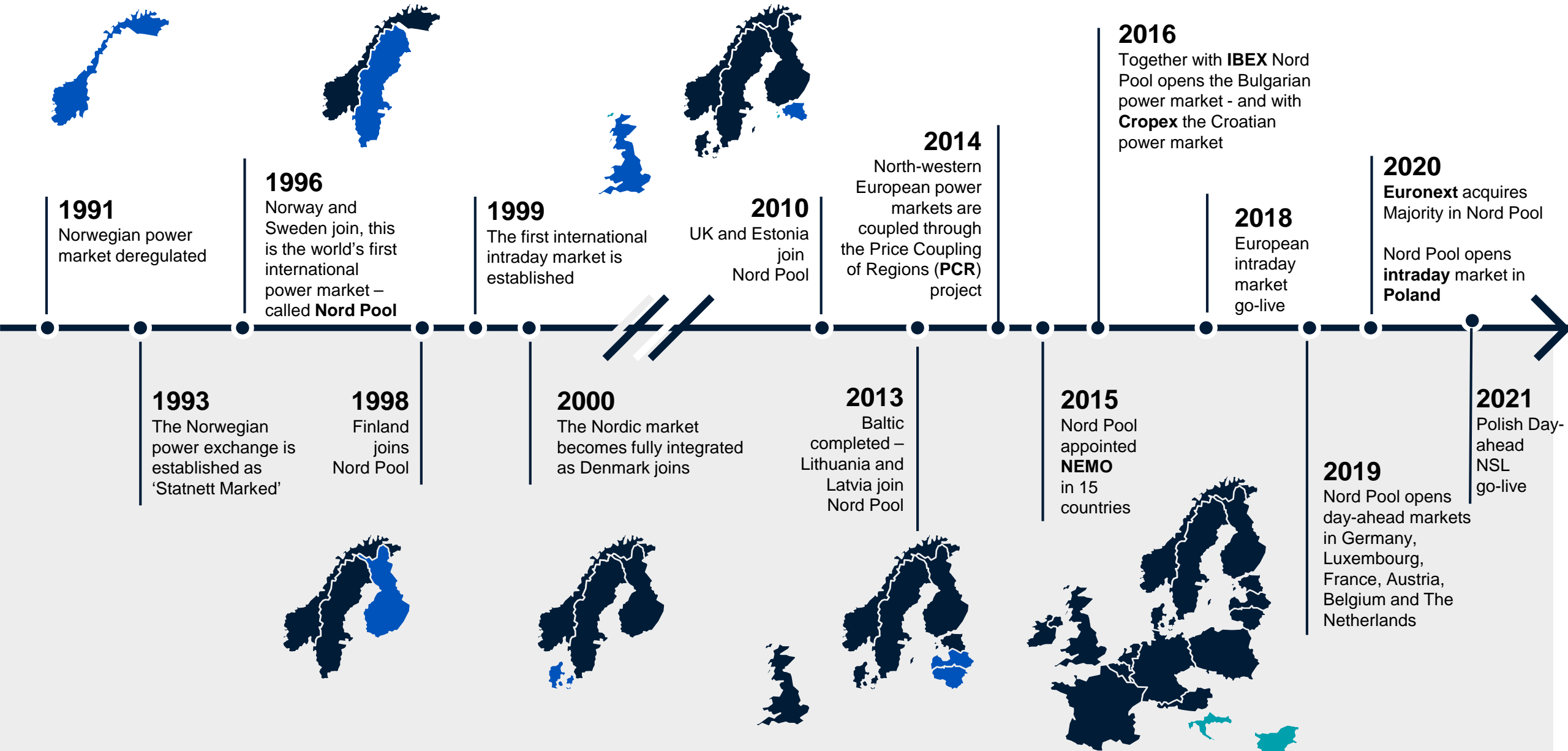
25 TWh  
intraday



400  
customers



# Nord Pool has been an integral part of shaping the European power market in close collaboration with energy market stakeholders



# WHY IS THE ENERGY TRANSITION (“GREEN SHIFT”) SO DECISIVE FOR REACHING THE CLIMATE TARGETS PUT FORWARD BY EU?

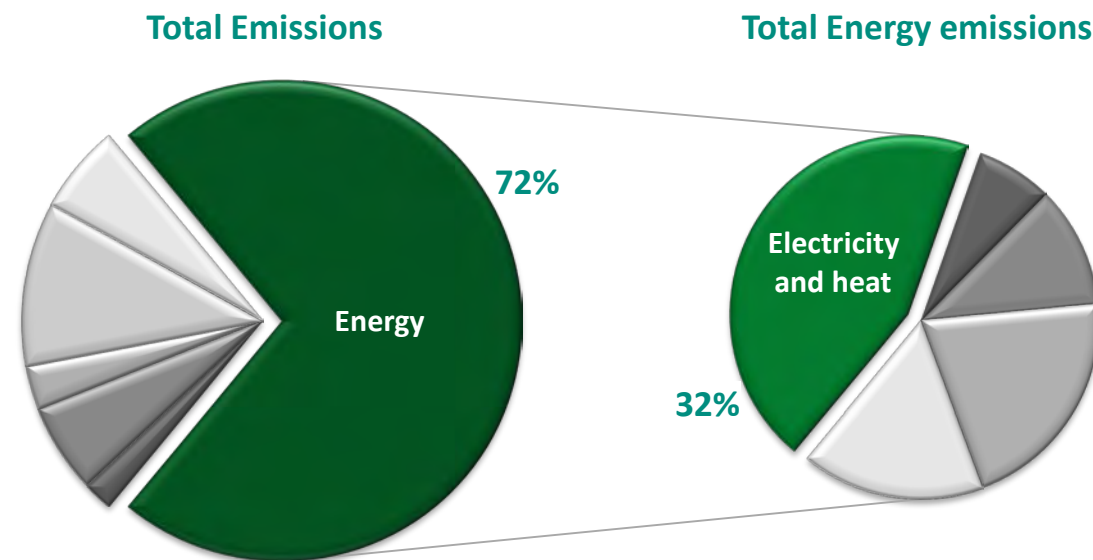
## Climate Change – The Challenge

- German Energi Wende passed legislative support already in 2010
- The European Green Deal set the blueprint for transformational change.



## Climate Targets

- 55% reduction in GHG emissions by 2030, compared to 1990 levels
- Net zero target for 2050 - carbon neutrality



European Environment Agency

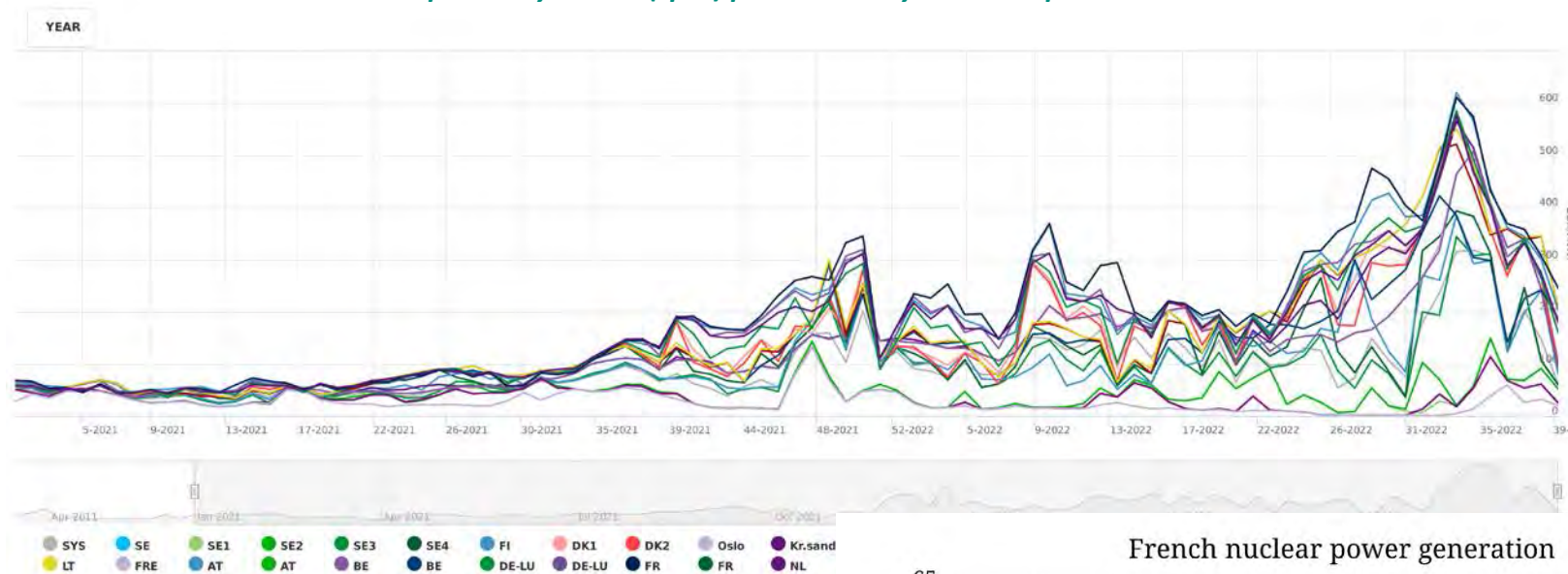


Electricity generation and heat production contributes around 1/3 of all CO2 emissions



# A 'PERFECT STORM' IN EUROPEAN ENERGY MARKETS

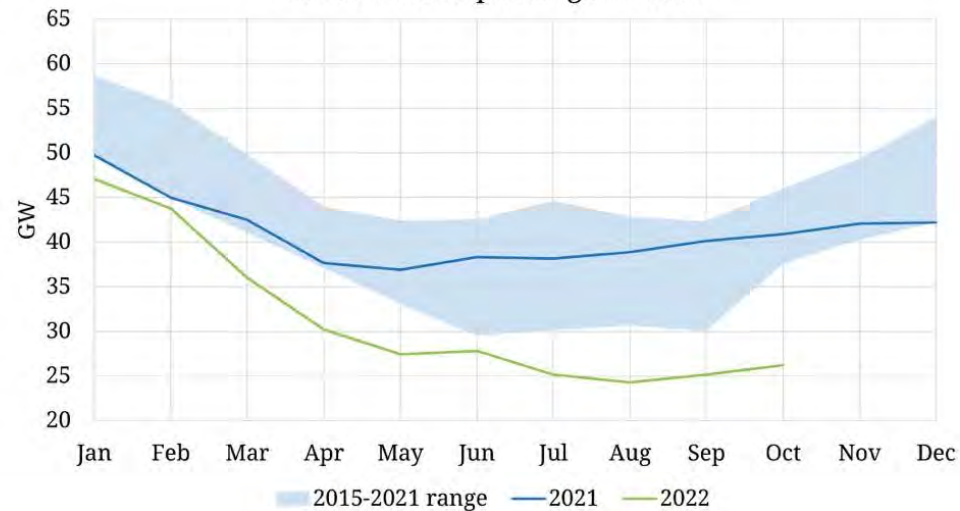
European Day-ahead (spot) prices January 2021 – September 2022



## 12 months ago: what we knew then..

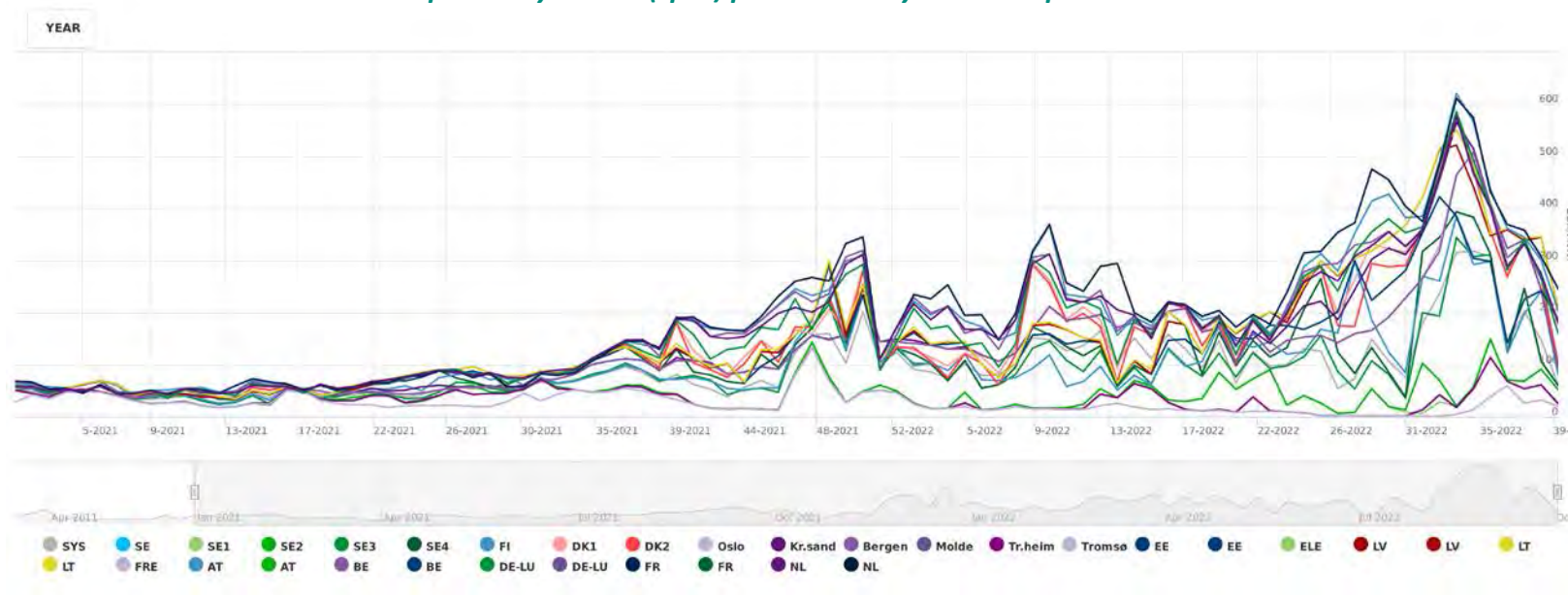
- Energy transition and decommissioning of nuclear, coal and thermal production capacity (phasing out large baseloads)
- Higher CO2 cost
- Intensified price volatilities due to larger share of intermittent sources

French nuclear power generation



# A 'PERFECT STORM' IN EUROPEAN ENERGY MARKETS (CONT'D.)

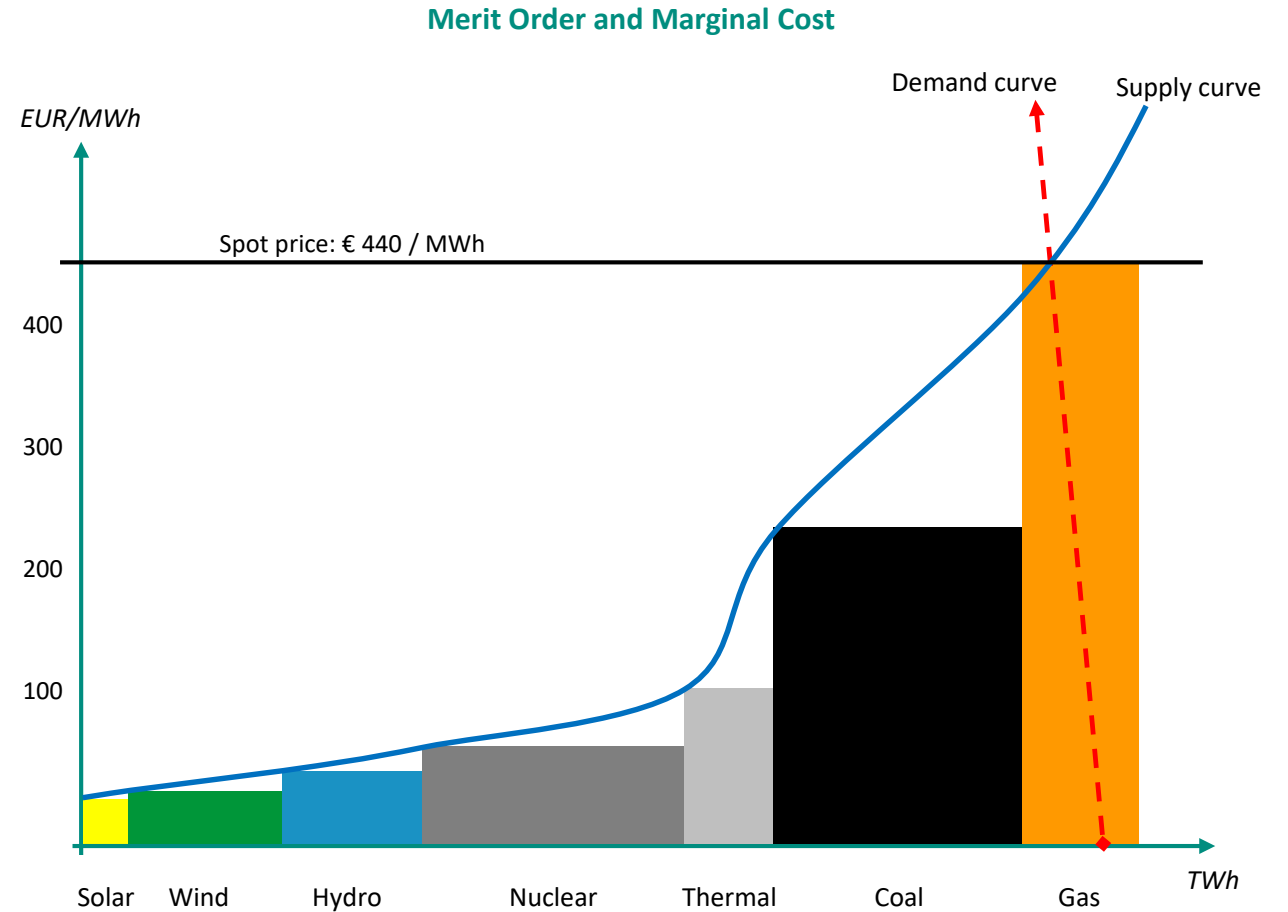
European Day-ahead (spot) prices January 2021 – September 2022



## However, we see some positive developments recently..

- European Gas storage reaching 92% - ahead of time
- High LNG import into to Europe (floating terminals being set up)
- Power consumption already reduced - ↓ 12% in Germany
- Coal fired power plants and nuclear plants being recommissioned
- EDF has undertaken to restart (all) its reactors for the winter
- Hydro reservoir levels are increasing, more rain recently
- We expect anyhow a very tight situation this winter – weather dependent!

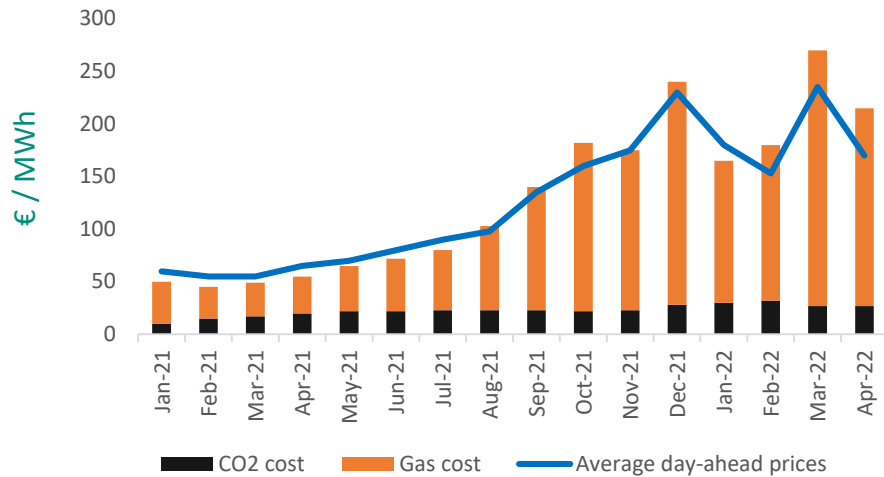
# WHY ARE WE TALKING SO MUCH ABOUT HIGH GAS PRICES AND ITS IMPACT ON POWER PRICES..?



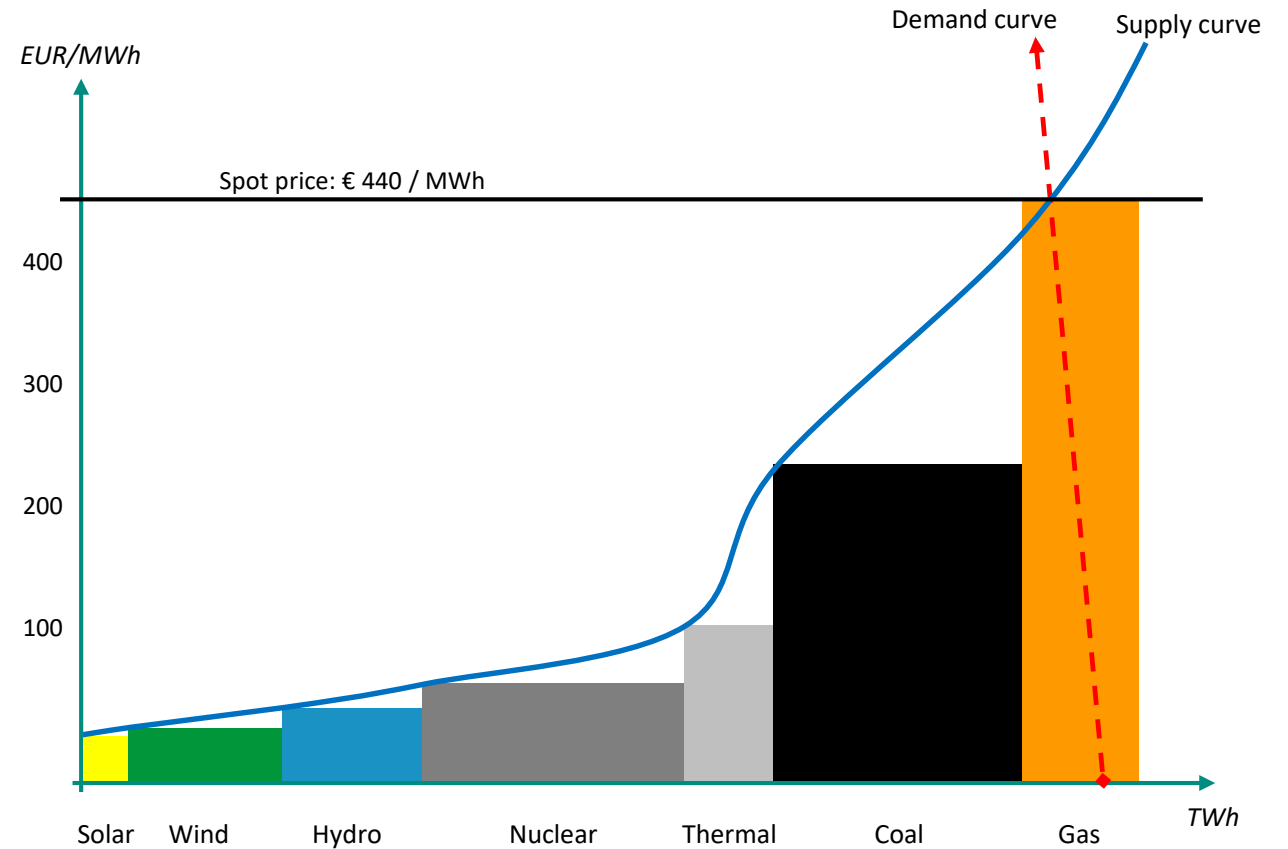
- The energy source with the lowest marginal cost is produced first
- The last unit of energy that must be produced to fulfill the consumption demand, sets the price for all previous production

# WHY ARE WE TALKING SO MUCH ABOUT HIGH GAS PRICES AND ITS IMPACT ON POWER PRICES..?

High electricity prices mostly fuelled by gas



Merit Order and Marginal Cost



- The energy source with the lowest marginal cost is produced first
- The last unit of energy that must be produced to fulfill the consumption demand, sets the price for all previous production



# TEMPORARY MEASURES AS PROPOSED BY EU

Temporary measures, supposed to last from December 2022 until June 2023, have been put forward by the Commission, as an answer to the economic burden on household and businesses across EU member states

## Defined measures

1. *Incentivising coordinated electricity demand-reduction across the EU*
2. *Capping the revenues of inframarginal electricity producers (...) with a € 180/MWh cap*
3. *Single European wide procurement of gas*
4. *Liquidity instruments that would ensure that market participants have at their disposal a sufficient collateral to meet margin calls (...)*

## Potential measures being discussed

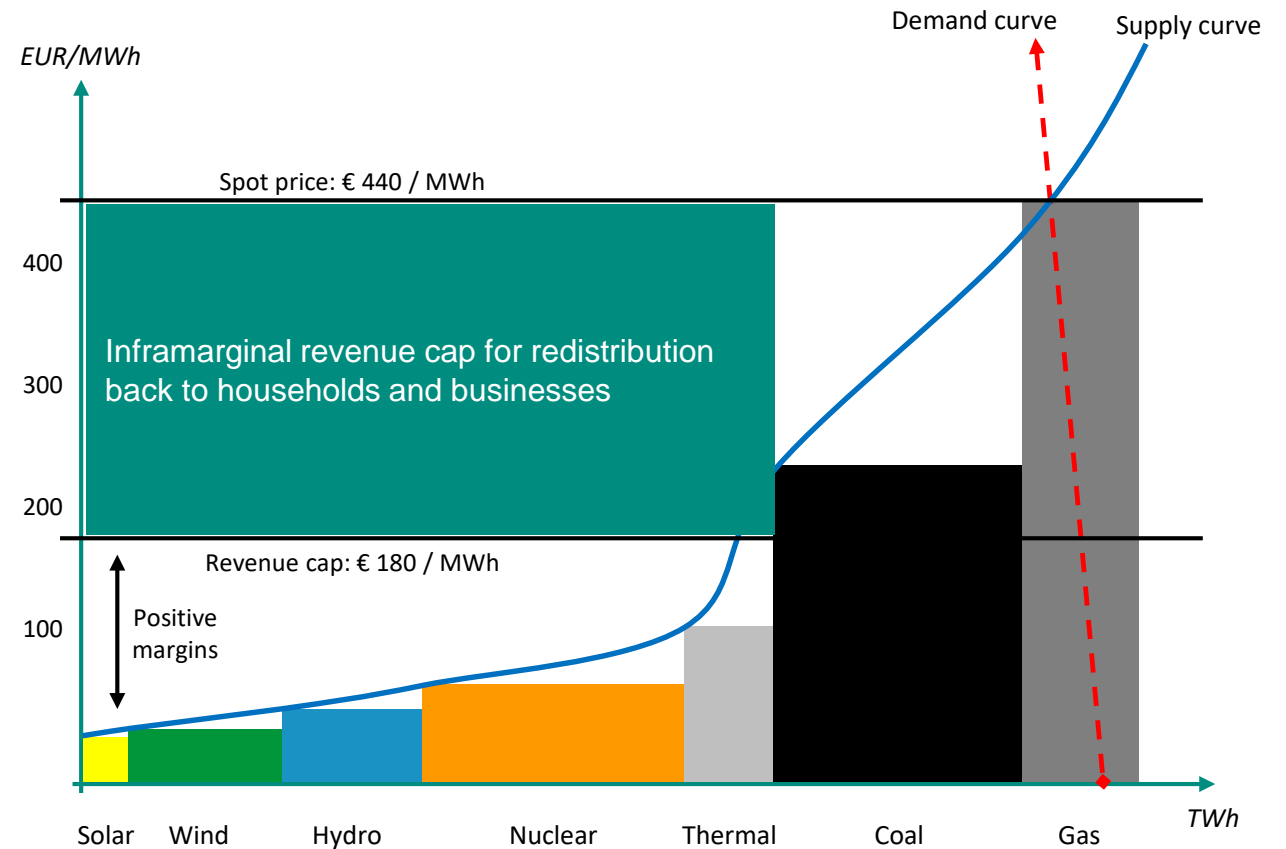
5. *Still evaluating gas price caps and/or long term fixed price contracts. Also assessing a Liquefied Natural Gas benchmark decoupled from the TTF index*
6. *Possible options on the EU ETS (carbon market)*



# WHAT DOES THE REVENUE CAP FOR CERTAIN ASSETS TYPES REALLY MEAN?

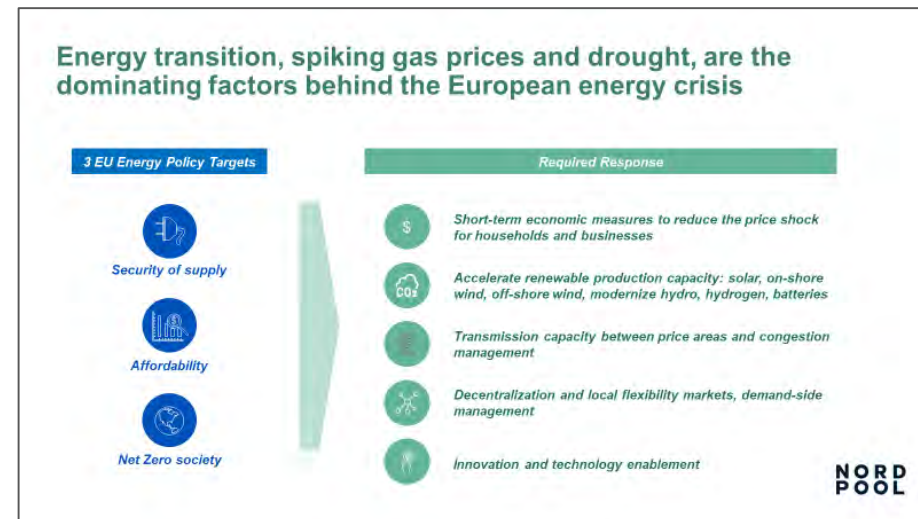
## Most likely measures

1. *Incentivising coordinated electricity demand-reduction across the EU*
2. **Capping the revenues of inframarginal electricity producers (...) with a € 180/MWh cap**
3. *Single European wide procurement of gas*
4. *Liquidity instruments that would ensure that market participants have at their disposal a sufficient collateral to meet margin calls (...)*



# THE “MARKET” SHOULD BE PROTECTED AGAINST SHORT-TERM MEASURES WITH NEGATIVE AND LASTING LONG-TERM EFFECTS

- The price signal should be protected (even though we don't like the price signal..)
- Market intervention ahead of the price signal can put security of supply at risk and deepen the crisis – every day we balance generation and consumption for an integrated market across 27 countries
- The surging power prices points to the obvious and underlying root causes, which are:
  - › There is an overall energy supply shortage at the moment
  - › The green transition (phasing out stable and flexible baseloads and replacing it with intermittent renewable sources drives price volatility)
  - › Europe (in particular Germany) has to become energy independent from Russia
  - › Demand side (consumption) needs to be more flexible and manageable
- It has never been more profitable to invest in new renewable production capacity, and policy makers have to accelerate legislative frameworks to allow for reduced lead times for renewable energy assets
- There is a political risk for market participants, including the power exchanges, and we should do our best to influence, and also position for the opportunities related to the energy transition



**Thank you!**

**NORD  
POOL**



GE



# The incremental price paradox

**APEX 2022**

Jean-Marc Moulin VP T&D Product Management, GE Digital



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# The incremental price paradox

**APEX 2022**

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# “4D” Megatrends Are Driving Change And Disruption In The Utility Sector



## Decarbonization

more variability requiring full awareness and encouraging exchanges



## Digitalization

enables creation of new transformative energy provisioning business models



## Decentralization

introduces the need for new network operating model



## Democratization

more parties in the energy value proposition and involvement of prosumers



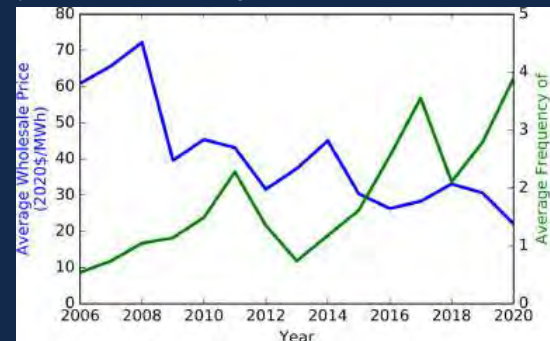


# A 5<sup>th</sup> Demarginalization ? ...

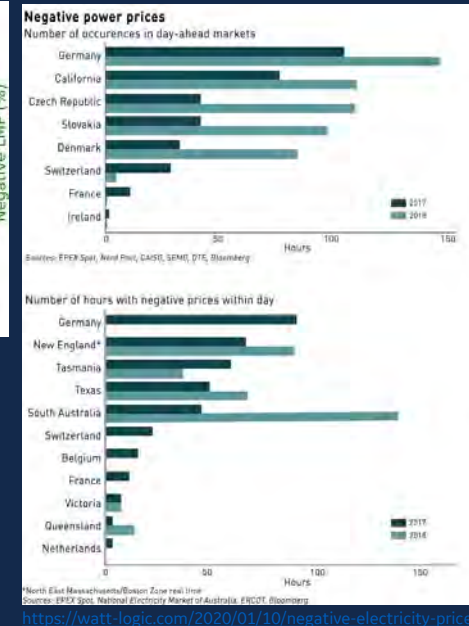
Fundamental questions MISO asks:

- How to run a market when marginal cost for main commodity is lower than average cost?
- If energy is cheap, what other services should resources be paid for?

Average wholesale prices and average frequency of negative locational marginal prices at nodes in the seven organized wholesale markets in the United States.



