Proposed Options for Bilateral Integration of Generation Portfolios and Load (BIGPAL)

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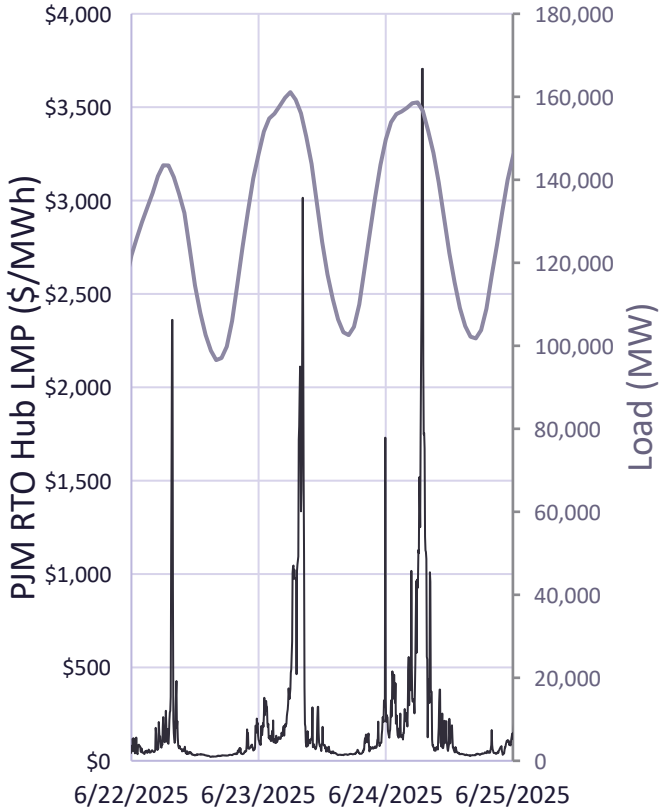
BIGPAL: A Path to Support New Capacity

The BIGPAL structure is designed to support rapid entry of new capacity resources + large loads, including (not limited to) battery energy storage (BESS) resources that are especially well positioned to mitigate near-term resource adequacy concerns

- BESS is increasingly deployed at scale, with over 7.6GW deployed in the U.S. in the first half of 2025 alone
- If PJM enables financing and offtake, BESS can play a meaningful role in resource adequacy:
  - Over 2GW of BESS in PJM has signed GIAs and potential online dates between 2026-2030
  - An additional ~16GW of BESS is seeking to connect in TC1 and TC2
  - Most projects are >= 4hr duration
- BESS can be constructed rapidly, reaching COD ~20 months from GIA issuance on average.



Sources:
https://cleanpower.org/resources/u-s-energy-storage-monitor/
https://emp.lbl.gov/sites/default/files/2024-04/Queued%20Up%202024%20Edition_R2.pdf

Proposed Options for Bilateral Integration of Generation Portfolios and Load (BIGPAL)

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PJM urgently needs solutions to bring online new capacity quickly to meet large load growth

- PJM expects ~23 GW of new load by 2030, but only ~12 GW UCAP of new total capacity => this contributes to **potential reliability shortfall** >10 GW, also creating affordability concerns

Brattle-Eolian BIGPAL solution options:

Operationally-linked capacity portfolio framework to allow large loads to cover their capacity needs with adjacent supply, with large load flexibility (including backup generation) as a backstop allowing for dependable emergency operations and commercially flexible allocation of ELCC, performance, and counterparty risk

90-day interconnection study (optional) for new generation operationally-linked w/ new adjacent load (and facilitate linked studies for load integration)

The benefits of this approach are:

- Accelerated connection of new PJM supply addressing capacity supply shock and reliability shortfall
- Flexible contracting allows adjacent but commercially distinct entities to self-supply resource adequacy, transferring risks (ELCC, performance, counterparty) from PJM to the contracting parties (w/ flexible allocation among them)
- Similar to established tariff mechanisms
- No mandates on load curtailment or use of specific resources; technology agnostic solutions
- Makes possible accelerated load interconnection by pairing new supply with new load

Design Sketch of Bilateral Market Construct under BIGPAL

Eligibility

- Available to **new large loads contractually linked with electrically adjacent, front-of-meter new generation of any technology**
  - Focus on new generation based on interconnection approach and goal of increasing supply
- Seeking feedback on **definition of "adjacent"** as either:
  - Variant i: electrically equivalent (e.g., same substation, can be different busses) Variant ii, borrowing from SPP HILLGA: load is within 2 substations of generation
- **CIRs not required**, because adjacent load takes deliverability risk (new BIGPAL generation can retain CIRs if obtained through the Queue)

Market Concept

- Bilateral capacity contractually ties BIGPAL load and generation such that they enter service jointly
- BIGPAL supply and demand not transacted through capacity market—BIGPAL load ICAP is removed from reliability requirement after pairing with BIGPAL supply at the same ICAP (net capacity market impact of BIGPAL is zero because load-flex-backed resource inherently meets capacity need of the load)
- Performance obligation of 0 MW net withdrawals across the BIGPAL portfolio + load during Performance Assessment Interval or other grid emergency (i.e., backstop of load flexibility if the adjacent portfolio of capacity resources fails to perform)

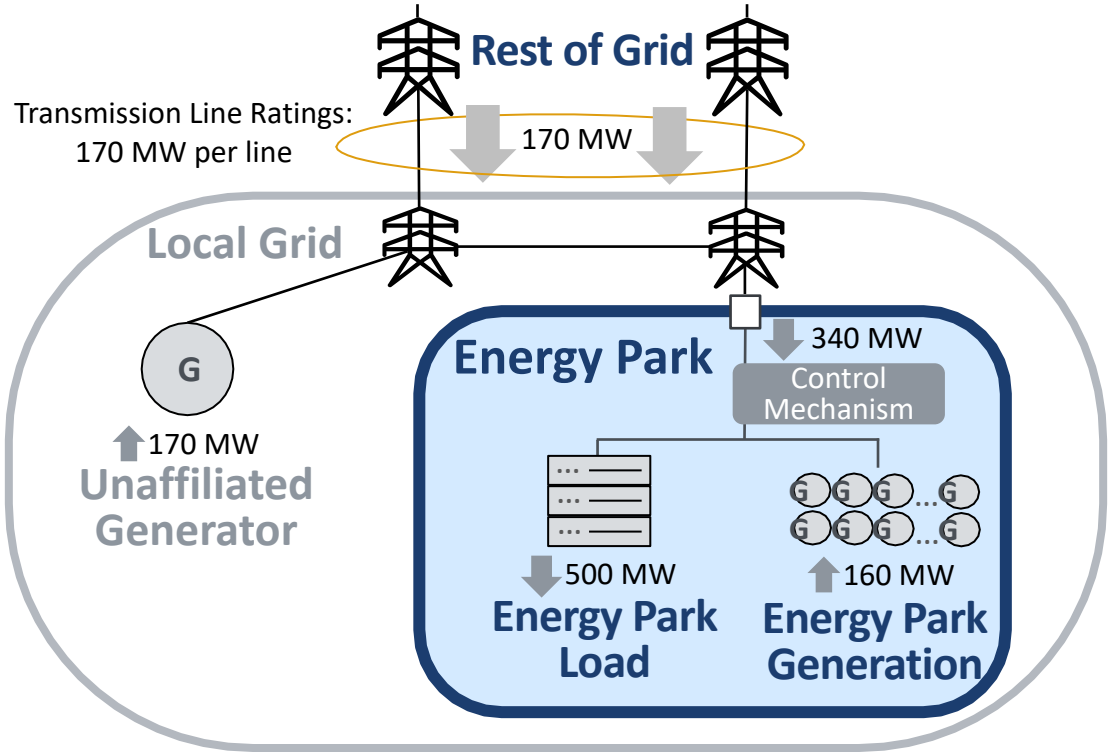
Benefits

- Allows parties to assume performance risk through contractual means, instead of PJM designations
- No ELCC accreditation (assumes dependable net performance of resource portfolio and load)
- Large load flexibility is *backstop only*, not called upon (by PJM) unless contracted capacity resources are short during PAI

Design Sketch of Fast Interconnection under BIGPAL: Adjacency w/ New Load Simplifies Studies and Avoids Transmission Upgrades

- **We propose a 90-day interconnection process for new generation linked with large load in a BIGPAL**, borrowing from SPP HILLGA proposal[1]
- Deliverability of BIGPAL generation to adjacent load can be established without extensive study or interaction with other generators in the Queue; BIGPAL therefore omits generator deliverability studies in summer, winter, and light load cases, **focusing BIGPAL generator interconnection studies instead on quicker short circuit and stability studies**
- By contractually obligating load to enter service with paired generation, **BIGPAL allows load studies to be conducted in the presence of the new generation[2]; SPP leverages this for a 90-day load connection study,** which could be possible for PJM TOs studying new BIGPAL loads (and for PJM when conducting its "Do No Harm" study)

Example of New "Energy Park" Generation Avoiding Overloads due to Addition of Adjacent Energy Park Load in Intact Grid Case (See Source and Next Slide Showing that Contingency Cases Are Also Secure)



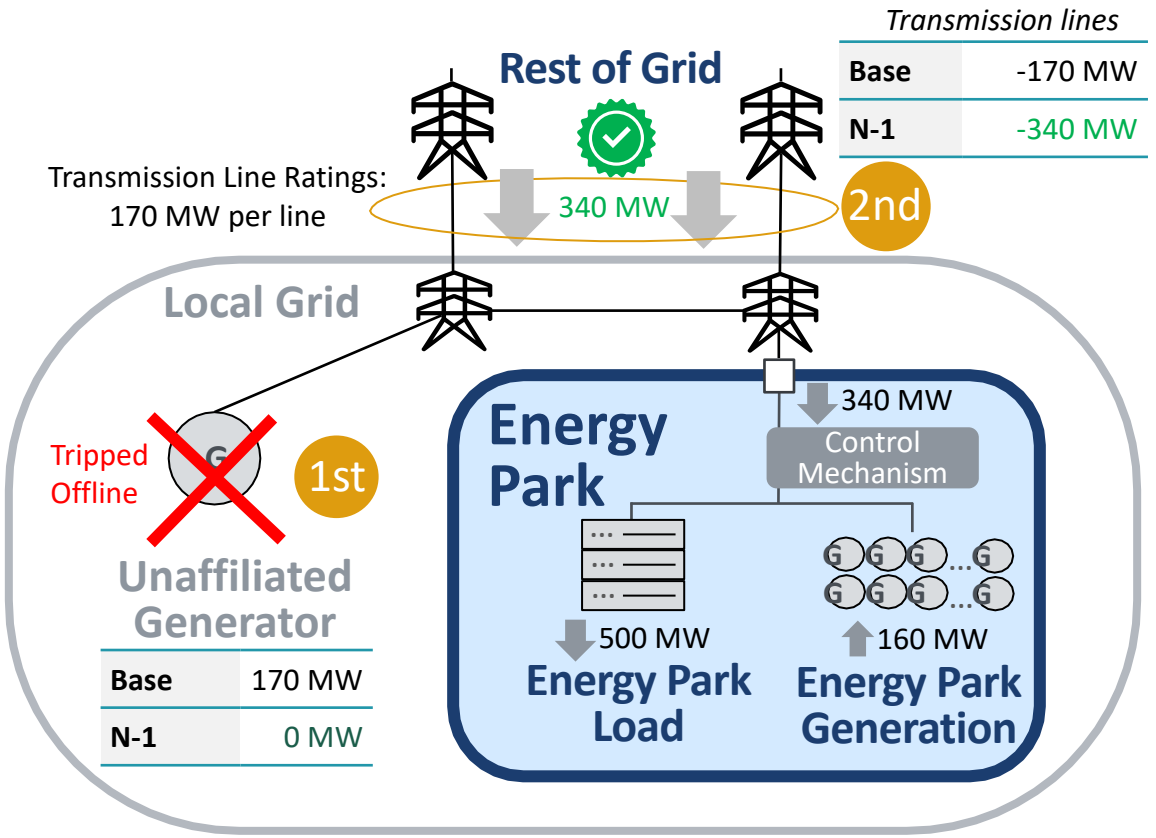
Source: Brattle, 2025, Accelerating the Integration of New Co-located Generation and Loads

[1]SPP, 2025, High Impact Large Load Integration

[2]MISO, PAC-2024-7 on Coordinating Transmission Planning and Generator Interconnection to Accommodate Large Loads

Example: N-1 Contingency Study for Adjacent Load + Generation

- In the N-1 case for reliability studies, an unaffiliated generator trips offline, stressing the grid near the new large load
- Because the adjacent generation is modeled in the same case as the new load, the increased flow over the transmission network does not cause overloads in this stress test N-1 case
- In this example, the system can return to N-1 security (immediately or within 10 – 30 minutes) via security constrained economic dispatch (SCED) or other controls that increase the output from the adjacent "energy park" generation to 330 MW
  - i.e., the configuration is also N-1-1 secure
- This shows that studying the linked adjacent load and generation jointly results in secure transmission cases and therefore **avoids upgrades for load integration** that would be needed if they were studied separately



BIGPAL Market Example: Adjacent Battery + Large Load

Large Load: 100 MW	Battery: 100 MW ICAP (ELCC UCAP is not applicable)

Capacity market impact = zero net MW

Under Brattle-Eolian BIGPAL Proposed Options:

- During PAI event if battery supplies 100 MW, **the paired large load is not subject to curtailment**
- **Allows parties to assume performance and ELCC risk:** ability of adjacent generation to match load is not a function of system-wide resource accreditation
- If storage is exhausted before the end of the PAI event or other grid emergency, the paired large load provides **backstop load reduction** of 100 MW (by leveraging back-up supply or drop in consumption) until end of emergency (but likely before PJM would end dispatch of demand response resources)

BIGPAL achieves PJM goals:

1. **Reliability**: PJM gets assurance of **net-zero withdrawals** during PAI (or other grid emergencies)
2. **Affordability**: Zero net MW **capacity market impact** (ensured through direct operation links/controls) isolates the capacity market from any effect from the BIGPAL participants

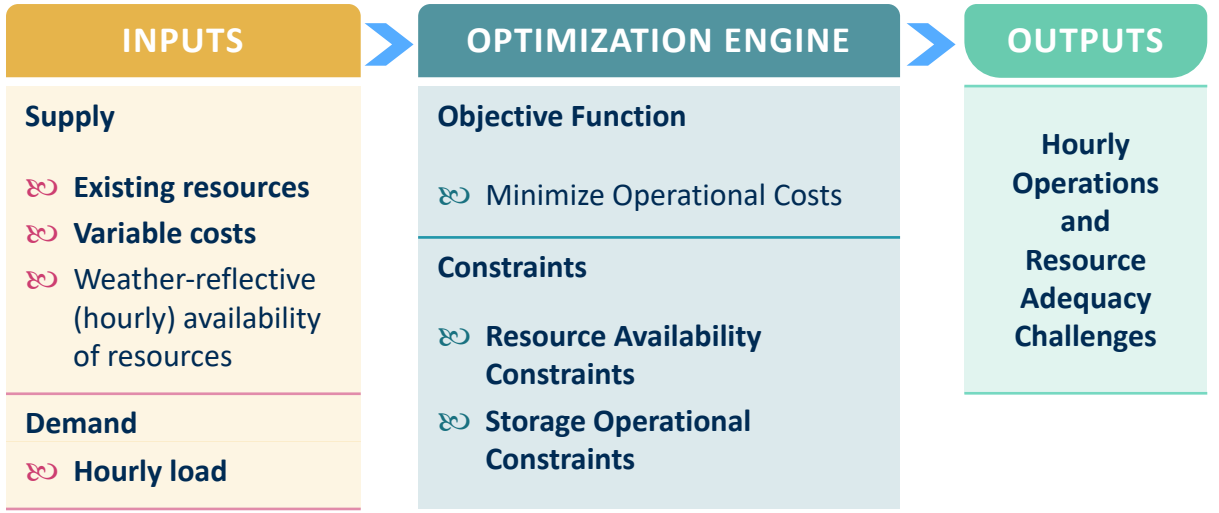
Benefits of BIGPAL Proposed Options

- **Flexible contracting** and risk allocation
  - Contractual risks with non-performance, ELCC degradation, counterparty risk can be internalized by (and privately allocated among) contracting parties, instead of being borne by PJM
  - This creates market-based solutions and signal for efficient capital allocation that encourages new supply to come online
- **Accelerates interconnection of new supply,** addressing fundamental problem of capacity supply shock
  - Pairing new adjacent generation with load can avoid significant network upgrades for load and generation reducing the time to interconnection and load integration
  - This brings new capacity online to serve large loads, reducing reliability shortfall and pressure on capacity market
- **No mandates** on curtailments or use of backup generation (backstop curtailments only)
  - Technology agnostic solution that allows a variety of resources to participate, be operationally linked and assume performance risk as a portfolio
- **Unlocks economic development** through accelerated generation interconnection
  - Other regions (e.g. SPP with HILLGA/CHILL) are pushing forward rapid 90-day interconnection for large loads and adjacent generation to maximize economic opportunities
  - PJM has recognized the need for new solutions that can ensure reliability and fairness for other market participants while meeting the needs of states and large loads to pursue economic development that may otherwise flow to other regions

Load Flexibility & Reliability Analysis

Reliability Analysis – Data Assumptions & Model

- Given PJM's 2030 load forecast and expected resource mix, we estimated the total hours of incremental large-load flexibility OR dispatch of BIGPAL resources (backed by large-load flexibility aka LL flex) required to maintain broader system reliability
- We draw on the following data inputs
  - PJM 2030 hourly load forecast
  - **Multiple weather years** (2015, 2018, 2022) to model a range of weather conditions that inform:
    - Hourly load shape
    - Hourly estimates of forced outages
    - Hourly profiles for renewables
  - PJM scenario analysis (presented at the Sep. 15 CIFP meeting)
  - PJM historical planned & maintenance outages for thermal units
- We built an optimization model that dispatches the least cost set of resources in every hour to meet load, subject to availability of generation



New large-load flexibility ("LL flex") of 25 GW (beyond existing cleared DR in 2026/27 BRA) is dispatched after existing DR; storage is dispatched to minimize production cost

Model does not account for transmission constraints and ramping and start up constraints for thermal units. Results are therefore likely to be an under-estimate of critical conditions on the grid.

