Y9.GEH2.1 Cost Benefit Analysis of FREEDM SST and Competing Technologies

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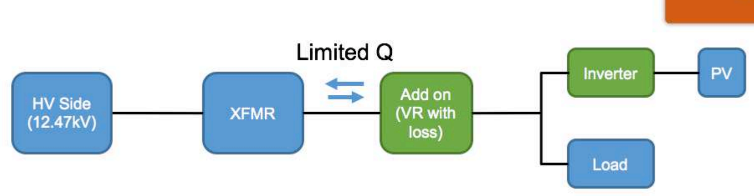
Background

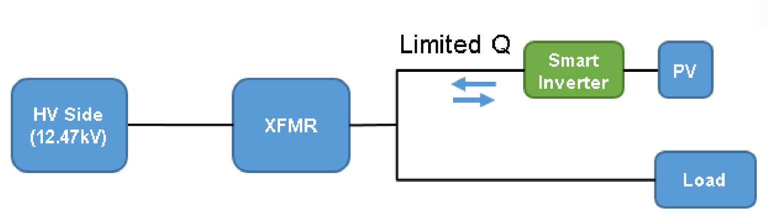
- The FREEDM system provides benefits to **utilities** and **customers**, particularly those with high levels of distributed energy resources (DER).
- In Y8, these **benefits** were compared to the **costs** of the FREEDM system, finding that partial deployment of FREEDM solid-state transformers (SST) provided the greatest net benefits.

Problem Statement

- Several **different upgrade options** exist in the distribution market. In this analysis, we will investigate how the standalone FREEDM SST compares to competing technologies that provide similar benefits.
- **Grid Edge Devices**
  - Added to low voltage side of distribution transformer (DT)
  - Power electronics
  - Voltage regulation
  - Var compensation



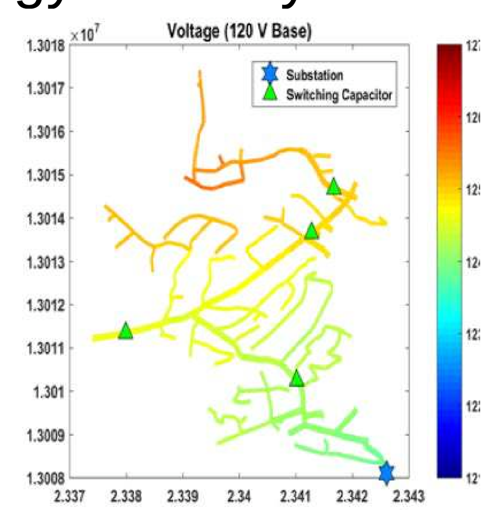
- **Smart Inverters**
  - Used with DER (PV)
  - Volt-Var control



Method

1. **Identify and quantify the relative benefits of each technology**

- Modeled each technology on utility distribution feeder using OpenDSS
  - One year time-series simulation with 15 minute resolution



- