Can DX Smart Inverters Provide TX Voltage Support?

MA-TSRG
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nationalgrid

National Grid’s Solar and Storage Program

Goal: Move from interconnecting DER to integrating it.
Reduce customer interconnection cost and time.

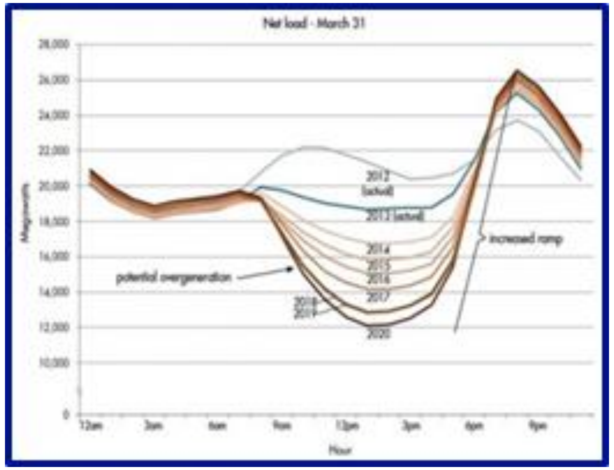
National Grid's Solar Website

Promising Technologies We are Exploring

Key Areas of Research in the program	Partner	Share updates
Increasing Hosting Capacity-Interim Report	EPRI	Offered Q2, 2018
DC Arc flash study	EPRI	Offered Q3, 2018
Increasing Hosting Capacity-Smart Inverters	EPRI	Offered Q2, 2019
PV +Storage+ Load Management systems	Fraunhofer	Offered Q4, 2019
Field Performance Assessment of Advanced Grid Support Functions.	EPRI	Offered Q2, 2020
Can DER be used to resolve Transmission Issues?	EPRI	Q4, 2020
Risk of Islanding of Smart Inverters	NPPT	Q1, 2021
Distribution Resource Open Management Optimization System (DROMOS)	Sandia	Q2, 2021

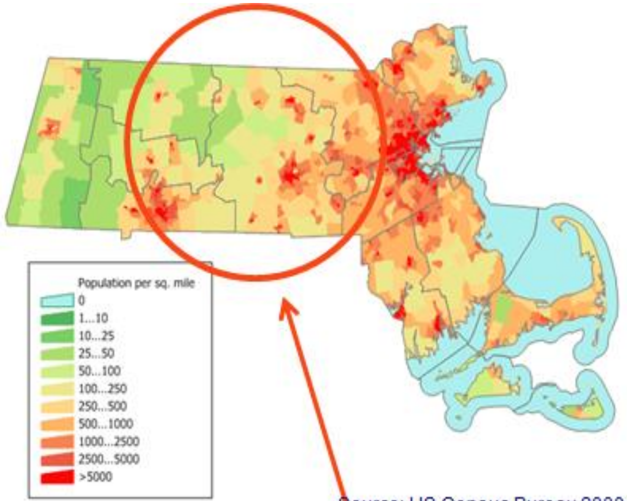
Impact of High Penetration DER on Transmission

- The Duck Curve is the most popular example of the impact of excessive distribution generation on the transmission system



- The Farranti effect is a much less known issue.

- Can Distribution tools be used to address Transmission problems?



Source: US Census Bureau 2000

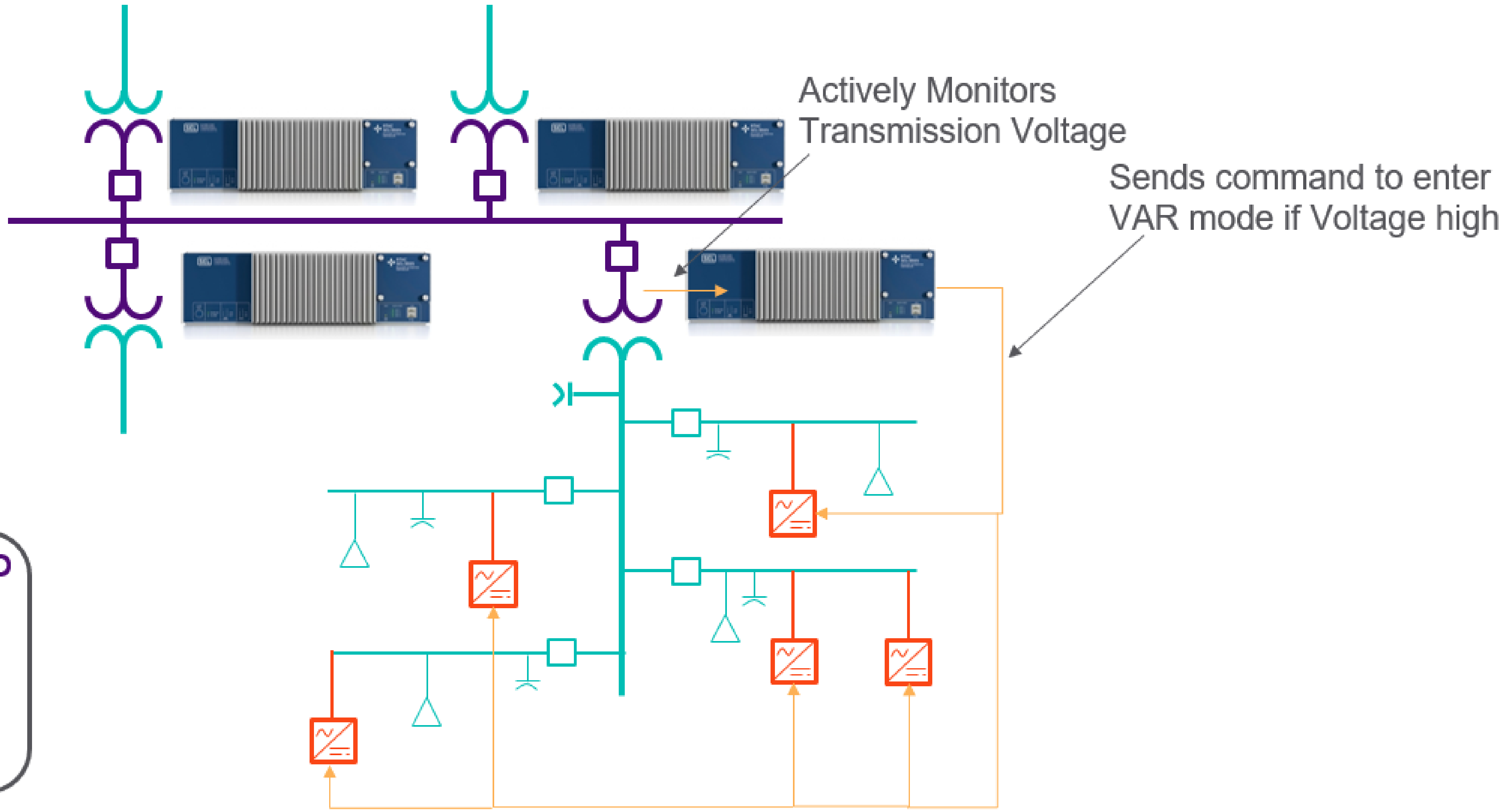
Source: ISO New England

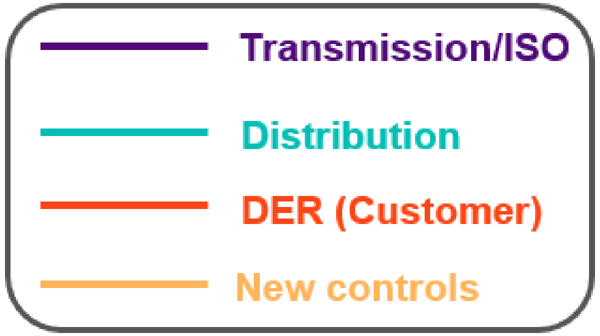
Low population density: ideal for large-scale solar farms

Coupled by system with long T-lines and fewer voltage support

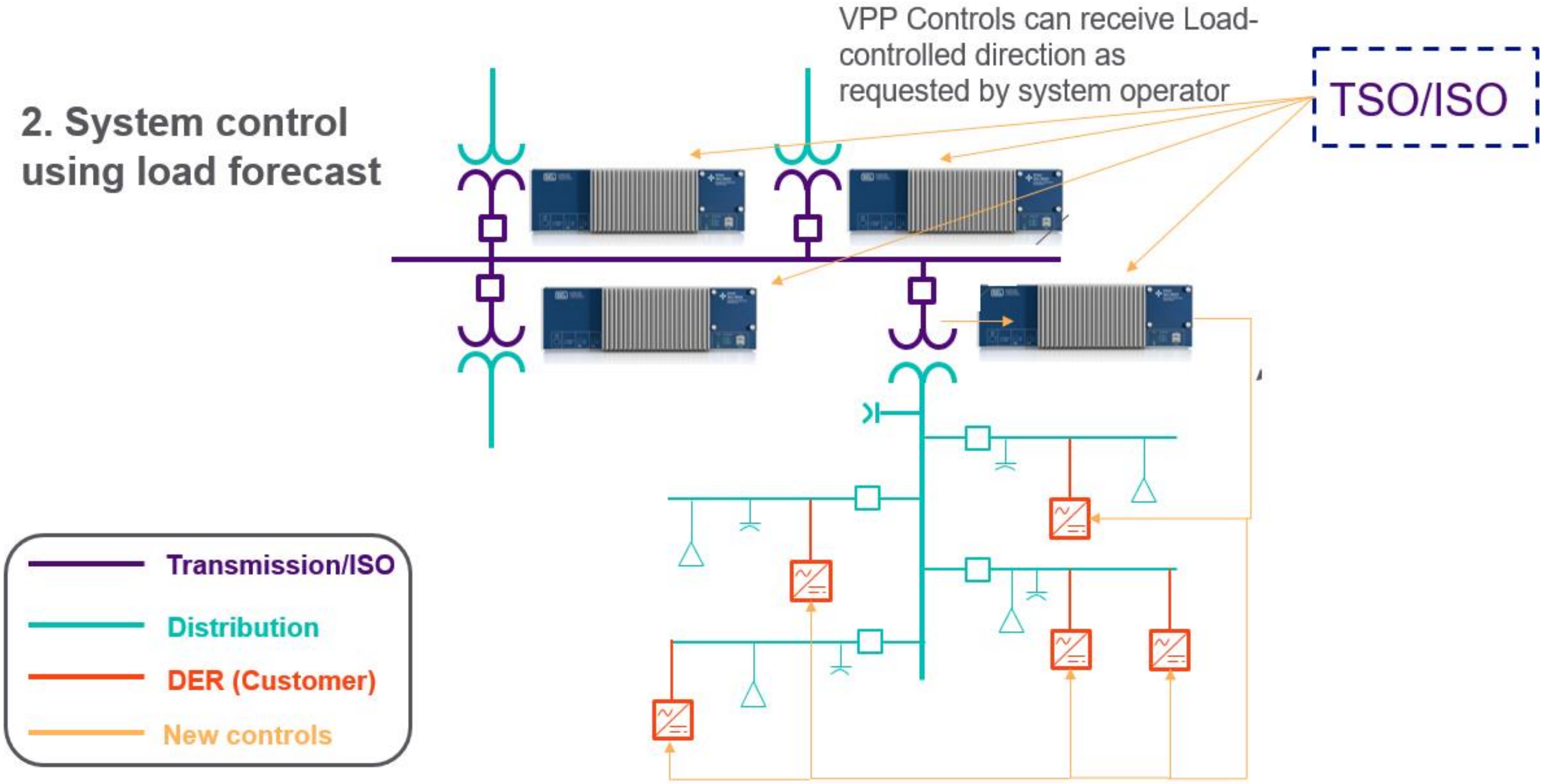
DER for Substation Voltage Regulation

1. Local substation control using voltage reading





DER for System Support



In partnership with EPRI

Develop **PV Deployment Scenarios** for each Feeder Analyzed

- PV penetration?
- Smart Inverter penetration?

Examine the Distribution System **Impacts and Mitigation Requirements**

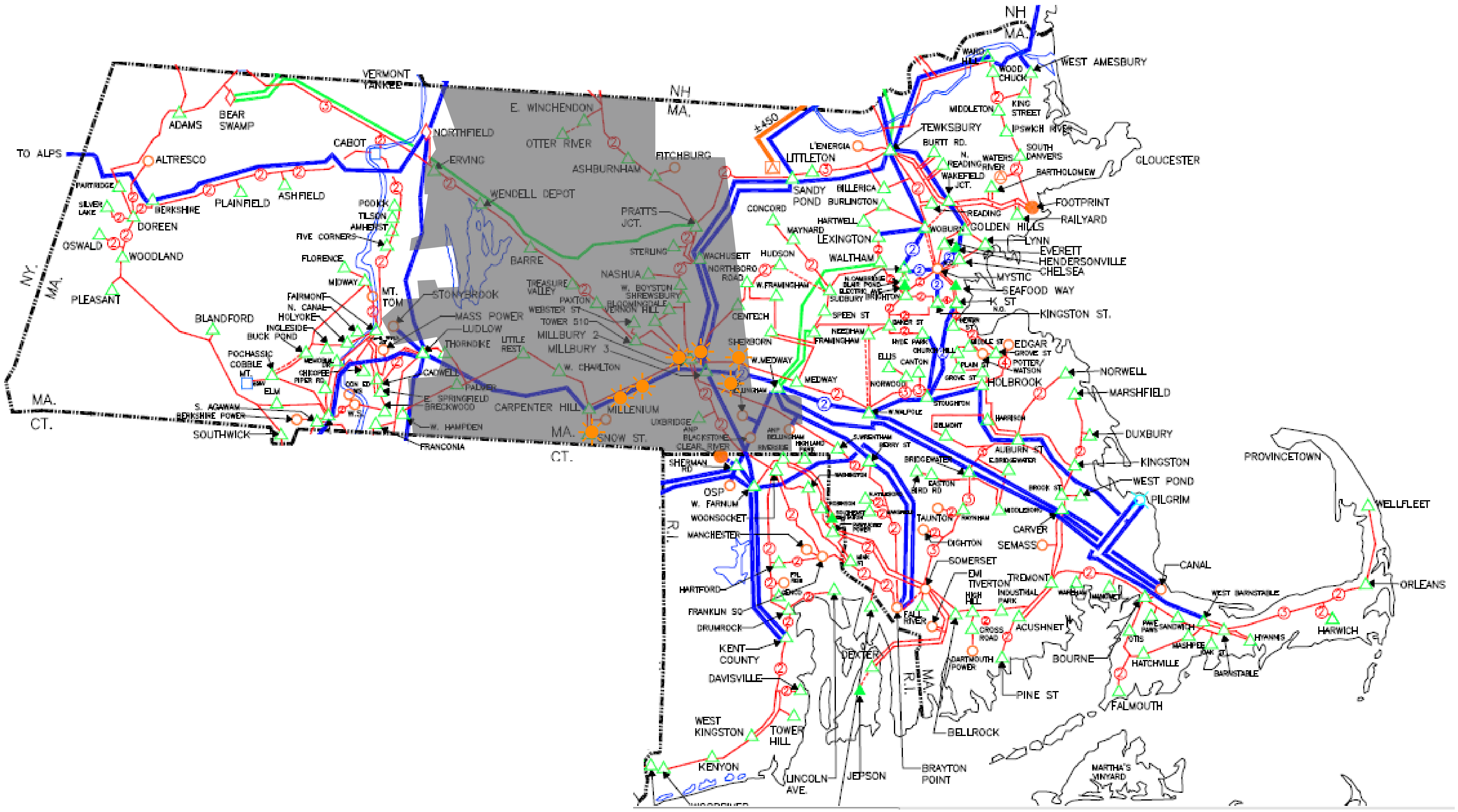
- Analyze Distribution System Impacts
- Assess Mitigation Measures

Estimate Impacts to Solar **PV Generation**

Evaluate the **Costs and Benefits** of using Advanced Inverters Compared to the Traditional Solution (Shunt Reactors)