Results: Large-Load Flexibility in 2030 Ranges from 0 – 109 Annual Hours; BIGPAL Reduces Flex Hours by 33% - 100%

We modeled PJM's scenarios 1 and 3 for 2030

Hourly analysis results are for weather years 2018 (moderate temps) and 2022 (hot and intensely cold)

"LL Flex Only" case has 25 GW of LL flex, while "BIGPAL" case has 20 GW of BIGPAL storage (4-hour) and 5 GW of BIGPAL gas, backed by 25 GW of LL flex

BIGPAL reduces load shed, eliminating it in one case

In Scenario 1 (short 24 GW), LL flex of 50 equivalent hours* in a moderate weather year is reduced to 0 hours under BIGPAL, and 109 hours in an extreme weather year is reduced to 73 hours under BIGPAL

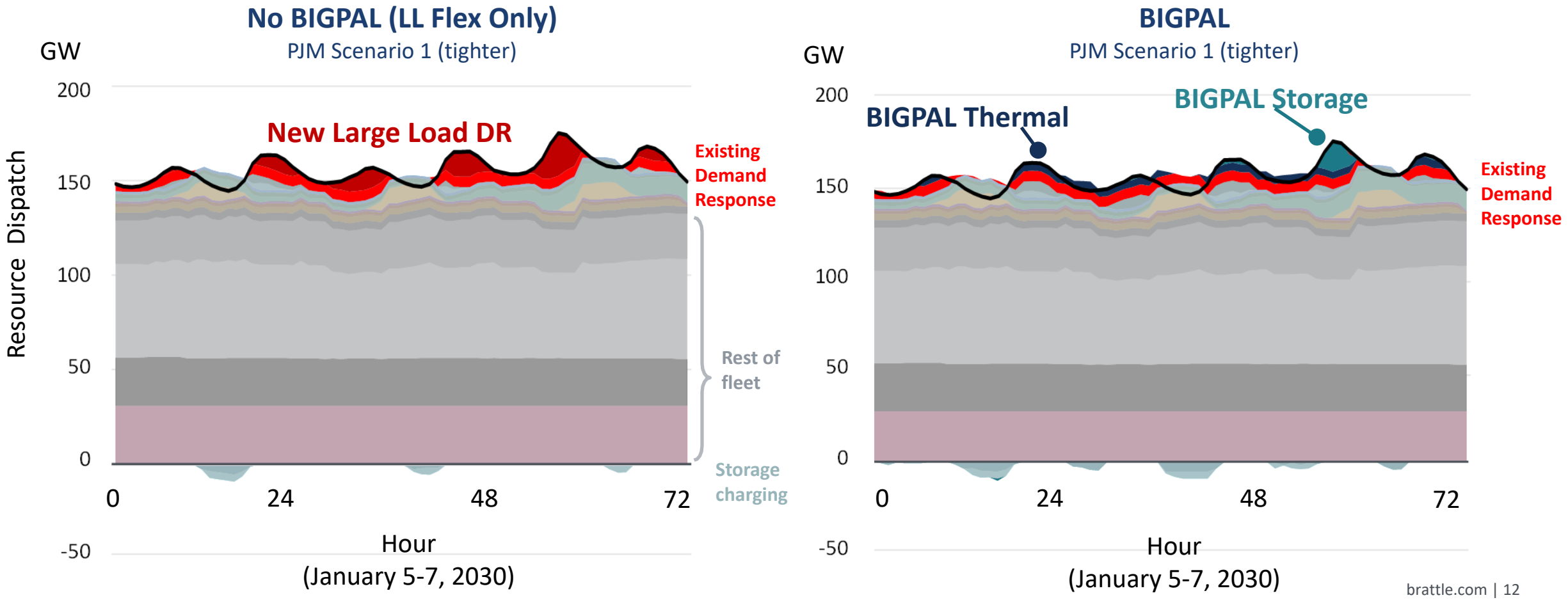
In Scenario 3 (short 10 GW), no LL flex is required in a moderate weather year, while 46 equivalent hours required in an extreme weather year is reduced to 29 hours under BIGPAL

