Affordability and Resilience Through a Decentralized Power Grid

OBSERVATIONS FROM NORTH AMERICA

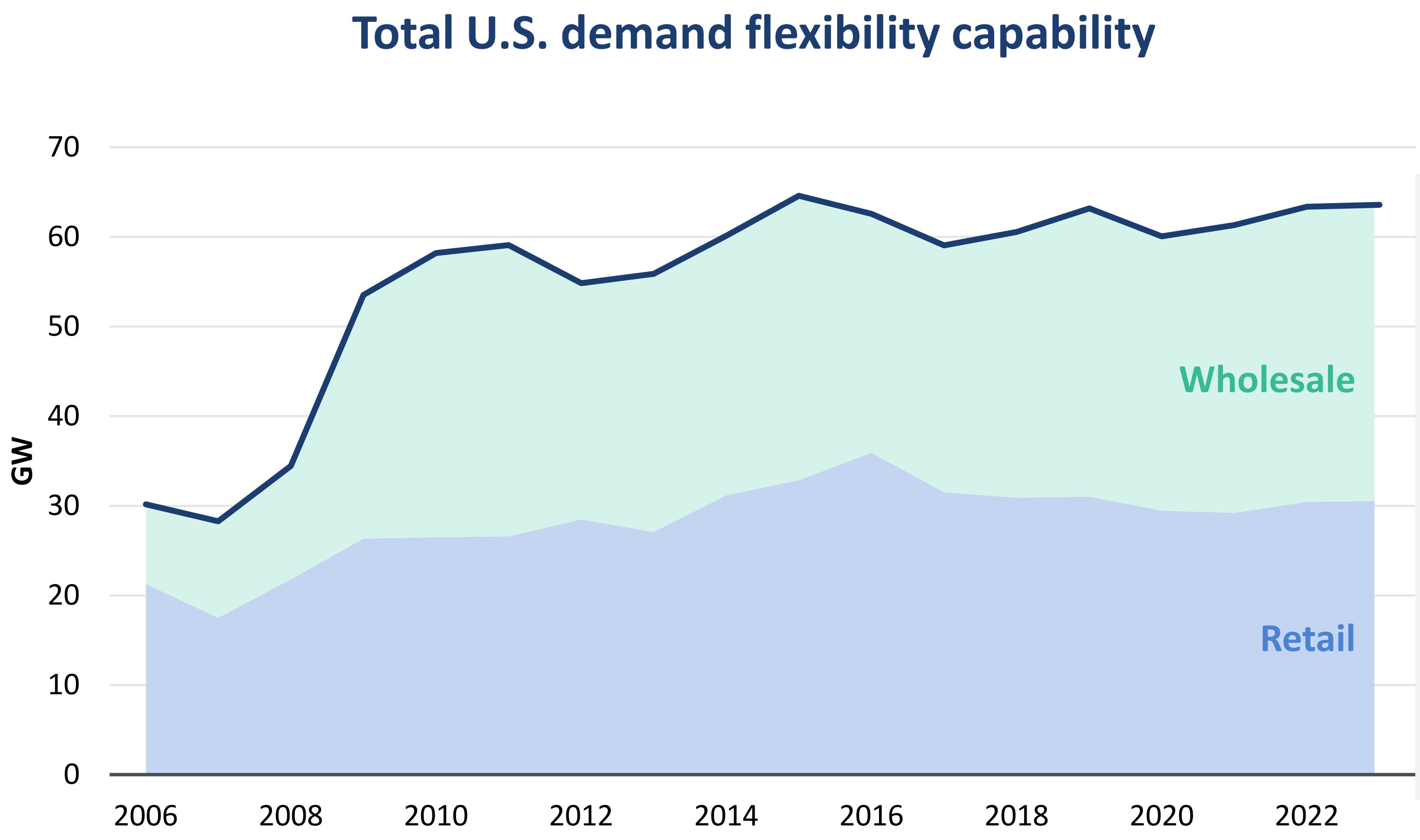
PREPARED BY

Ryan Hledik
Sasha Kuzura

IEA "EMPOWERING UKRAINE" WORKSHOP
COPENHAGEN, DENMARK
10 JUNE 2025

Brattle

Controllable DERs have reached ~8% of peak demand in the U.S.

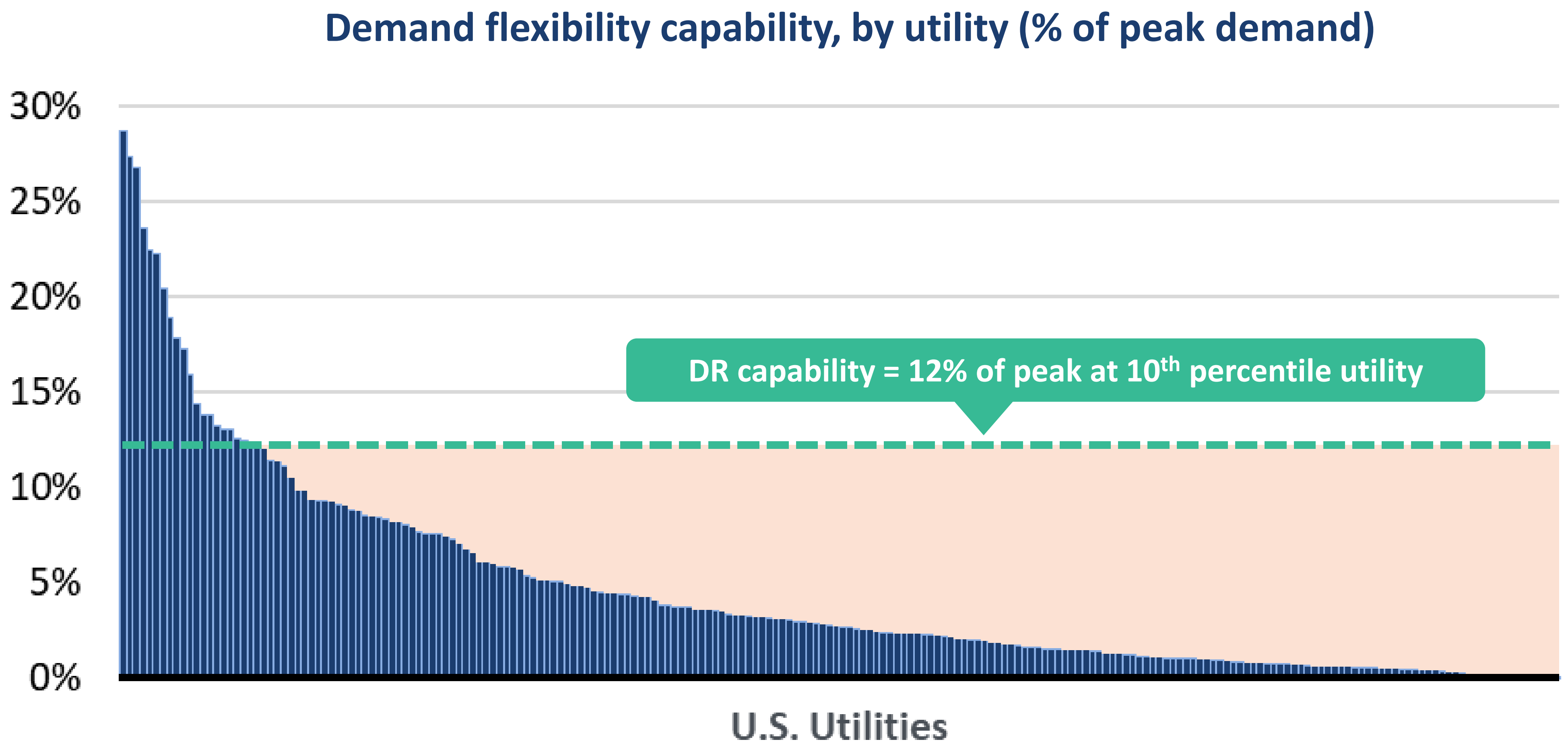


Mature:
- Large C&I manual demand response
- Large C&I backup generation
- Residential A/C control
- Residential water heating control

Emerging:
- Distributed storage
- EV managed charging
- Large C&I automated demand response
- Thermal storage

Sources: EIA-861 database, FERC annual DR reports. Note that wholesale and retail DR may not be entirely additive.

Some utilities have developed more DER capability than others



Source: Brattle analysis of data from Form EIA-861 2022. The 50+ GW opportunity to scale is estimated as the additional capacity that would result from all analyzed utilities scaling capability to 12% of their peak load. The analysis includes the 214 utilities that: (i) reported DR capability to EIA in 2022, (ii) reported peak demand of at least 100 MW, and (iii) are investor-owned, municipal, cooperative, state, or federal utilities. 12 utilities are excluded due to data anomalies.

Successful practices for a decentralized power grid

Foundational steps:

1. **Deploy** — DERs at grid edge
2. **Enroll** — DERs in flexibility offerings
3. **Utilize** — DERs to maximize grid value

Example options:

1 Deploy

- Accommodate organic DER adoption (e.g., due to reliability challenges, high rates)
- Incentivize customer adoption of DERs (e.g., tax credits, rebates, net metering/billing)
- Allow utility to deploy / own DER as grid asset
- Streamline installation and interconnection

2 Enroll

- Offer enrollment incentives (e.g., up-front capacity reservation payments)
- Promote time-varying rates (e.g., time-of-use, peak time rebates, hourly marginal cost "stack", subscription pricing)
- Streamline DER enrollment process (including default enrollment)

3 Utilize

- Compensate based on performance
- Automate DER response / dispatch (via utility or aggregator)
- Manage customer impact (e.g., event limits, minimum battery reserve levels)

These activities are often motivated by:

- Response to emergencies
- Financial incentives for utilities
- Regulatory requirements / targets
- Competitive, transparent markets

For more information, see Brattle, Distributed Energy, Utility Scale: 30 Proven Strategies to Increase VPP Enrollment.

Puerto Rico case study: Recovering from a devastating hurricane

Background

- After 2017 hurricane, all 1.6 million customers lost power
- Roughly 1 year to fully restore grid; system remains fragile
- Subsequent island-wide blackouts in 2020 and 2022
- Frequent outages persist; 24 outage hours per year (avg)
- 500 MW supply shortfall (15%) anticipated this summer
- Electricity costs are rising; rates approaching 30 c/kWh
- Despite these challenges, strong clean energy goals; 60% by 2040, 100% by 2050

Puerto Rico case study: Recovering from a devastating hurricane

Key actions

- Privatize utility; separate generation business from T&D
- $6 billion of federal investment
  - Grid hardening
  - Advanced metering
  - Large-scale renewables and storage
  - Customer-sited solar and storage (focus on low income)
- Ongoing customer adoption of solar and storage; utility must connect all customer solar/storage systems
- **Introduce "Customer Battery Energy Sharing" Program**

Puerto Rico case study: Recovering from a devastating hurricane

Key features of the CBES program

- Participants enroll batteries through an **aggregator**
- Utility pays **simple incentive** of $1.25/kWh for energy during emergencies
- Manual communication to aggregators; **automated** dispatch of batteries by aggregators
- Emergency event duration **limited** to 2-4 hours, often with **day-ahead notification**
- **Customers choose** battery's minimum energy reserve level, can opt out of events
- Batteries not dispatched during storm

Key participating aggregators

SUNRUN

TESLA

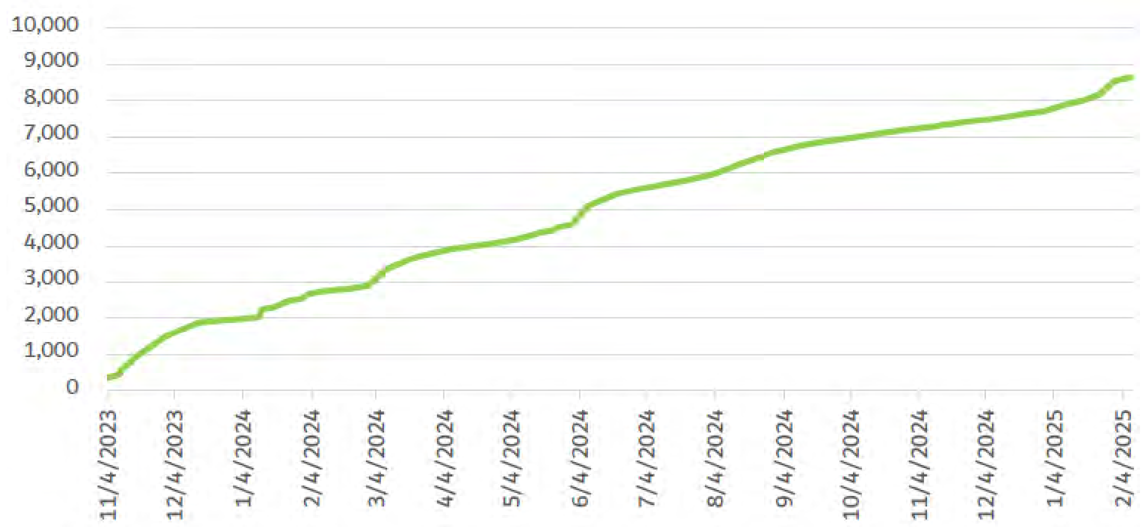
sunnova

Puerto Rico case study: Recovering from a devastating hurricane

Outcome

- Pilot program scaled to nearly 50 MW of enrolled capacity in ~1 year; **20-30 MW consistently available**
- Transitioning to full scale: all customers with batteries will be defaulted on to program this summer

CBES Pilot Enrollment



Challenges

- Continuing to scale program
- Increasing committed energy per battery
- Managing customer fatigue
- Migrating to DERMS-enabled dispatch

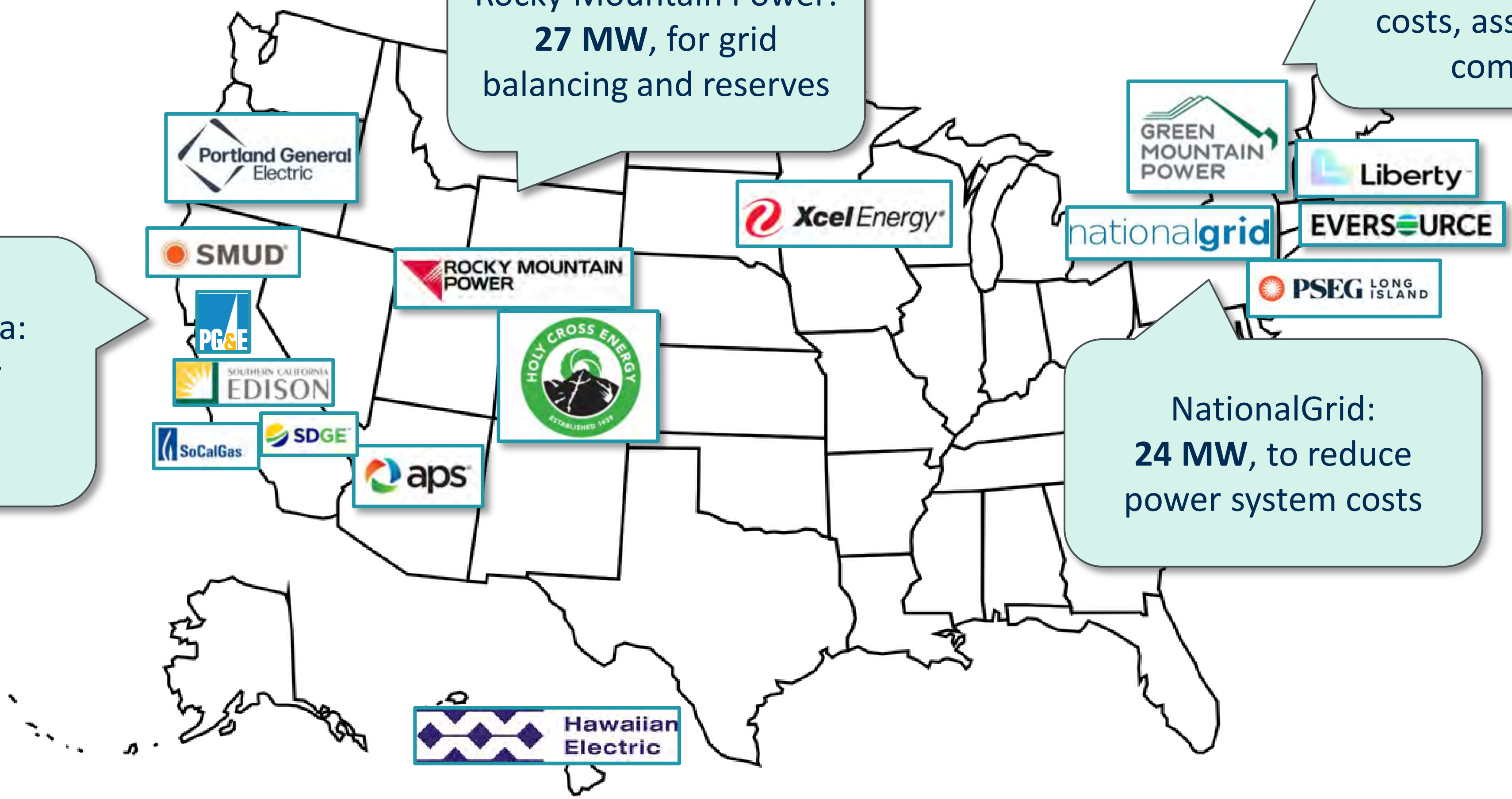
Other storage programs like Puerto Rico’s are beginning to scale

Green Mountain Power: **50 MW** (1% of all customers), to avoid T&D costs, assist vulnerable communities

Rocky Mountain Power: **27 MW**, for grid balancing and reserves

SunRun & Tesla: **350 MW**, for emergencies

NationalGrid: **24 MW**, to reduce power system costs

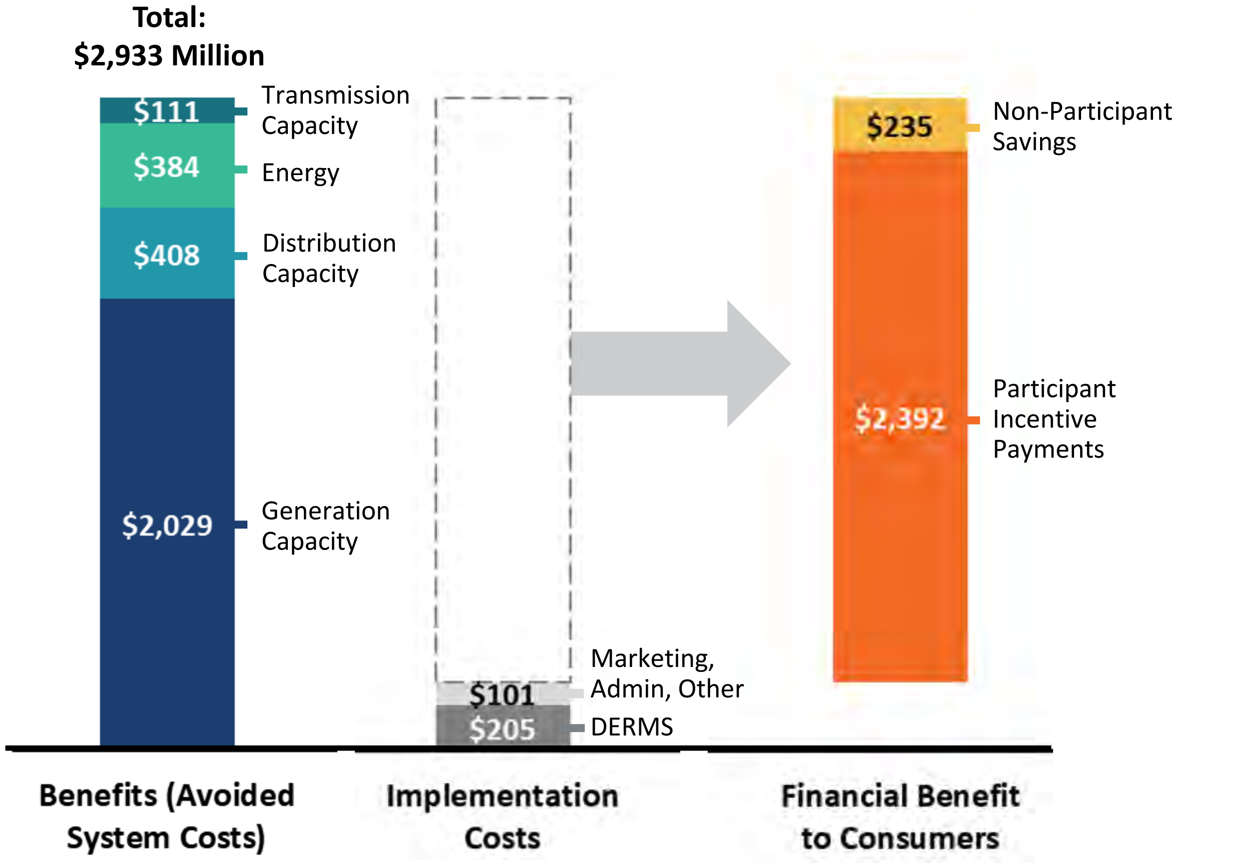


At scale, DER programs significantly improve energy affordability

We estimate that 20% of New York's peak could be served from DERs and demand flexibility

- Nearly $3 billion/year in avoided system costs (capacity, energy, distribution, transmission)
- Only ~$300 million/year in implementation costs (systems, admin, marketing)
- Over $2 billion/year in cost savings returned to **customers**, with portion of value also retained as savings for non-participants

New York Demand Flexibility Potential Benefits (2040)



Potential next steps for Ukraine

Understand the DER opportunity

- Market assessments, customer surveys inform design

Pilot with a plan to scale

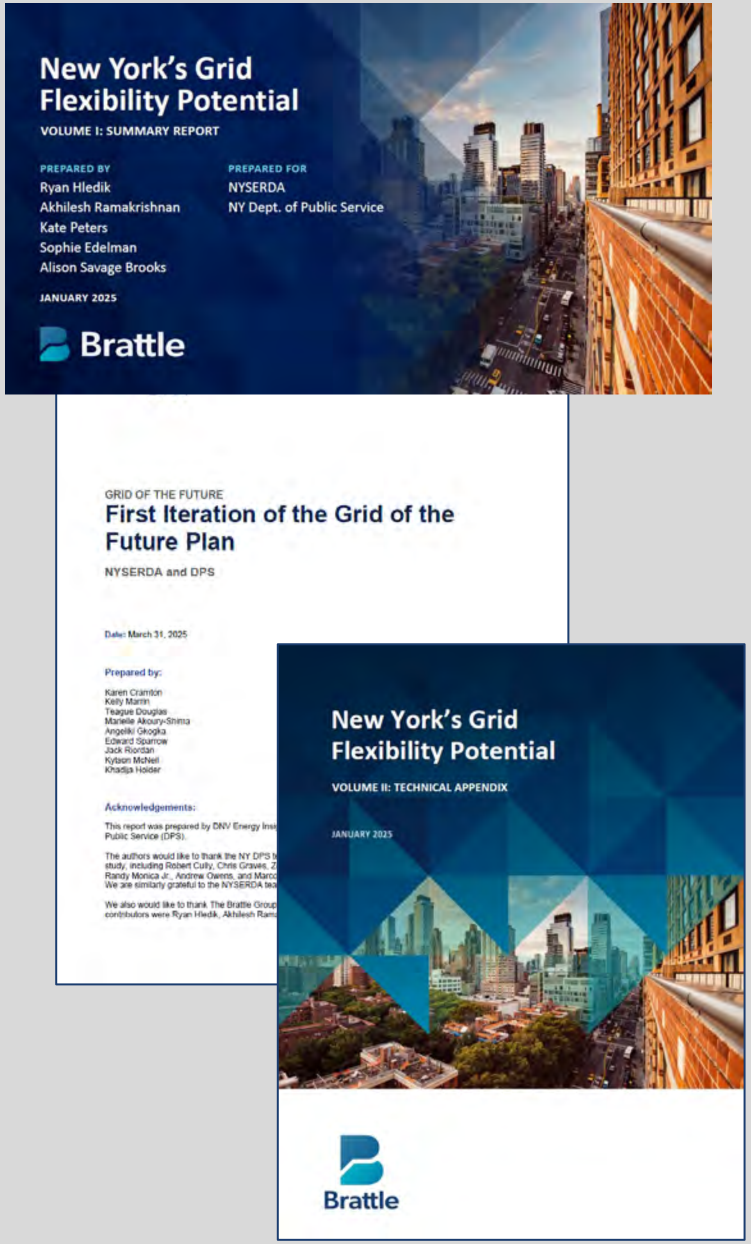
- Assume the pilot will succeed; be ready to build when it does

Ensure basic DER communications infrastructure is in place

- It’s much more expensive to retrofit DERs after they’re installed

Enable aggregator participation in wholesale market

- With appropriate accompanying consumer protections



Appendix A:

Additional DER Resources

Utility ownership: A path forward for DERs?

There is emerging interest in the "Distributed Capacity Procurement" model

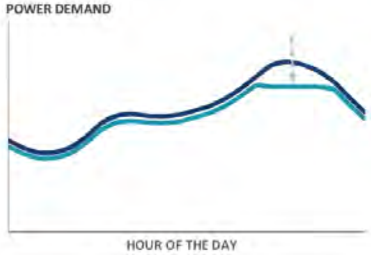
Approach	Advantages
• Identify **constrained** locations of the grid • Determine if DERs are the most **cost-effective** option to relieve constraint • Allow utility to **deploy, own, and operate** DERs at the location • Utilities earn a **return** on the DER assets, may also operate DER to provide **private benefits** to customer	• **Participant**: Revenue from hosting DER asset, improved reliability • **All customers:** Reduced rates (relative to more expensive traditional solutions) • **Private sector:** Large counterparty (utility); reduced/eliminated customer acquisition costs • **Utility:** Expanded rate base while pursuing cost-minimizing solution

For more information, see Sparkfund website.

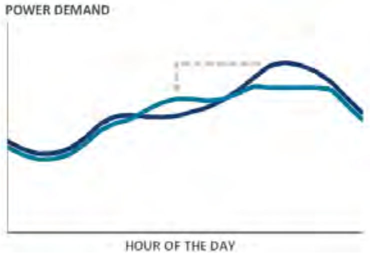
Benefits of VPPs

VPPs provide many operational benefits, along with the potential to mitigate other concerns such as lengthy resource interconnection delays and unprecedented uncertainty in load forecasting.

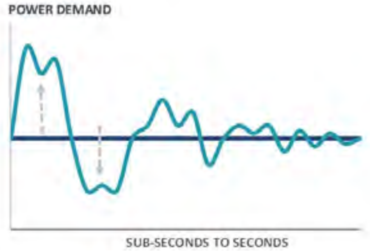
Sources of VPP Operational Value



Peak demand reduction
Dispatchable and event-based, with a limited number of events per season. Primarily provides capacity value.



Load shifting
Occurs frequently. Provides capacity and energy value, and potentially GHG emissions reductions. Helps to integrate renewables by reducing curtailments.



Real-time grid balancing
Some VPPs elements, such as batteries or grid-interactive water heaters, can provide ancillary services to address real-time imbalances on the grid.

Speed and Flexibility of VPPs

	Supply-centric approach	VPP-centric approach
Resource development timeline	Transmission-connected resources constrained by 4+ year interconnection approval process	VPPs can be "built" as quickly as customers enroll and the required control software is implemented
Resource development flexibility	Investments in traditional capacity are a 20-40 year commitment once steel is in the ground	VPPs can scale as demand grows and, to an extent, downsize if needed

Other Sources of VPP Value

VPPs can provide other benefits as well, such as:

- Avoided infrastructure buildout
- Increased renewables deployment
- Better power system integration of electrification
- Enhanced customer satisfaction
- Improved behind-the-meter grid intelligence
- Overall energy savings
- Improved resilience

Additionally, VPPs are the only resource that pays customers to participate in the energy transition.

For further discussion, see Real Reliability: The Value of Virtual Power and Power Shift.

30 strategies to increase enrollment

Marketing

1. Concise messaging about program benefits
2. Multiple motivators for participation
3. Top-of-funnel marketing
4. In-person promotional events

Enrollment Process

5. Create a seamless enrollment process
6. Pre-enroll devices sold on utility marketplaces
7. Point-of-sale enrollment at retailers
8. Offer easy enrollment in multiple programs
9. Integrate value-add services into programs
10. Provide referral incentives

Ecosystem Partners

11. Harmonized messaging from utilities and OEMs
12. Engage customers through trusted entity
13. Partner with local installers
14. Exchange learnings with other utilities

Incentive Design

15. Maximize the financial incentive
16. Ensure customer pays a portion of device cost
17. Offer ongoing participation payments
18. Bundle device financing options with programs
19. Align price signals
20. Offer active and passive control models

Engagement and Retention

21. Improve program design over time
22. Regularly remind customers of their rewards
23. Compensate through channels customer will notice
24. Communicate societal impact of participation
25. Call regular testing events
26. Offer easy unenrollment
27. Offer flexibility to opt out of events
28. Limit event notifications in automated programs
29. Allow customers to set control range
30. Offer technology choice where available

30 Strategies: Impact and Ease of Implementation

Based on perspectives of VPP solutions providers

Key highlights

1 **Concise messaging about benefits.** The headline should be the financial incentive. Also, key program features such as the ability to opt out

5 **Seamless enrollment process.** E.g., offering multiple options for user authentication, pre-populating forms with customer data, and minimizing the number of clicks/forms

7 **Point-of-sale enrollment at retailers.** For example, a checkbox to indicate enrollment when adding a device to the cart on a marketplace or retailer website

9 **Package with other value-add services.** For example, subscription pricing or real-time energy monitoring.

15 **Maximize the financial incentive.** Requires navigating the tension between financial attractiveness and cost-effectiveness.

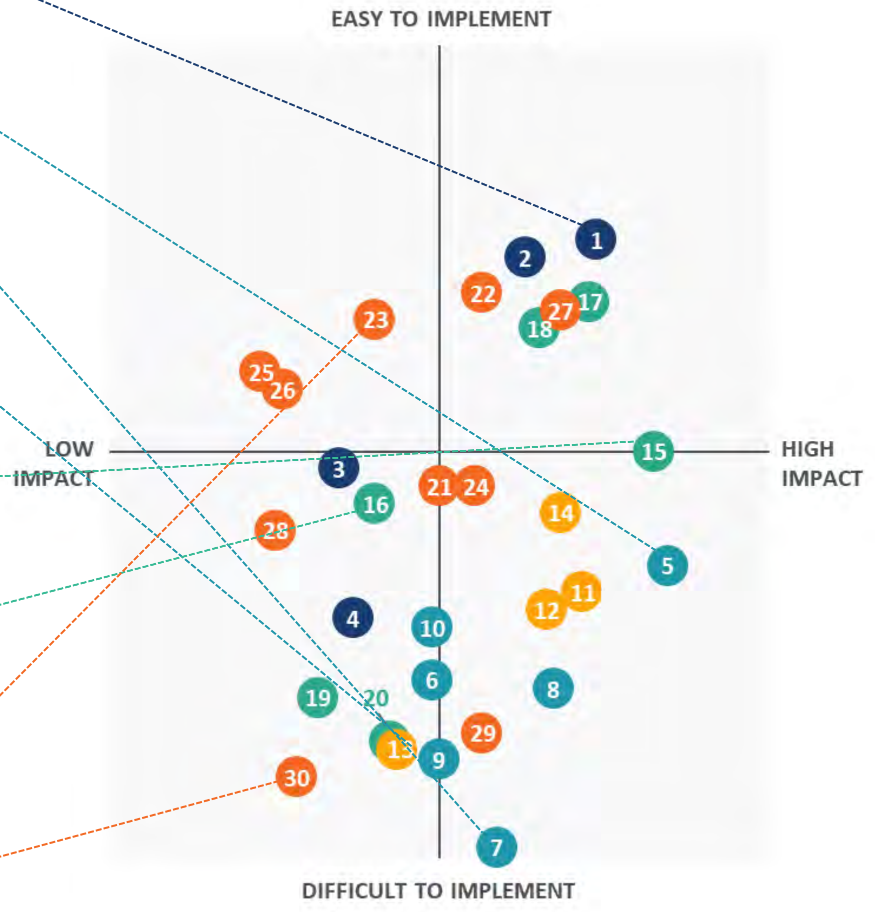
16 **Ensure customer pays a portion of the device cost.** This ensures customers are emotionally invested in their purchase.

23 **Pay through channels customers will notice.** It is important for customers to realize that they are benefitting from participation

30 **Offer technology choice where available.** E.g., smart thermostats and A/C switches have different advantages and disadvantages.