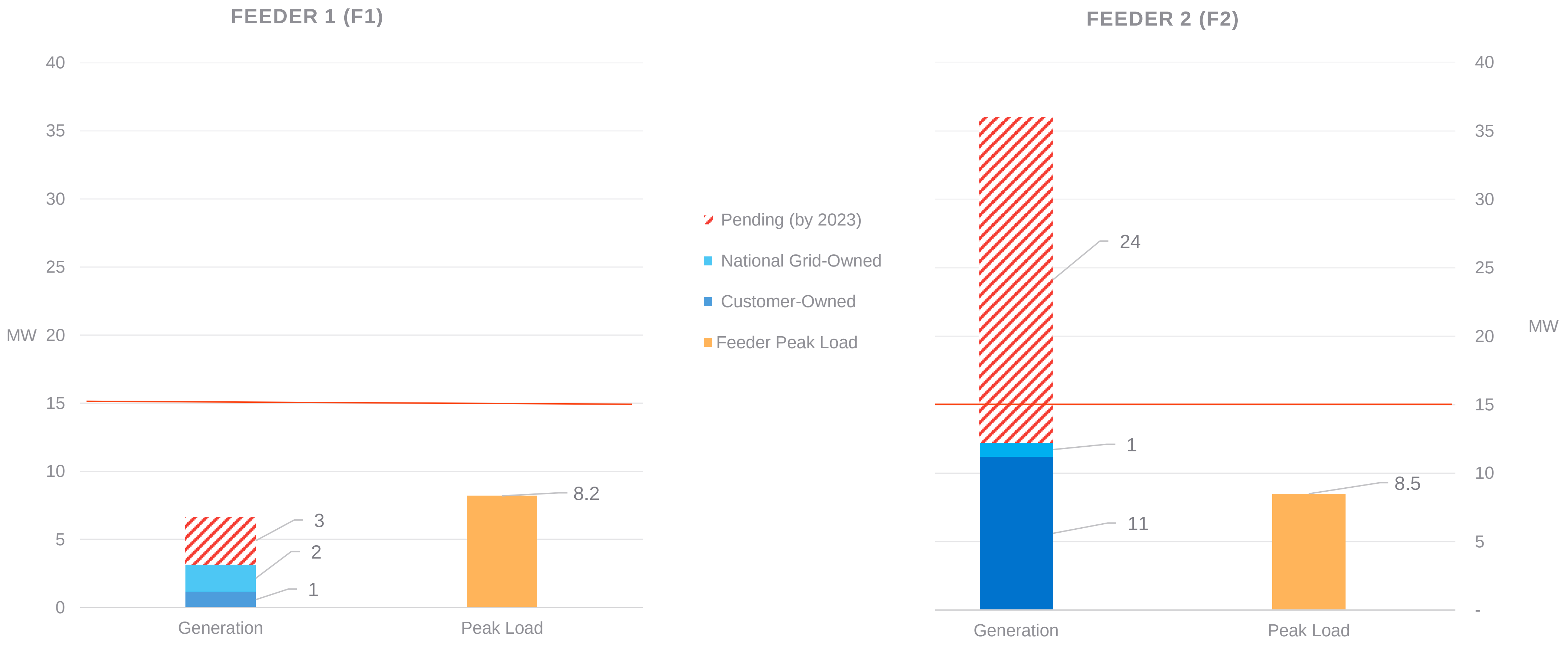
- Analyze Costs for Each Feeder
- Analyze Total Costs And Benefits

7 SPII sites fall in the National Grid Central & Western Mass



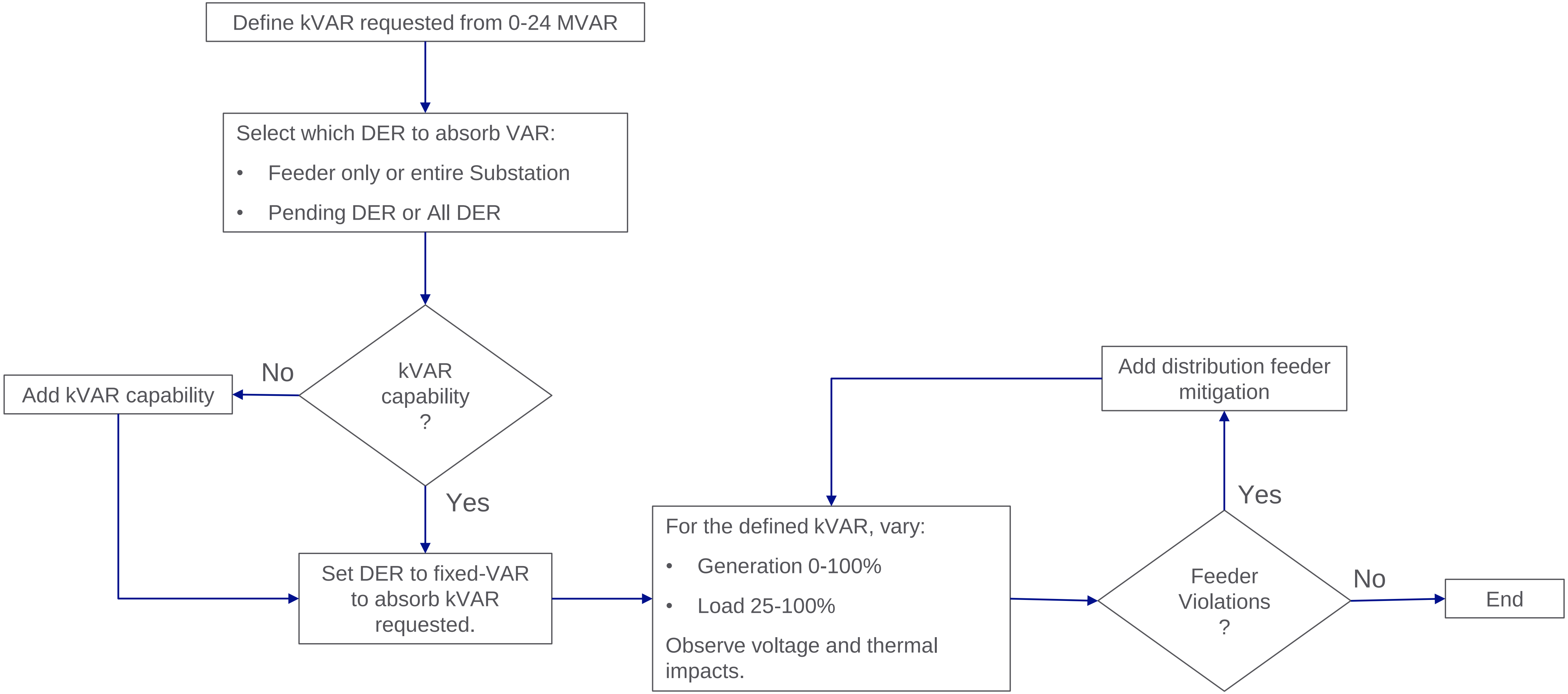
Source: ISO New England

Two Sample Feeders chosen for their diversity

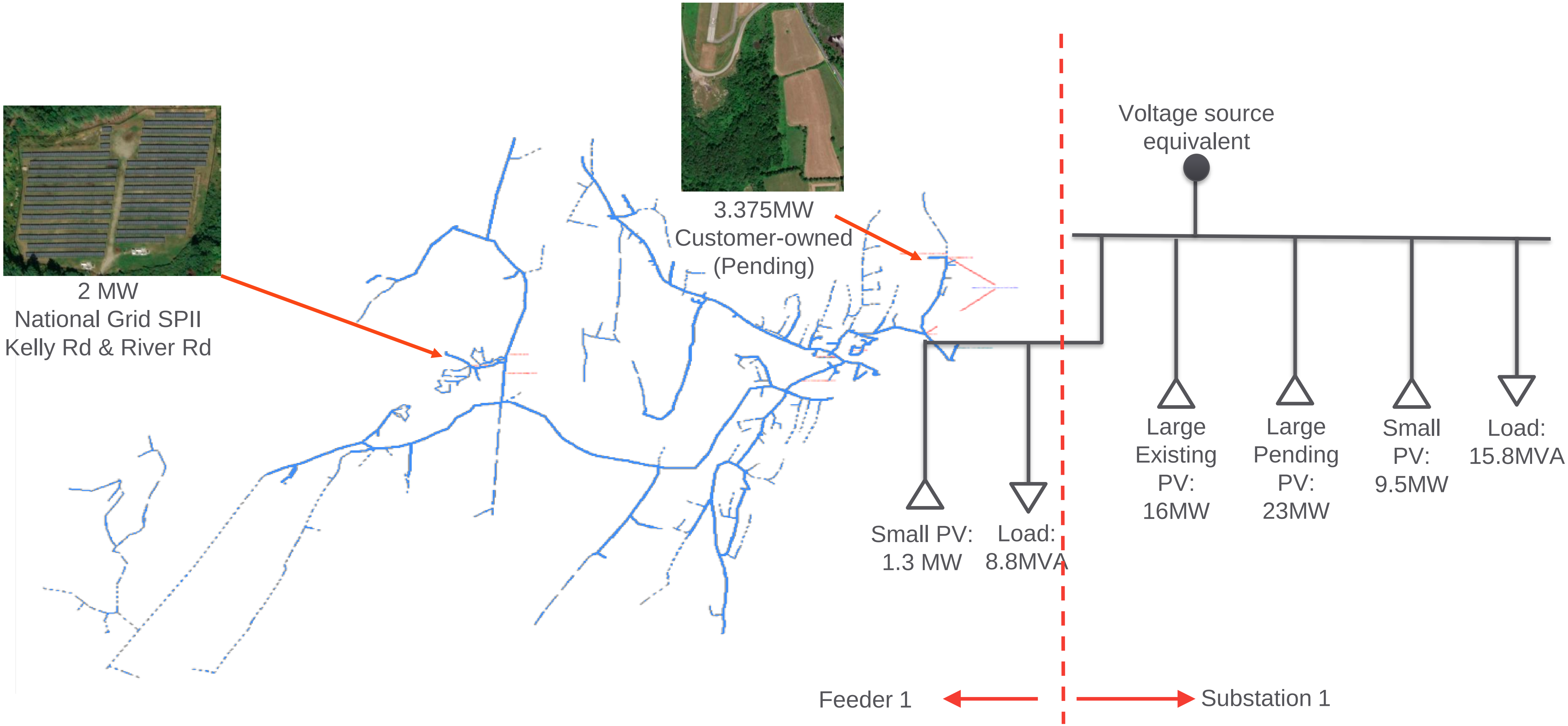


Modelling Methodology

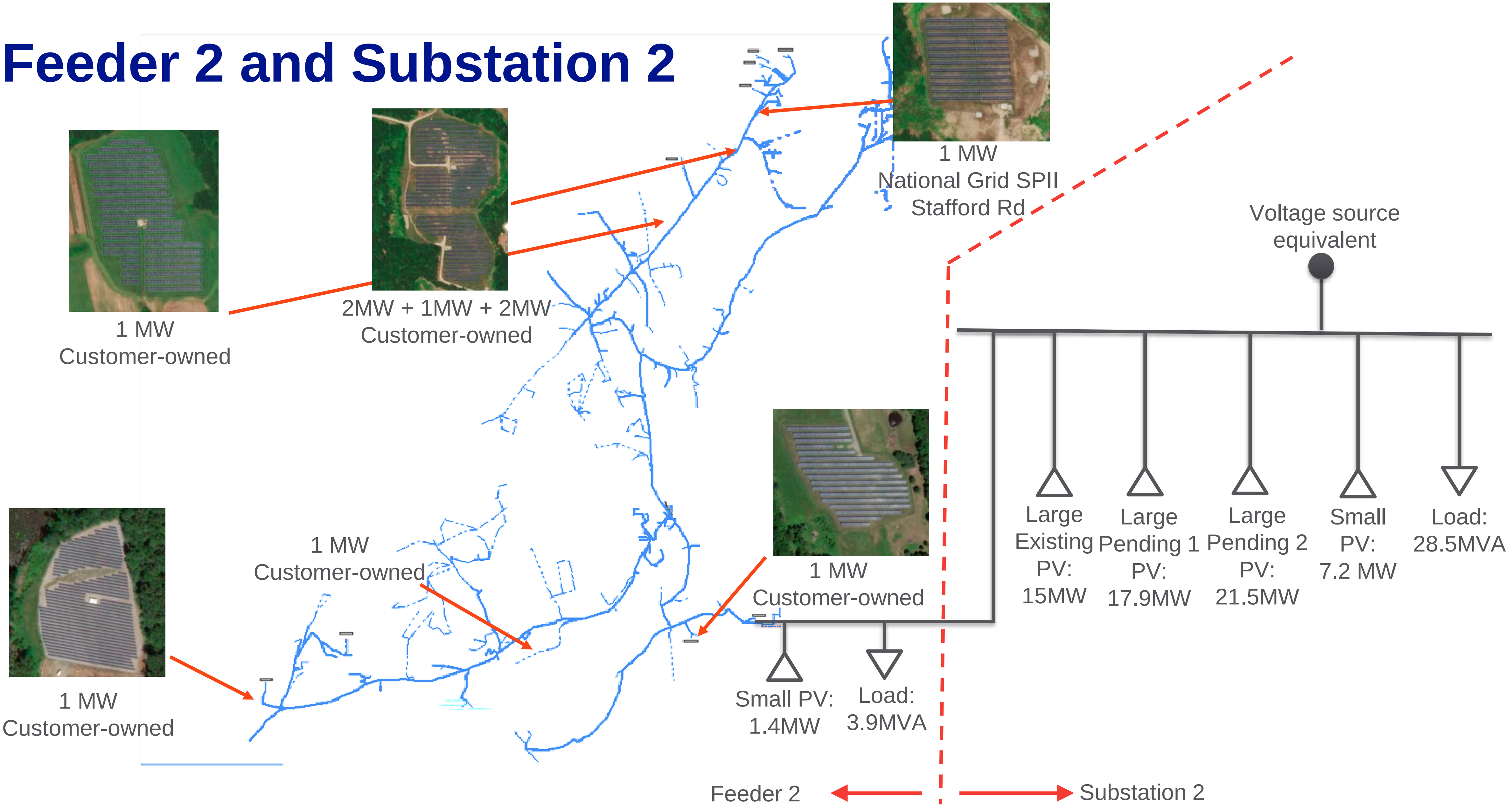
ELECTRIC POWER RESEARCH INSTITUTE



Feeder 1 and Substation 1



Feeder 2 and Substation 2



Results are plotted per scenario

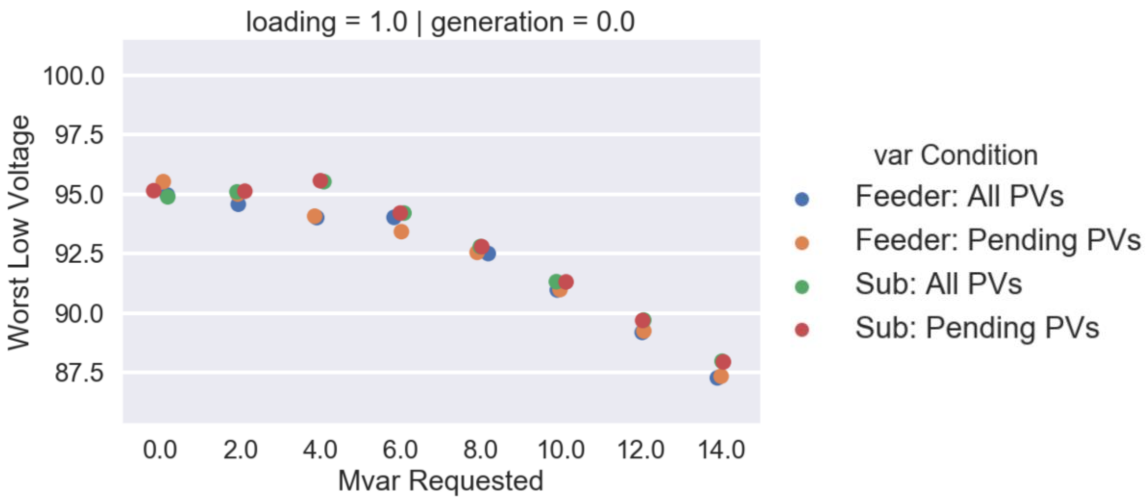
Two types of control needs:
- Load-level control
- Voltage-level control