	LL Flex/ Reliability Metric	Weather Year	No BIGPAL: LL Flex Only (All 25 GW)	BIGPAL (e.g., 20 GW storage + 5 GW gas, backed by 25 GW LL Flex)
PJM 2030 Scenario 1: 6 GW UCAP Additions, 8 GW UCAP Retirements	**Equivalent Hours of LL Flex at ICAP***	2018	50 hours (0.57% of annual energy)	0 hours
		2022	109 hours (1.24% of annual energy)	73 hours (0.83% of annual energy)
	# Large Load-DR Events	2018	214	1
		2022	222	98
	PJM Load Shed	2018	0 hours	0 hours
		2022	34 hours	16 hours
PJM 2030 Scenario 3: 12 GW UCAP Additions, No Retirements	**Equivalent Hours of LL Flex at ICAP**	2018	0	0
		2022	46 hours (0.52% of annual energy)	29 hours (0.33% of annual energy
	# Large Load-DR Events	2018	1	0
		2022	82	58
	PJM Load Shed	2018	0 hours	0 hours
		2022	1 hours	0 hours

*Equivalent hours of LL flex means annual energy dispatched from LL flex divided by LL flex ICAP of 25 GW; this is the amount of system capability that could be extracted from the LL flex if each large load site were fully dispatched to flex for all of the equivalent hours; it is lower than the total number of hours with any amount of LL flex dispatch on the system

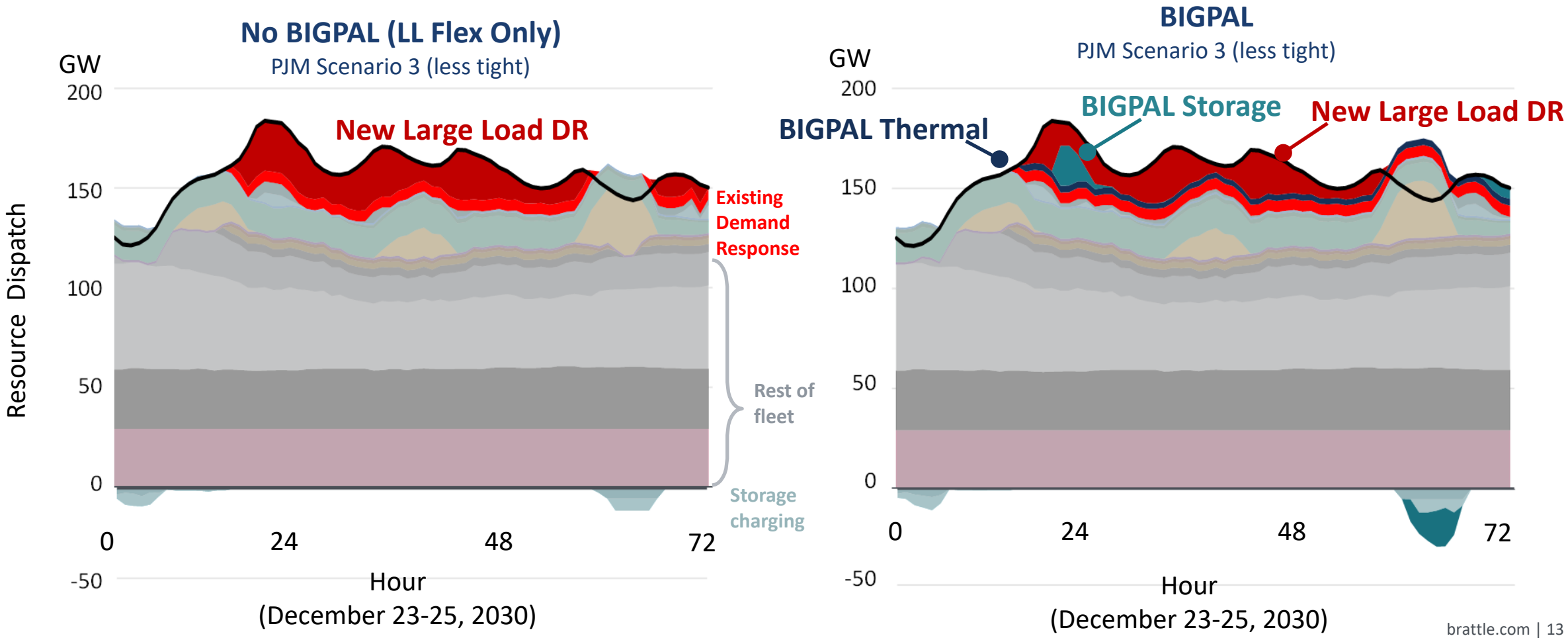
Resource Dispatch During Tight Conditions for 2030 (under Weather Conditions like 2018)

Dispatch of BIGPAL resources avoids the need for extensive deployment of new large load flexibility, as shown here for a January period in 2030 based on weather year 2018



Resource Dispatch During Tight Conditions for 2030 (under Weather Conditions like 2022)