<https://www.sciencedirect.com/science/article/pii/S2666792421000652#fig0001>



Designing the electricity market of the future – MISO, 2019

<https://www.cmu.edu/ceic/assets/docs/seminar-files/2018-2019/rose---cmu-epp-seminar---2019-june-07-v1.pdf>

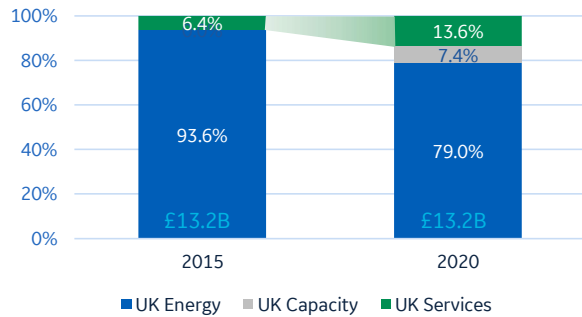


# Energy Markets Are Changing To Satisfy Flexibility Needs



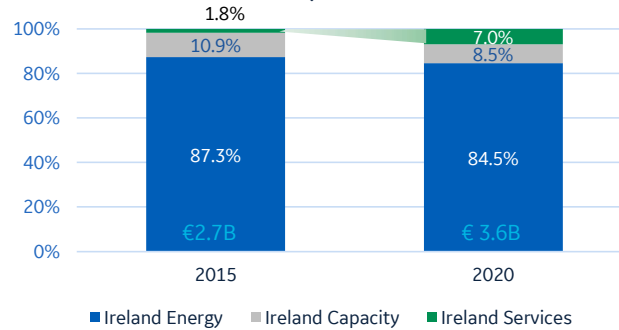
VRE penetration 24% → 43%  
(Variable Renewable Energy)

**UK Electricity Market 2015-2020**



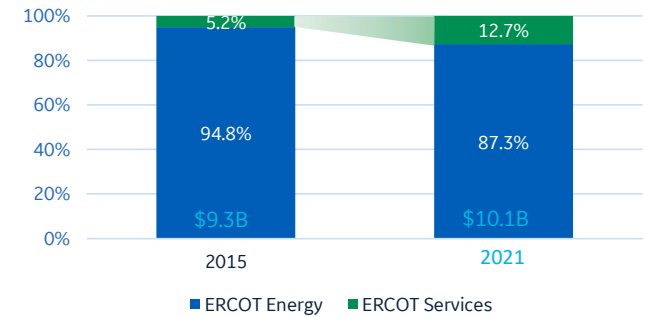
VRE penetration 27% → 42%

**Ireland Electricity Market 2015-2020**



VRE penetration 12% → 25%

**ERCOT Electricity Market 2015-2021**



Reduced energy percentage in the clearing mix



... but at same time, wholesale prices ...

### Prepare For Even More Electricity Price Hikes

By **Ronald Blewett** • 26 COMMENTS

31 October and Australia's wholesale electricity price crisis has entered its sixth month. Massive retail electricity price hikes in the eastern states are becoming more likely (from July 2022). These could exceed 10 cents per kilowatt-hour.

This post is a quick update on the current situation, followed by a short video.

Here's a six-point summary to bring you up-to-date on the current crisis:

1. Putin decided to put an end to the threat of Russia not invading Ukraine by invading Ukraine on February 20th.
2. Because east coast natural gas is sold on the international market, its price soared.
3. Even though Australia only generated 5.4% of its electricity from natural gas last financial year, wholesale electricity prices soared because gas is a price setter in our electricity market.
4. The cost of black coal also increased, but despite supplying 43.3% of Australia's electricity, due to its inelasticity this has had a much smaller effect on wholesale prices than the gas price rise.
5. Behind-the-scenes arm twisting pushed down the price of east coast natural gas from extremely high levels at the end of July, but they are still well above normal.
6. The situation should improve as we head into warmer spring weather and solar energy output increases, but the crisis may not end until after the war in Europe ends.

<https://www.solarquotes.com.au/blog/more-electricity-price-hikes/>

### U.S. should pump more oil to avert war-level energy crisis, says JPMorgan's Jamie Dimon

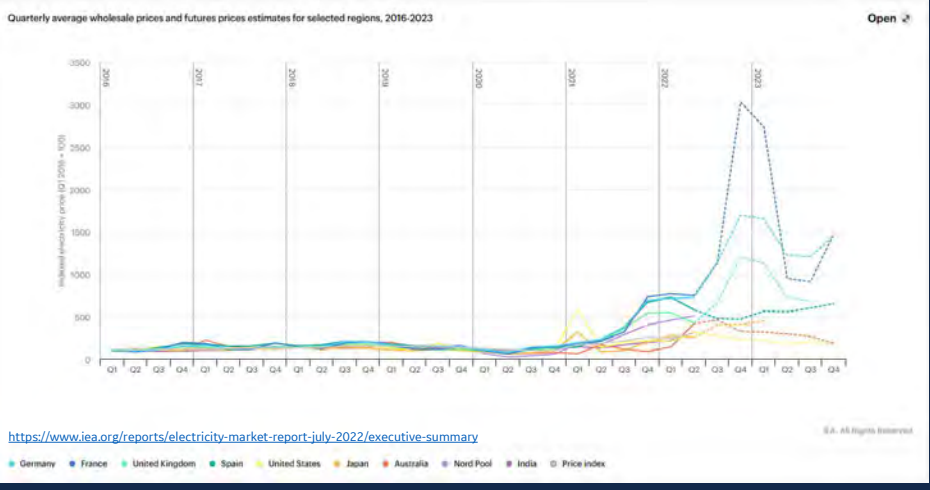
By **Karen Gibbrat**

Published Mon, Oct 10 2022 7:19 PM EDT | Updated: 4 hours ago

**KEY POINTS**

- JPMorgan Chase CEO Jamie Dimon told CNBC Monday that the U.S. should forge ahead in pumping more oil and gas to help alleviate the global energy crisis.
- Likening the situation to a national security risk of war-level proportions, Dimon said Western allies should support the U.S. in shoring up supply.
- "America needs to play a real leadership role. America is the swing producer, not Saudi Arabia," Dimon told CNBC's Juliana Tatekman.

<https://www.cnbc.com/2022/10/11/us-should-pump-more-oil-to-avert-war-level-energy-crisis-jpmorgans-jamie-dimon.html>



### Energy crisis: how the EU hopes to tackle high power prices while protecting its cross-border electricity market

By **Pauline** • 21 November 2022 • 10:51 GMT

Europe is getting more of its power from **accessible sources** every year but, as the current crisis has shown, power markets remain at the  **mercy**  of increasingly volatile gas prices. The EU Commission has recently  **announced**  a plan to reduce the crisis by decoupling electricity and gas prices. But the plan must strike a balance between addressing skyrocketing prices and protecting the cross-border power market the EU has been building out across its member states  **since the 1990s** .

A key feature of liberalised power markets is marginal cost pricing. Gas-fired power is often the most expensive source of electricity, and if this kind of plant is required to balance supply and demand it becomes what's called the marginal plant, which effectively sets the price for the entire power market.

<https://theconversation.com/tackle-high-power-prices-while-protecting-its-cross-border-electricity-market-191015>

### Britain's grid warns of winter blackouts if Europe energy crisis escalates

By **Michael**

Britain's electricity supplier said homes and businesses could face  **three-hour blackouts**  this winter if supplies run too low, preparing for a  **winter**  of low wind and solar energy.

The company described it as "unthinkable" that the lights would go out but said it could be the prospect of a "series of extreme events" in its winter forecast.

<https://www.washingtonpost.com/world/2022/10/07/uk-energy-blackouts-warning-russia/>

### Europe's Energy Crisis Could Last for Years

By **Gregory**

This winter will be bad, but next year's could be worse.

Europe is facing a generational energy crisis as it heads into winter. A shortfall of 150 billion cubic meters of gas—gas that Russian won't be delivering to Europe this year because of its war in Ukraine—has left Europe scrambling to find alternatives and contain the fallout. Gas prices in Europe are now about eight times the average of the past 10 years—and about eight times more expensive than prices in the United States. Governments are appealing to the public to reduce their gas usage while also trying to ensure consumers and businesses can afford to pay their gas and electricity bills at all—all the while preparing for the worst-case scenario, ranging from periodic blackouts to cascades of industrial bankruptcies.