30 Strategies: Impact and Ease of Implementation

Based on perspectives of VPP solutions providers



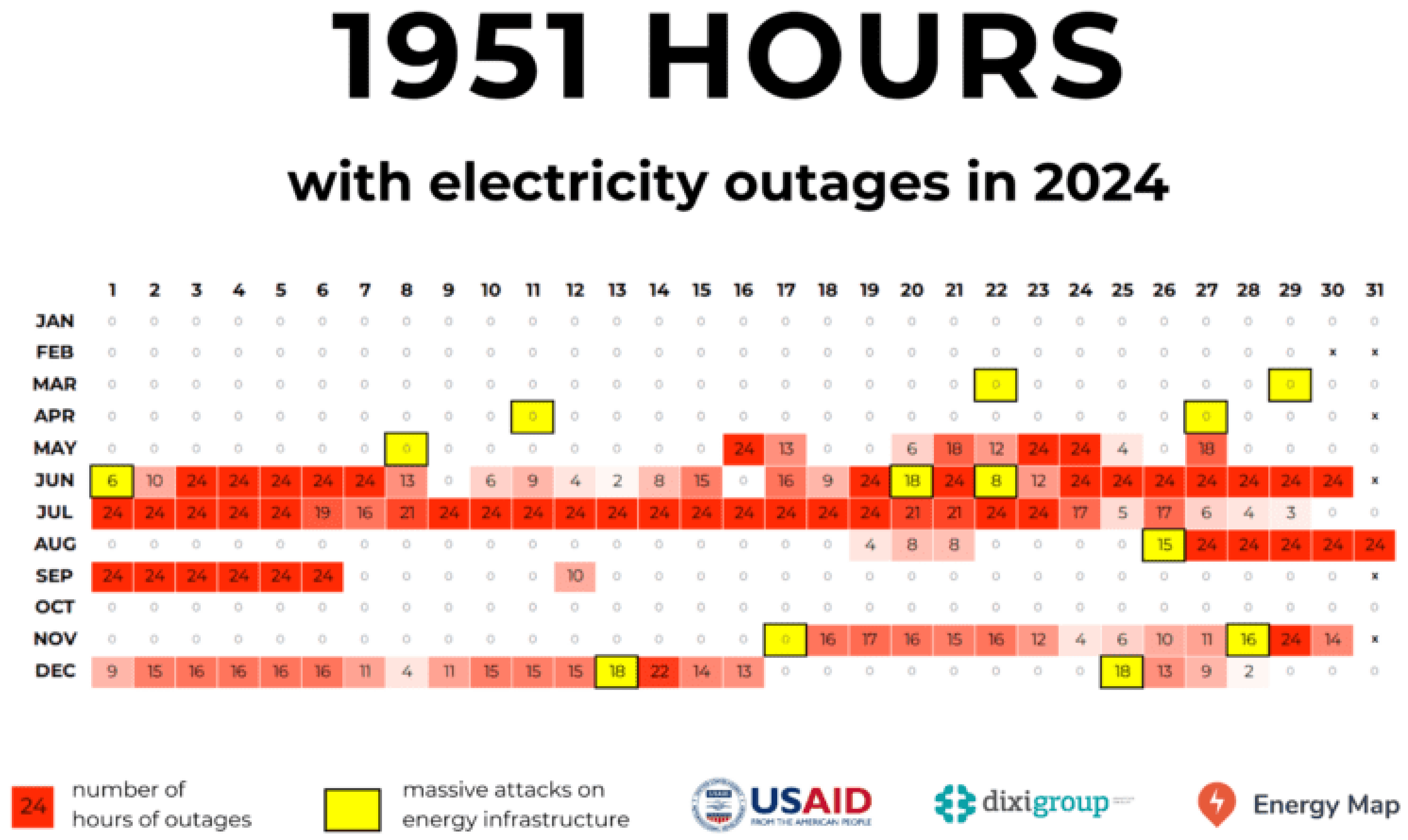
Appendix B:

The Potential Role of DERS in Ukraine

Ukrainian Households Were Left Without Power For More Than a Fifth of All Hours in 2024

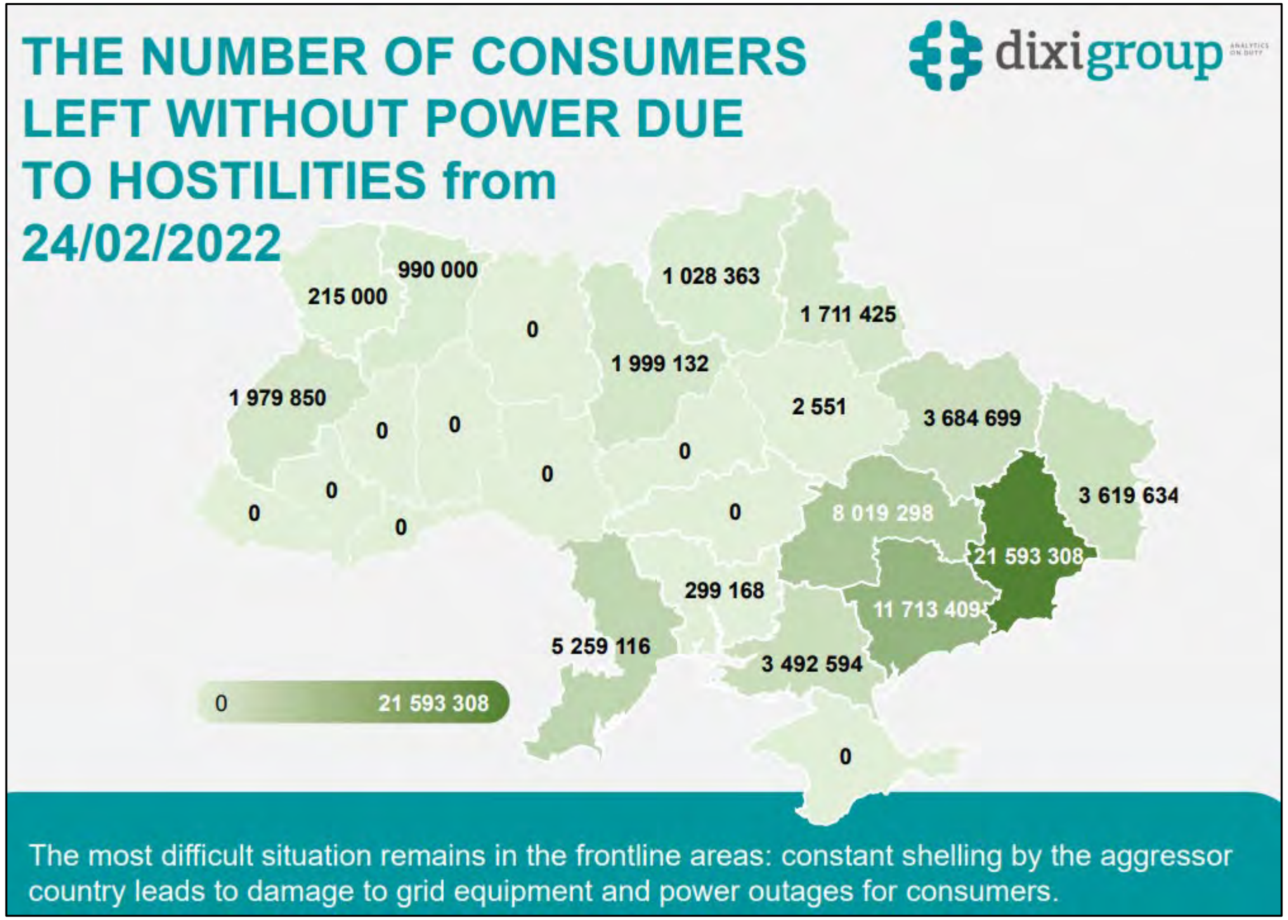
After the massive August 26 attack on energy infrastructure, Ukrainian households were left without power for 11 straight days

DERs and microgrids can help bring power back in the wake of massive attacks and rotating outages



Source: DiXi Group. Scheduled stabilization outages affecting all or most (>50%) of oblasts are reported. Rotating outage schedules implemented on an oblast-by-oblast basis and unplanned emergency outages are not reported in this graphic.