Dispatch of BIGPAL resources reduces the deployment of new large load flexibility, as shown here for winter storm conditions in 2030 based on weather conditions from 2022



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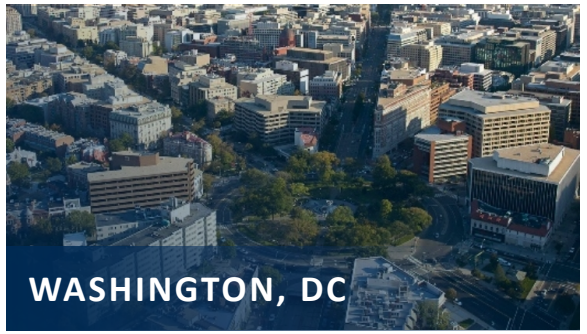

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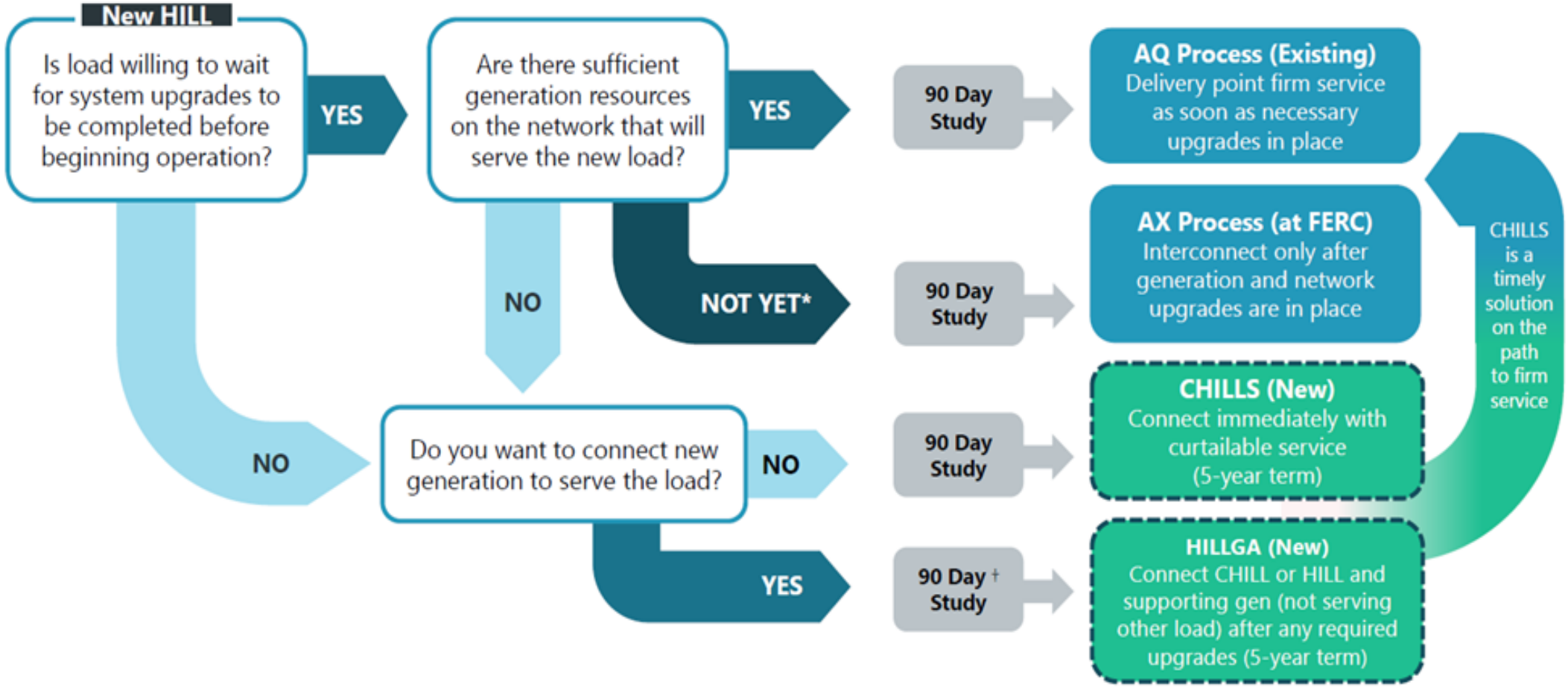
Appendix

Appendix: 90-day Interconnection Process for New Adjacent Resources Builds on SPP HILLGA Proposal