MVAR Request:
- Range from 0.0 to 40.0MVAR

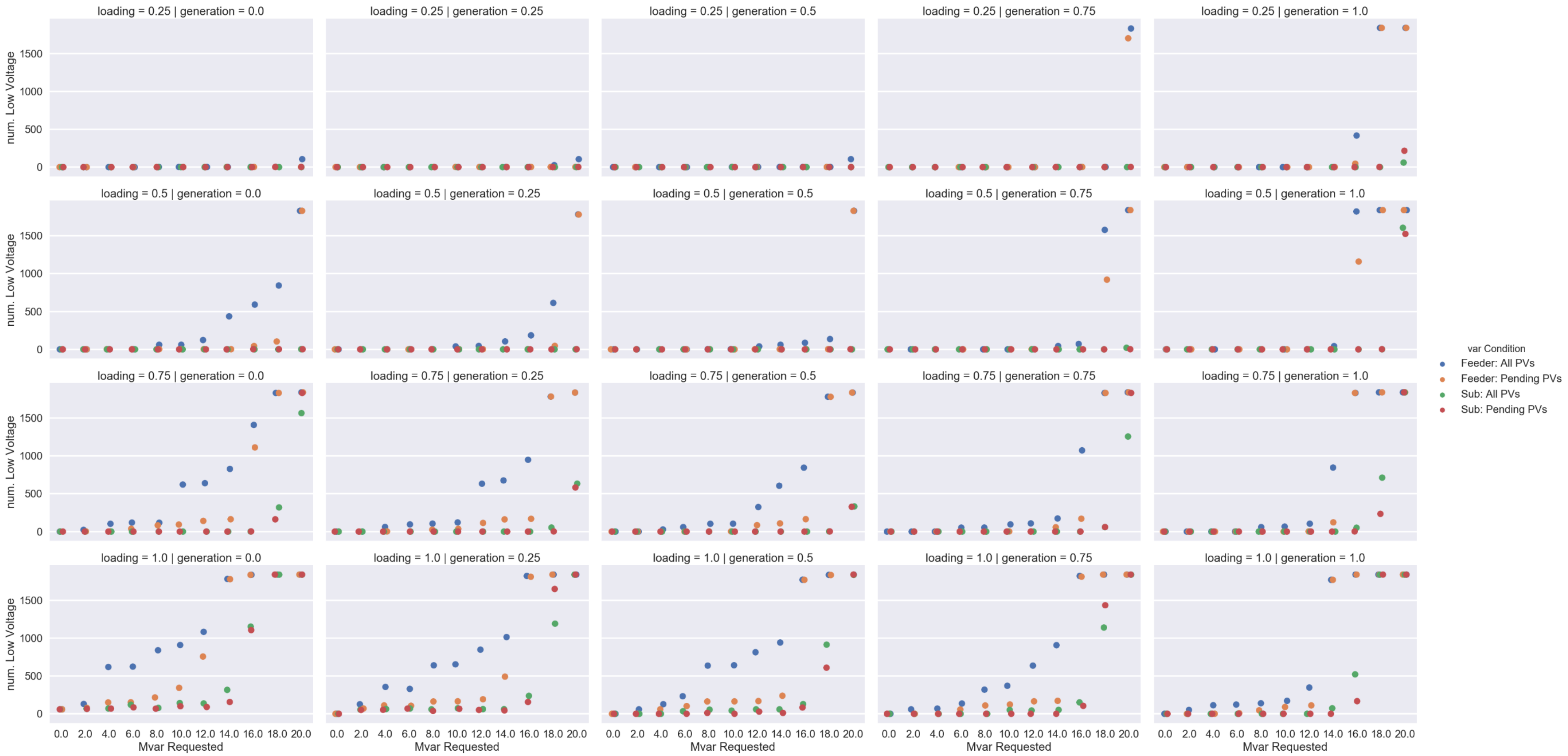
Load Level:
- Range from 25% to 100%

Generation Level:
- Range from 0% to 100%

Results include:
- Additional MVAR Capability Needed
- Real Power Curtailment
- Substation Apparent Power
- Substation Power Factor
- # of additional substation regulator tap changes
- # of Overloads Thermal limit of conductor and equipment
- # of Undervoltages V_dist < 0.95 p.u.
- # of Overvotlages V_dist > 1.05 p.u.

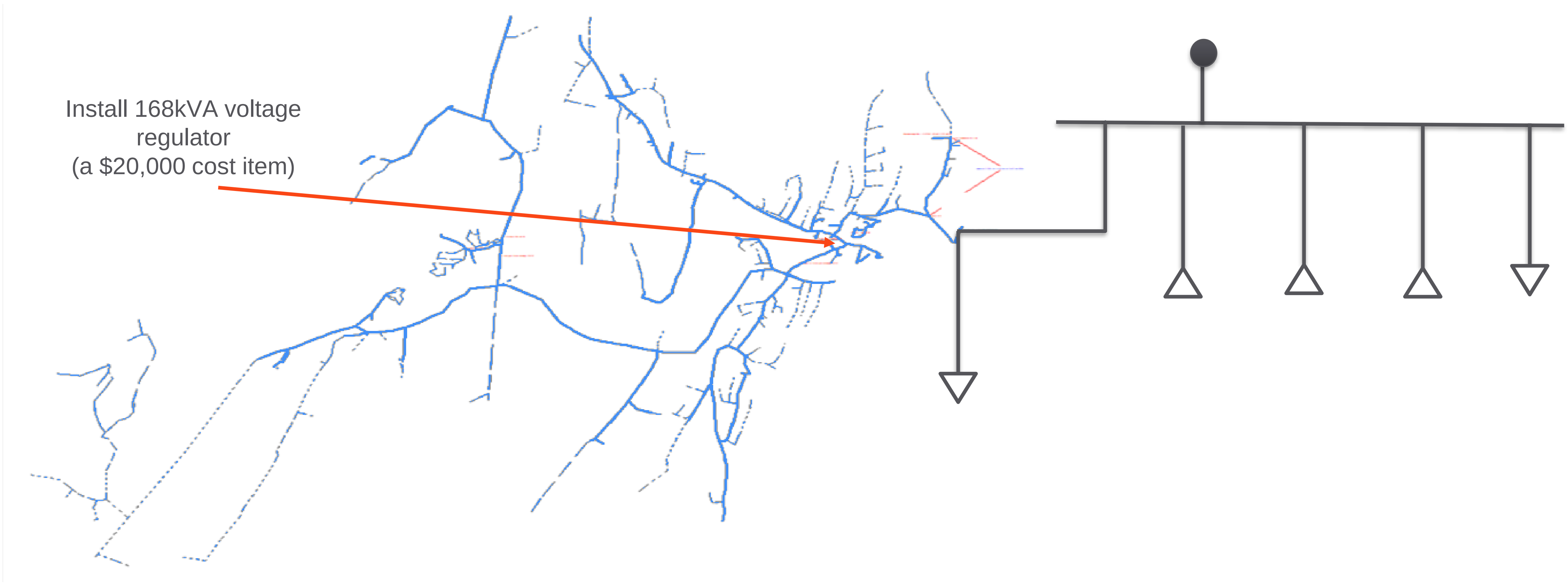


Substation 1 Results – Number of Undervoltages



Takeaway: Undervoltages worsen in conditions of high load, light generation, and increasing MVAR requests. Sub preforms better than Feeder only.

Based on results, mitigation efforts were applied: undervoltage > voltage regulator



Feeder 1 w/ mitigation Results – Number of Undervoltages

Takeaway: No undervotlages observed up to 10MVAR requested. This is technocritical upper limit adding one (1) regulator can provide.