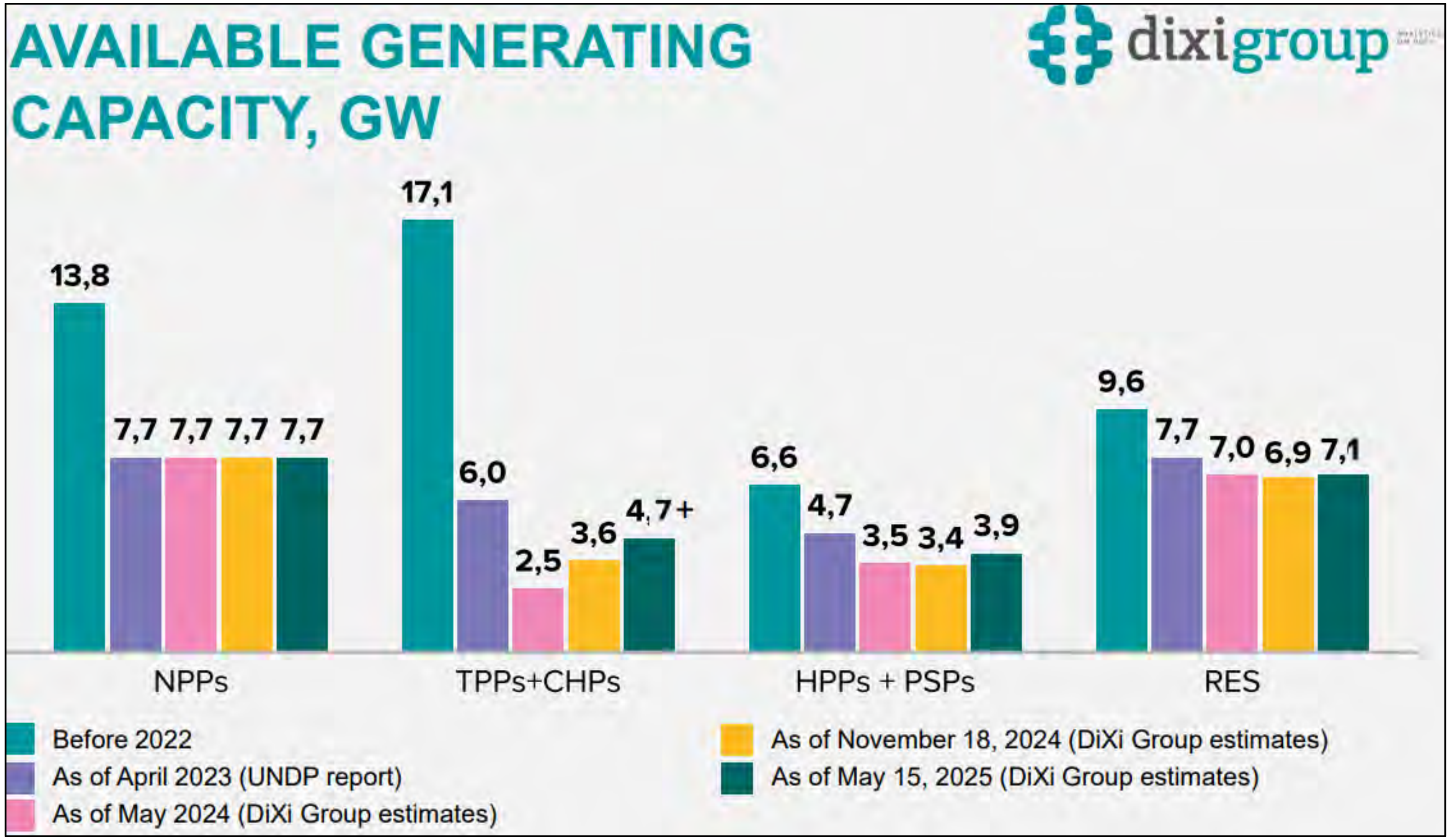
VPP Pilots Could Be Most Impactful in Oblasts Targeted in Attacks on Energy Infrastructure



Source: DiXi Group. Summer 2025 Electricity Outlook. May 28, 2025.

Attacks Substantially Reduce Ukraine's Bulk Generation Capacity

Distributed generation can help fill the gap in Ukraine's power supply.