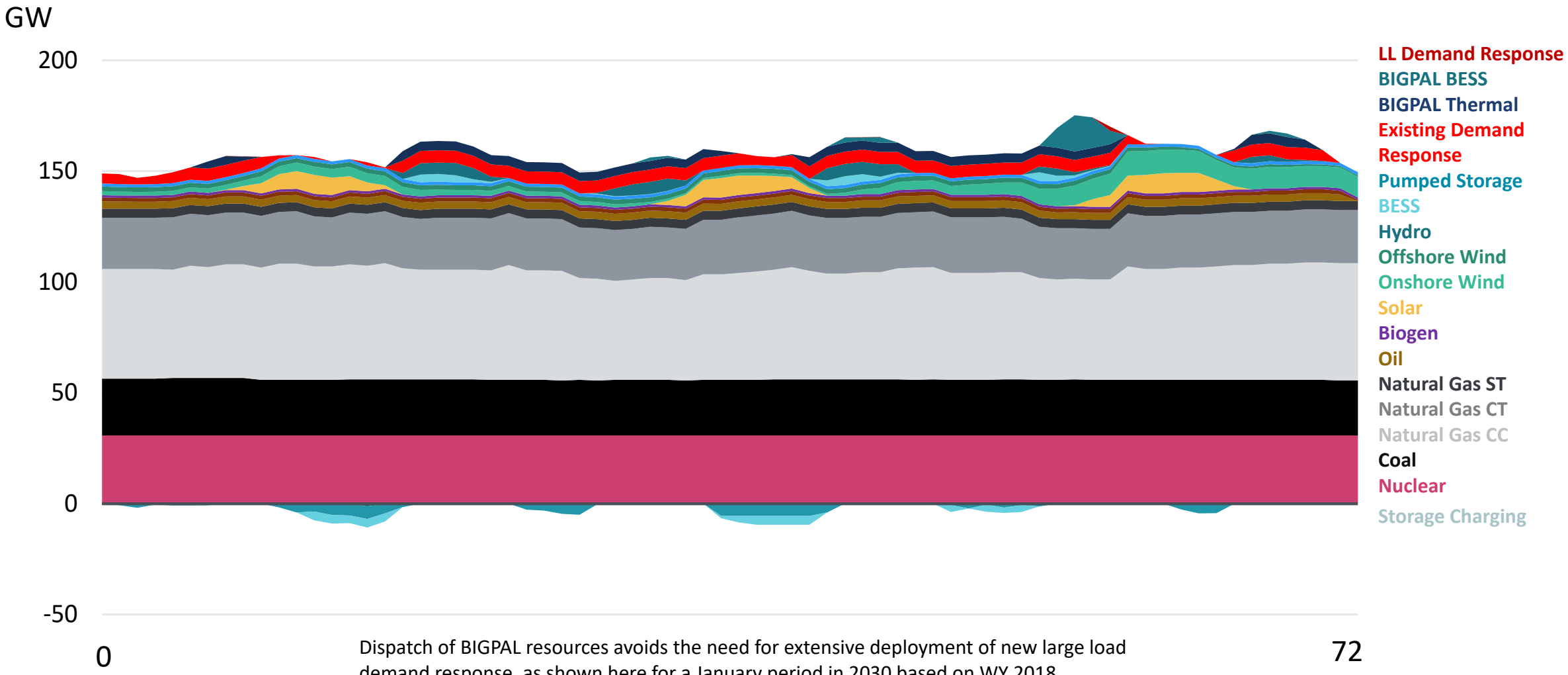
SPP, Large Load Stakeholder Engagement Forum, July 2025

Appendix: BIGPAL Compared with PJM NCBL Proposal

Enhanced arrangement for and operational control of adjacent supply and load to allow parties to flexibly manage risks (ELCC accreditation, performance, counterparty), minimize curtailments, and gain faster interconnection

Risks	PJM NCBL + Current Bilateral Capacity Design	Brattle-Eolian BIGPAL Proposed Options
Gen (ELCC)	• PJM's tariff and accreditation methodology could change over the life of the asset • Generation faces ELCC risk during contracting with load with no flexibility on risk assignment between parties	• ELCC of linked portfolio hedges risk of individual resources • ELCC risk can be shared across gen & load in portfolio • Also hedges risk of ELCC changes
Load	• Load subject to curtailment pre-DR even if supply resources overperform ELCC during PAI • Penalty risk if load is offline and cannot curtail	• Performance risk shared across gen and load in the portfolio (with overperformance credited)
IX	• Generation goes through generator interconnection, load through load studies, no benefit from being nearby or contractually linked	• 90-day interconnection for generation that is adjacent and operationally linked with load

Dispatch of new resources during tight conditions: 2030 WY 2018



Dispatch of BIGPAL resources avoids the need for extensive deployment of new large load demand response, as shown here for a January period in 2030 based on WY 2018