<https://foreignpolicy.com/2022/10/10/eu-ope-energy-crisis-russia-ukraine-war-ones-and-twos/>



APEX 2022, October 20<sup>th</sup>, Dubrovnik

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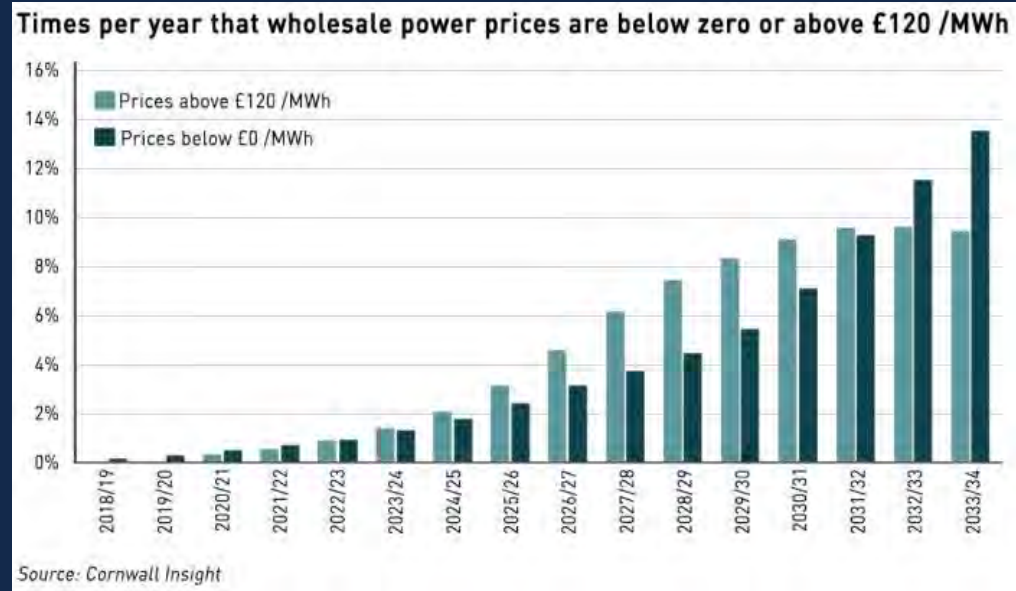
# Is Electricity cheap or expensive ?

Raising some open questions:

- Cap on prices?
- Separate fuel-based markets?
- Co-optimize Energy and Ancillary services?
- Redesign?
- ...

**Will price volatility increase over time?**

Analysis by Cornwall Insight in the UK







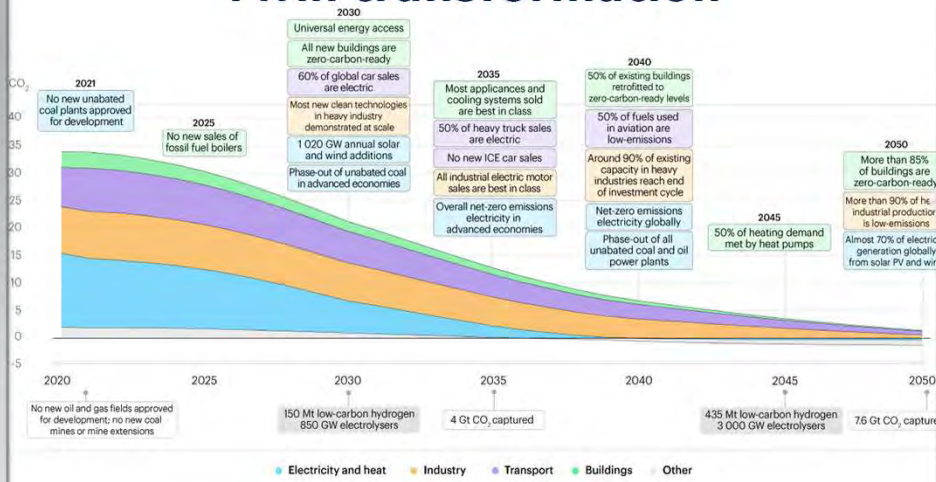
**Existing Markets**

**Today**

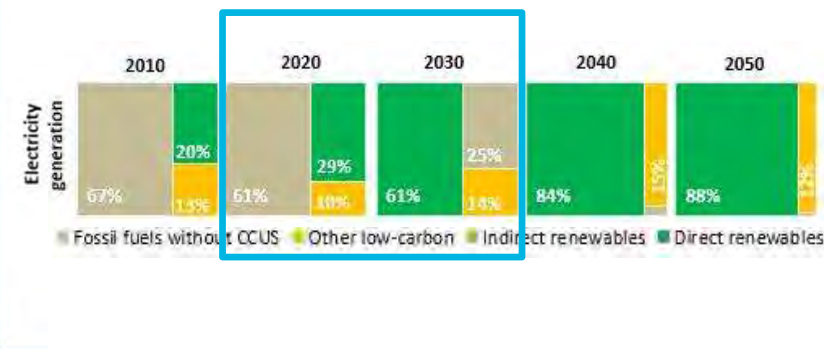
**Next Gen Carbon Free Markets**

# IEA Net zero by 2050 <https://www.iea.org/reports/net-zero-by-2050> – May 2021)

## Twin transformation



Doing more in 10 years than what we ever have done



**88%** **2050** **70%**

of Electricity produced from renewable energy from Variable Renewable Energy (VRE)

Renewable penetration combined with Electrification of sectors to drive emission reduction



# New Services are being created!

## Observations:

- UK, Spain, France, Italy and US already have ancillary services markets >\$1B
- Global market is expected to more than double over the next 5 years

## With new products

- Fast frequency response, Ramping products, flexibility, inertia, restoration, reactive P...

Are these services enough?

National Grid ESO claims world first approach to inertia, awarding £328m in contracts

<https://agileenergy.net/national-grid-eso-claims-world-first-approach-to-inertia-awarding-328m-in-contracts/>



A Wood Mackenzie Business

news research squared events

**gtm:** Solar Grid Edge Storage Wind Podcasts White Papers Webinars

## Electric Trucks Provide Frequency Regulation in ERCOT

<https://www.greentechmedia.com/articles/read/Electric-Trucks-Provide-Frequency-Regulation-In-ERCOT>





# Effective Inertia

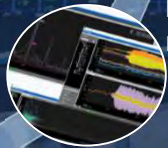
Area  
Effective  
Inertia



The **Inertia Challenges**



**Measuring** Effective Area-Inertia  
with WAMS



**Forecasting** area-inertia by  
machine learning



Inertia Measurement and Forecast

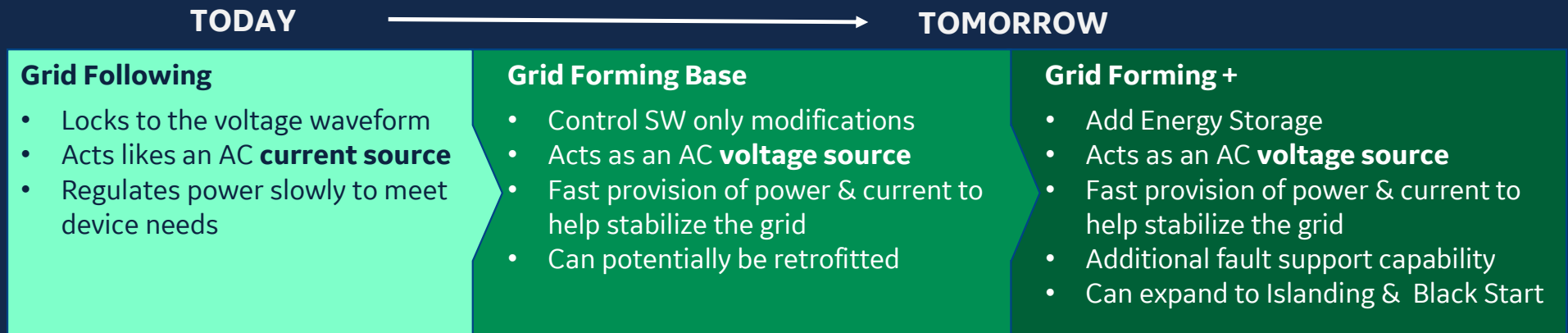
## Effective Inertia as a valuable service

- Enable higher penetration of low inertia renewable generation.
- Reduce curtailment fees and penalties.
- Lower frequency response services.
- Increase network resilience; minimize risk of system separation.