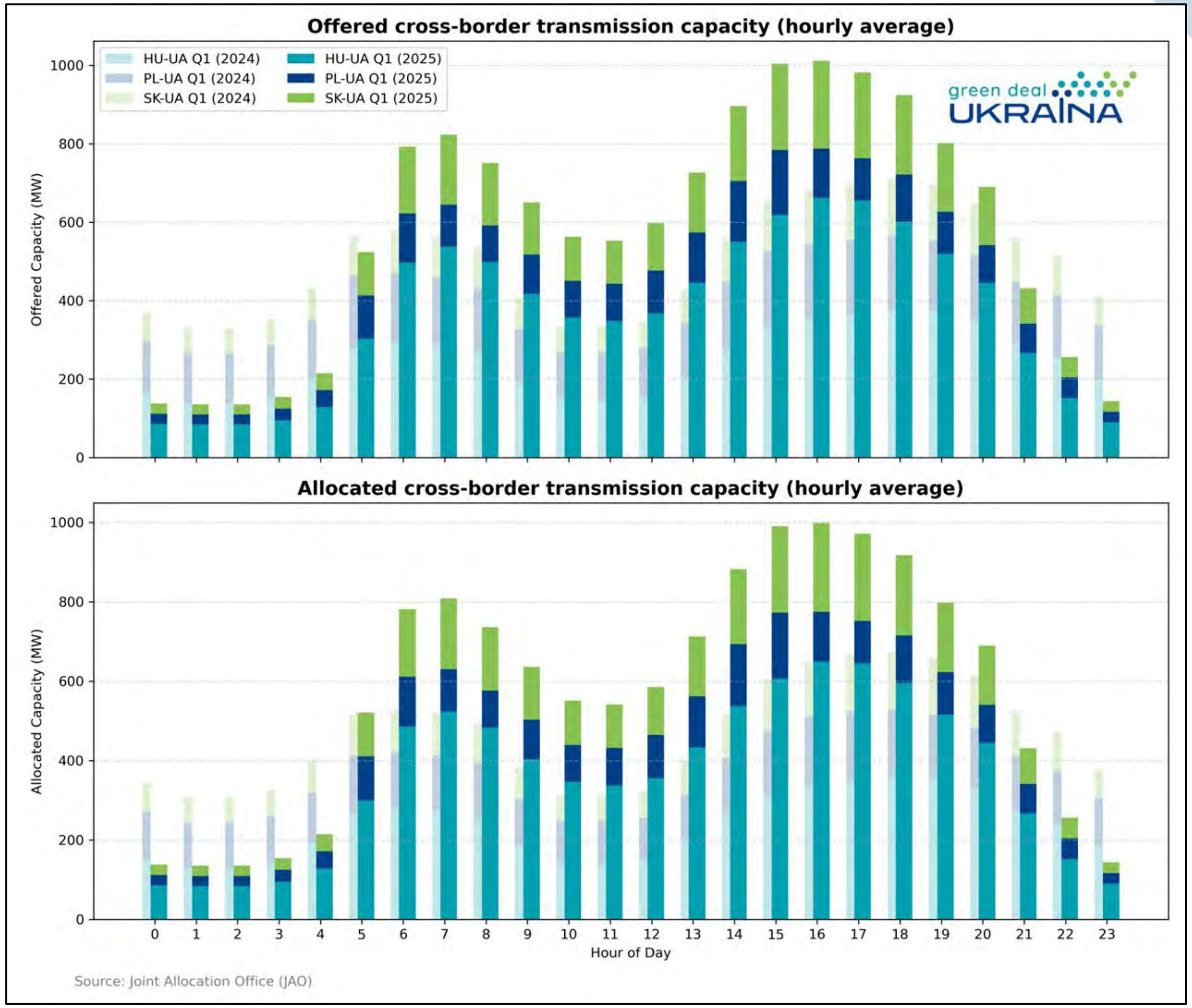


Sources and Notes: DiXi Group. Summer 2025 Electricity Outlook. May 28, 2025. TPP = Thermal Power Plants; CHP = Combined Heat and Power Plants; HPP = Hydro Power Plants; PSP = Pumped Storage Plants; RES = Renewable Energy Systems.

Ukraine's Electricity Imports Peak During Evening Hours and Increase From Q1 2024 to Q1 2025

Increasing import volumes since 2024 highlight the need for additional generation capacity.

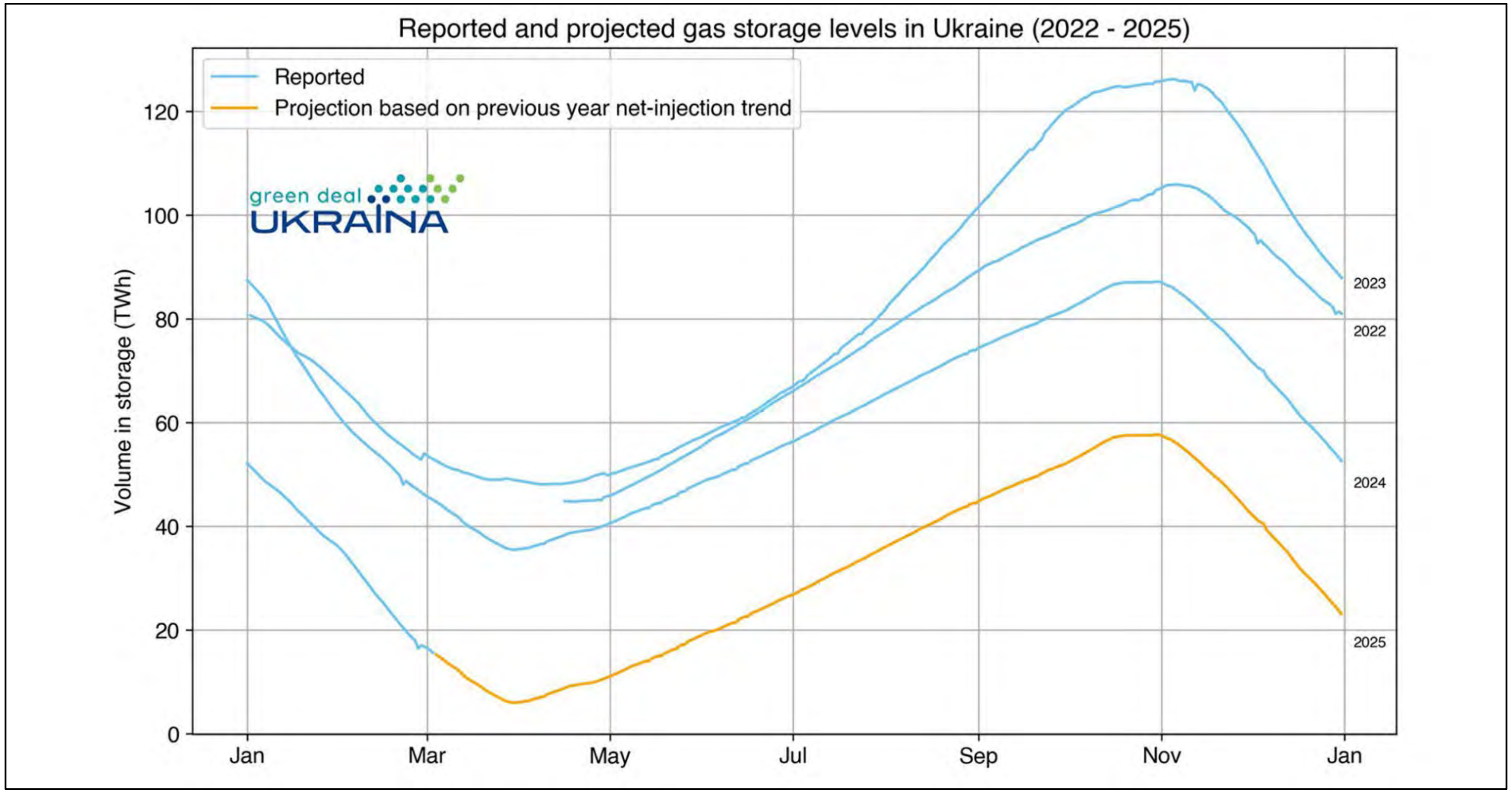
Continued DER deployment can contribute to serving peak loads during evening hours, when imported energy tends to cost more.



Source: Green Deal Ukraina.

Ukraine’s Natural Gas Storage Levels Are Decreasing

Distributed renewable generation, energy storage, and biofuel-powered generators can help reduce reliance on natural gas for distributed generation.



Source: Aggregated Gas Storage Inventory (AGSI), accessed via Green Deal Ukraina.


Nanna Bak-Jensen
Danish Energy Agency (DEA)
Talya Vatman
Ryan Hledik
The Brattle Group
Jacques Warichet
International Energy Agency (IEA)


Empowering Ukraine:
Addressing Barriers to Increased use of
Distributed and Renewable Energy
Resources towards 2030
Copenhagen, 10 June 2025
International Energy Agency
iea
International Energy Agency
This project is co-funded by the European Union


Mikkeller