Moving on to Substation 2

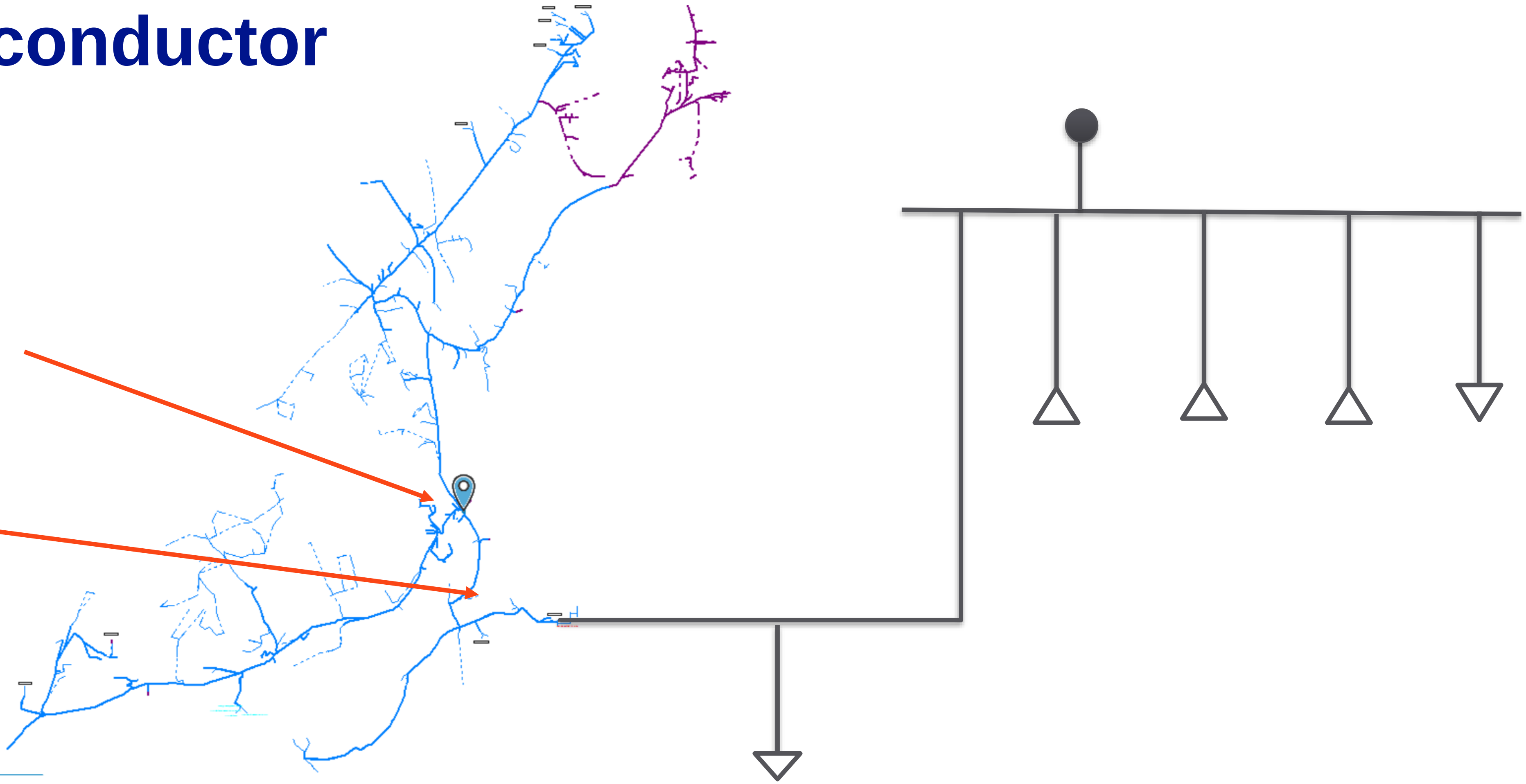
Feeder 2 Results – Number of Undervoltages

Takeaway: Undervoltages only occur at 12MVAR+

Based on results, mitigation efforts were applied:
undervoltage > voltage regulator
overload > reconductor

Install 416.3 kVA voltage
regulator
(a $20,000 cost item)

Re-conductor to 477 size
1100ft of feeder
(a $165,000 cost item)



Feeder 2 w/ mitigation Results – Number of Undervoltages

Takeaway: No undervotlages observed up to 28MVAR requested. This is theoretical upper limit adding one (1) regulator can provide.

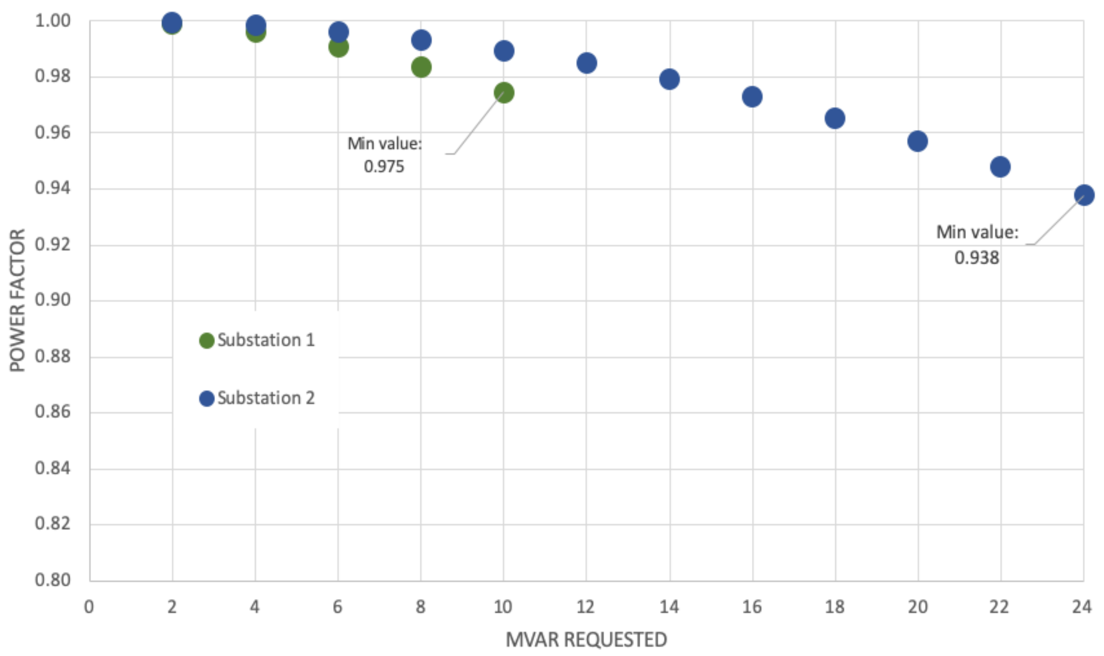
Summary of results

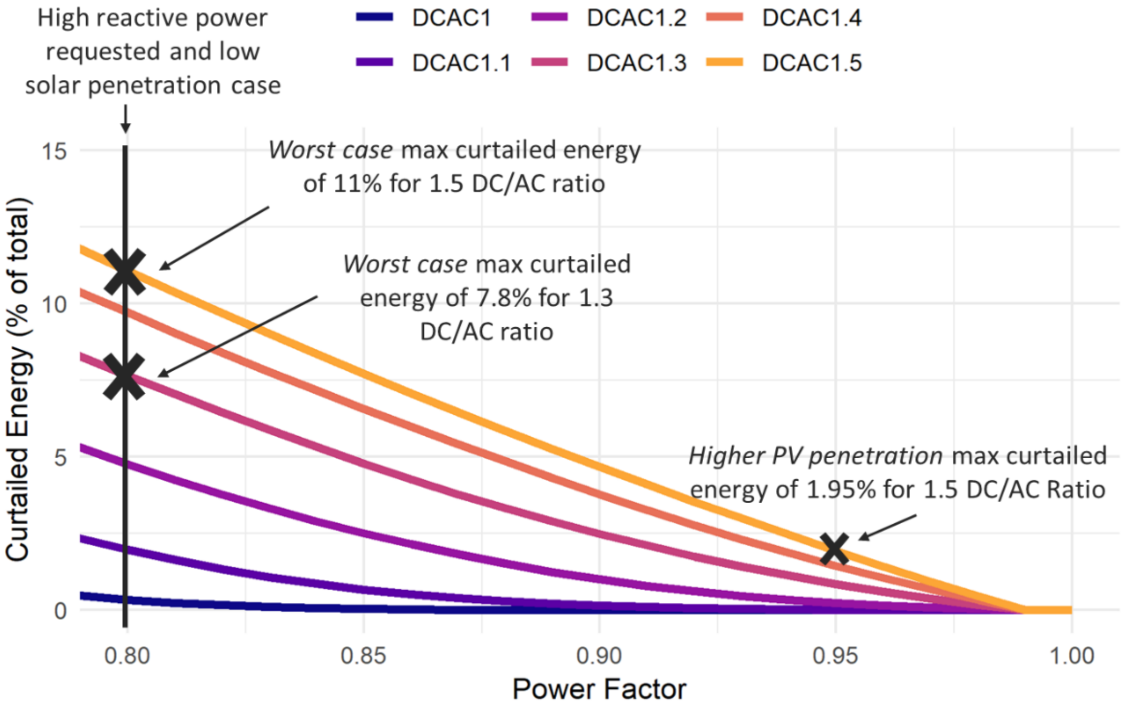
Substation	No mitigation	With mitigation		MW of DER	# of DER sites
Substation 1	0	10MVAR	168kVA voltage regulator	44.65	24
Substation 2	12 MVAR	24 MVAR	413.8kVA voltage regulator 1,100 ft re-conductoring	69.11	30