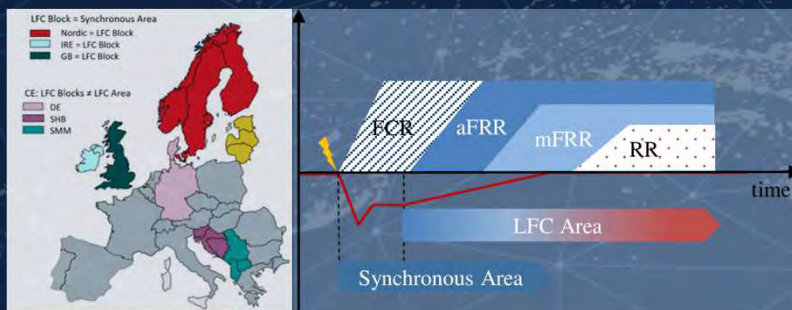




# Grid Forming



# Load Frequency Control



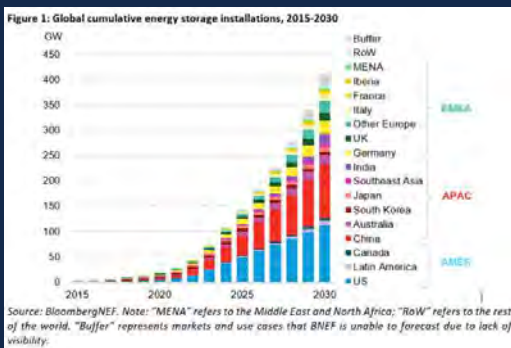
## ENTSO-E EBGL driving the regional harmonization and optimization in reserves activation

- Interchange schedules processing
- Realtime multi-sources measurements ingestion
- **Regional optimization in aFRR signal calculation (AOF/PICASSO)**
- **Market bids processing for BSPs activation - Merit Order List based**
- Open loop (study) or closed loop, configurable periodicity & time cycles (e.g. 1-4sec)
- Modular, IEC CIM based, state of the art UI/UX, cybersecure, HA, interoperable



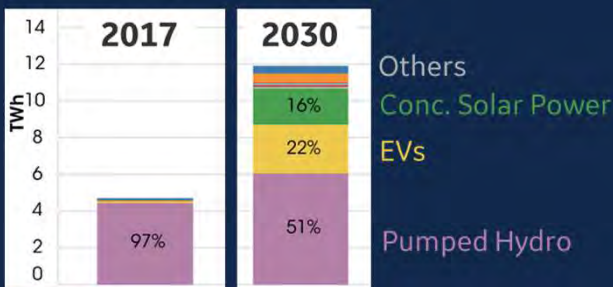
# Storage

## CAPACITY



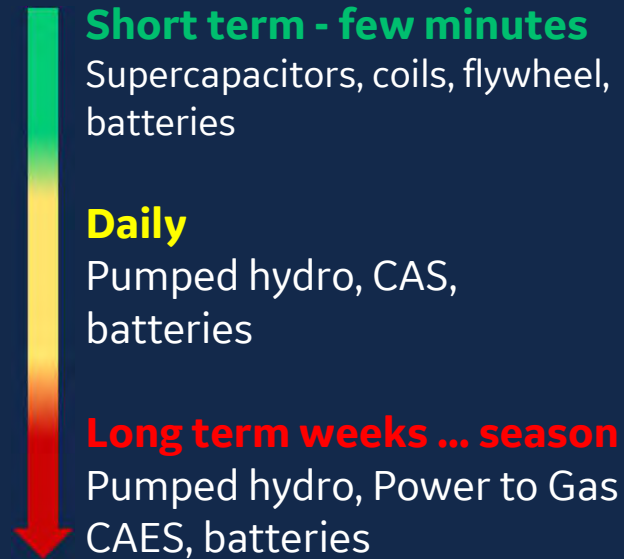
BloombergNEF (Oct. 2022) :  
Global Energy Storage Market to  
Grow 15-Fold by 2030

BNEF's definition of energy storage excludes pumped hydro  
storage.



# GRID SERVICES

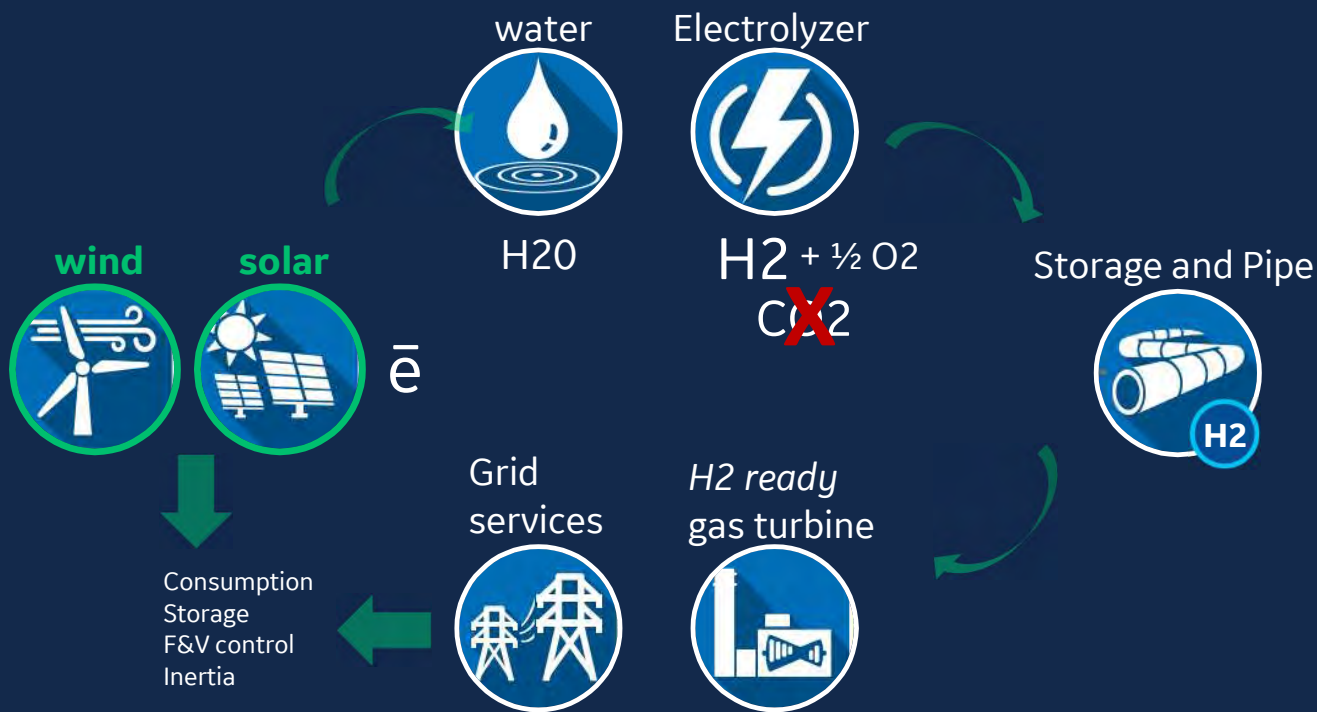
## STORAGE APPLICATIONS



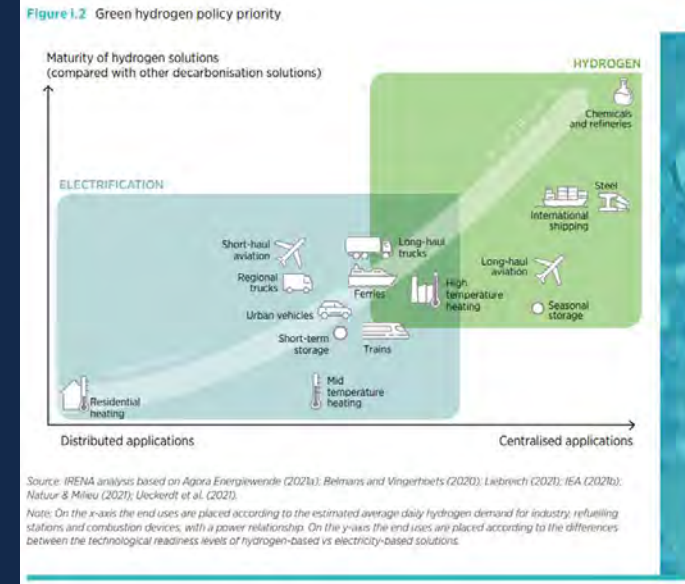
# Power to Gas – Circular energy

## Why curtailing VRE sources while you use gas at the same time?

Curtailment: 2% of total VRE (av 2018)



[https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA\\_Green\\_Hydrogen\\_Industry\\_2022.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Industry_2022.pdf)



The total hydrogen production is expected to **expand by almost five times**, to 614 MtH<sub>2</sub>/year, to satisfy 12% of the final energy demand by 2050 in a 1.5°C scenario.