Results are based on a PV deployment scenario of:

- Only Large PV (950kW+) can participate in VAR voltage control
- All (existing + pending) PV will participate
- All Substation PV (including PV on parallel feeders) will participate

Opportunity Cost of Real Power





Power Factor was greater than 0.92, for most of the cases in the feeders studied.
This translates to less than 2.5% of energy curtailment.

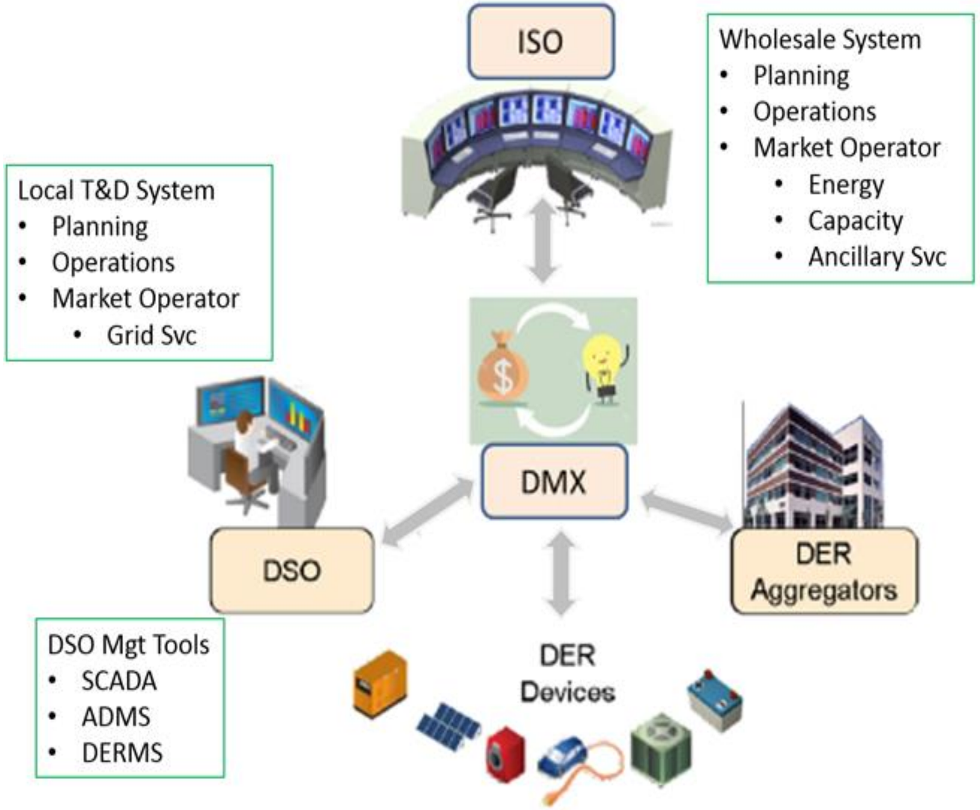
The Grid of the Future

- Grid management will become more granular, considering near real-time impacts and specific locational values and constraints to reliably manage an increasingly complex and dynamic system.

- Likely to create new opportunities for DER integrators.

- The modern grid operator will use integrated processes and tools to leverage Distributed Energy Resources (DER) as an efficient resource for customers and the resiliency of the grid.

- Communication and coordination managed through a common exchange.



Thank You

All questions and comments are welcome.

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Link to Paper:
https://www.nationalgridus.com/massachusetts-solar/document-library

Samples from Overseas

nationalgrid

Nodal Controllers is an example of TSO-DSO controls

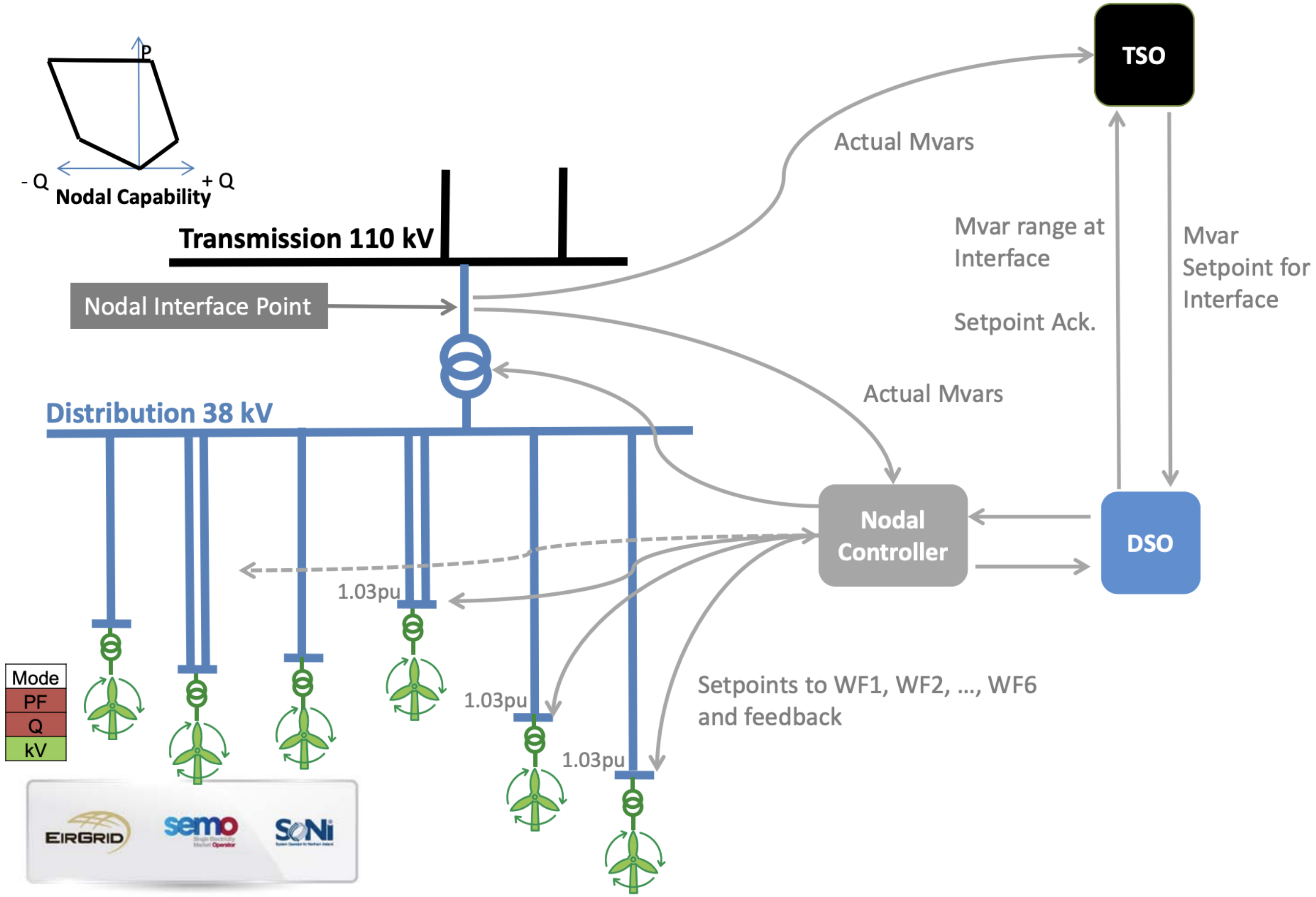
In Ireland,

EIRGRID and ESB NETWORKS

have partnered to introduce TSO-DSO nodal controllers to control wind sites in +/- Q operations

References:

- Joint workshop IEA PVPS TASK 14 & IEA ISGAN ANNEX 6, TSO-DSO engagement in Ireland and Northern Ireland, Séamus Power, 2015
- ISGAN Workshop, Interaction of DSO and TSO requirements on Distribution Networks, Tony Hearne, 2019



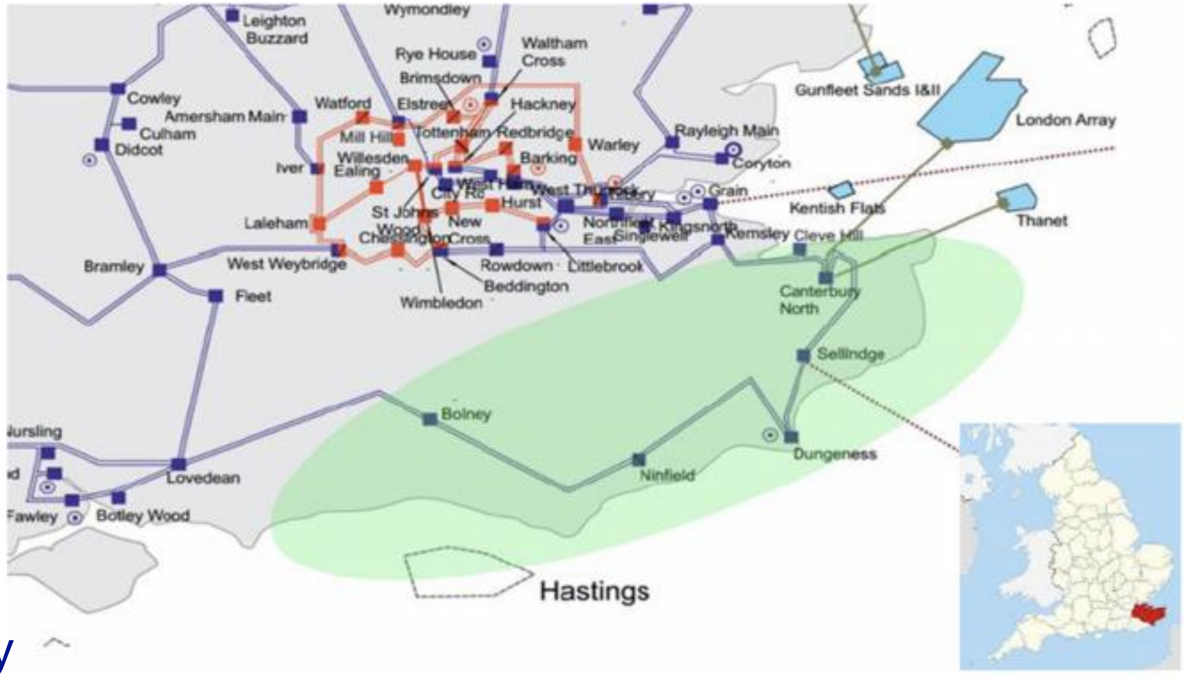
Source: EIRGRID

Power Potential, an innovation project from nationalgridESO

"Innovation project" funded by OFGEM and carried by National Grid ESO and UKPN.

Four substations to provide services to the transmission system:

- The utilization of DER on Distribution substations as "Virtual Power Plants" for real and reactive power controls
- The design of a DERMS system to control DER based on transmission-level signals
- The design of a reactive power market to compensate DER on their reactive power flexibility



Source: NaitonalGridESO Power Potential

Power Potential, an innovation project from nationalgridESO

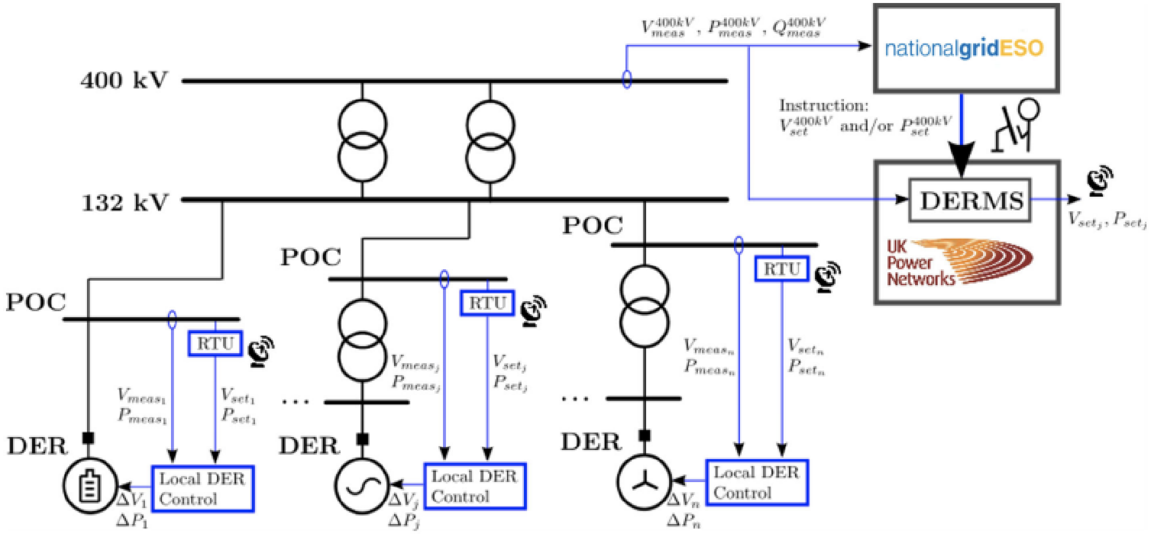
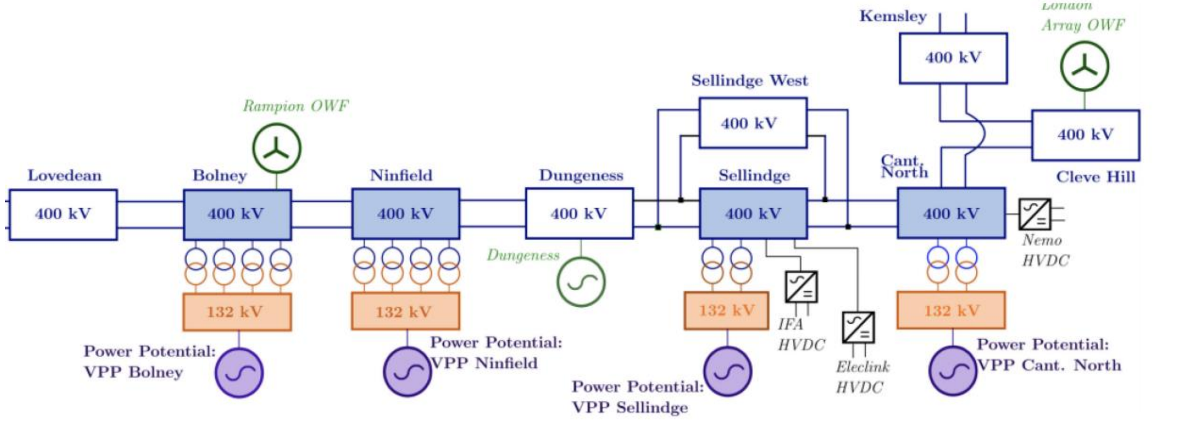


Table 1 Number of DERs considered per GSP and associated total MW rated value

GSP	DER number	Total MW
Bolney	8	92.15
Ninfield	6	108.13
Sellindge	4	32.50
Canterbury North	9	274.95
Richborough[a]	6	64.2

[a]Richborough is a substation expected to be present by 2025 but which will not be considered for the Power Potential project trials.



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