This is driven by growth in the industrial and transport sectors, where hydrogen mitigates close to 12% and 26% of the CO<sub>2</sub> emissions, respectively (IRENA, 2022a)





# A geographical paradox ?

**More Regional coordination**



**More Local consideration**



[https://www.entsoe.eu/network\\_codes/bzr/](https://www.entsoe.eu/network_codes/bzr/)



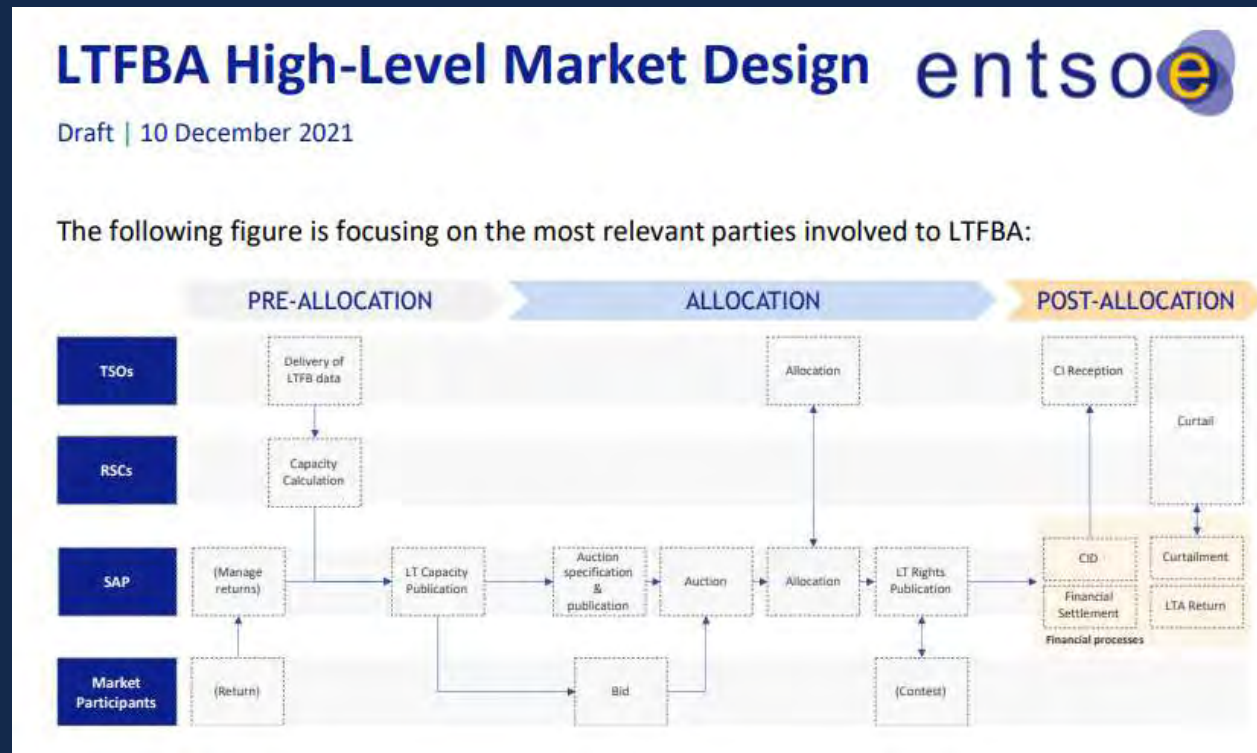
# Extending **Flow Based** methodology to Long Term Allocation

Important milestones are passed:

- ✓ March 2022, The Nordic TSOs and the Nordic RSC jointly decided to start the external parallel run (EPR) of the Nordic flow-based methodology – [news](#)
- ✓ June 2022, Day-Ahead Flow-Based Market Coupling project is **live in the Core CCR** – [press](#)

*And as a next step,*

Core and Nordic CCRs to implement **LTFB** with JAO by the end of 2024 – [JAO.eu/news](#)

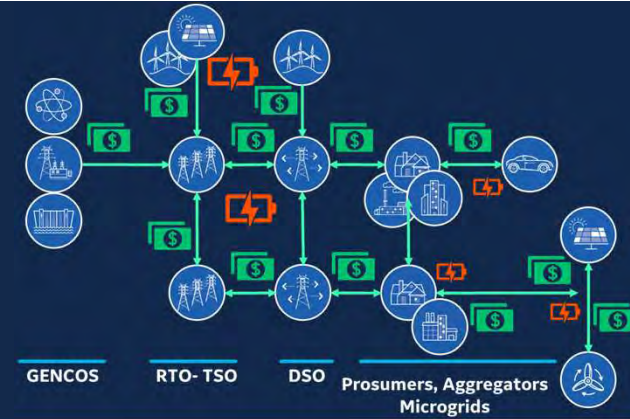


[https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/NC%20FCA/publications/220330\\_ALL\\_TSOs\\_TOP\\_3.5.1\\_b\\_LTFBA\\_High\\_Level\\_Market\\_Design\\_Document.pdf](https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/NC%20FCA/publications/220330_ALL_TSOs_TOP_3.5.1_b_LTFBA_High_Level_Market_Design_Document.pdf)



# Value emerging all along the Chain

## Flexibility



Together, we offer a suite of natively interoperable software solutions purpose built for Transmission, Distribution, and **Market Operators**

to plan, manage, optimize and **trade renewables and DERs** across the energy network.



APEX 2022, October 20<sup>th</sup>, Dubrovnik

### Sample Partners



### Challenges

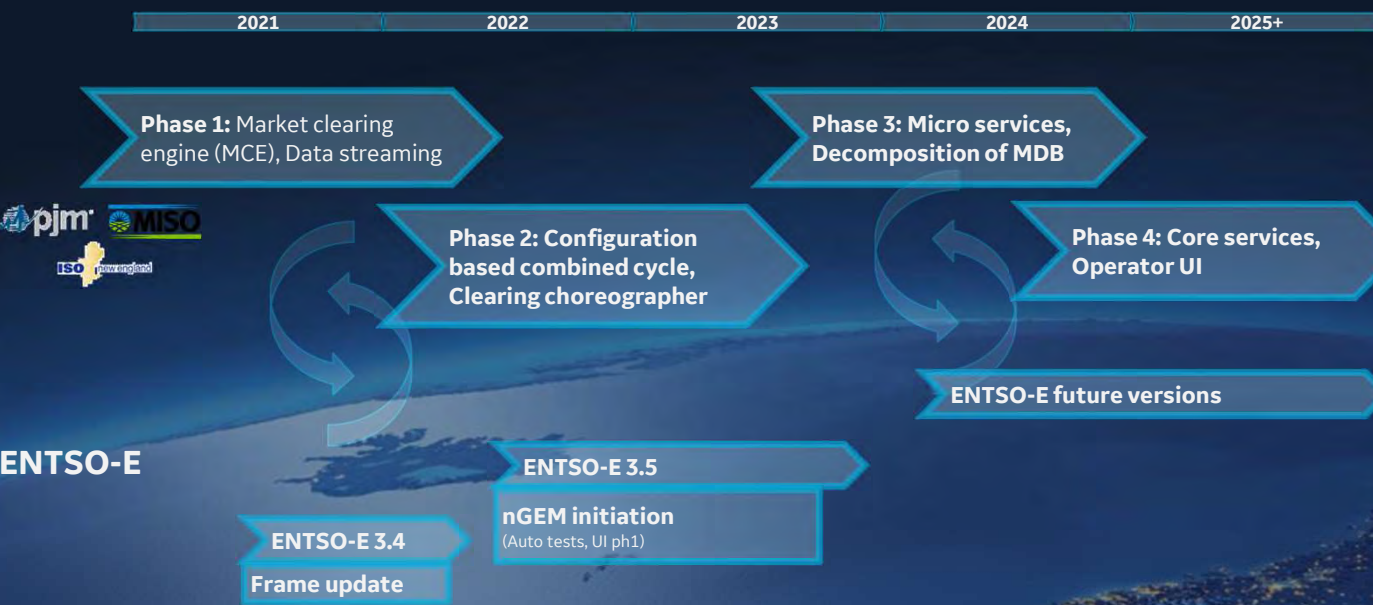
- Flexibility markets are increasingly important and economic in the management of congestion, especially at LV.
- However, current approaches to zonal flexibility markets through contracts may not identify the most efficient and effective use of DERs, and lock aggregators out of other markets where constraints are not expected.
- GE and Opus One support day-ahead optimisation of flexibility markets, down to the lowest visible voltage level.



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# Learning together to overpass a common **Challenge**



## The opportunity to leverage several region's experience

- **Locational price** in North America
- **Renewable** penetration in Europe

## And be growingly flexible

- Composability
- Modularity
- Scalability
- Deployable at the point of impact.. Cloud.. Prem.. Edge





# How Energy Market Success Will Look Like?

Fair Energy prices

Green energy

Flexibility rewarded

Consumers

100% of Capacity rewarded

Flexibility and Capacity Rewarded

Minimum Renewable Energy Lost

Minimum Deviation from scheduled power balance traded

Maximum of lines capacities used



Business 100% participants

Business Flexibility

Fair Market with liquidity

Multiple Energy Exchange Relations

Interoperability with all Nodes

Security: Zero Failure

**Grid:** quality of supply, no blackout

**Privacy:** Respect privacy sensitive data

**Cyber:** Strong protection, no intrusion



Thank you



# Wrap-up & Q&A

Jean-Marc Moulin VP, Product Management, GE Digital





GE Digital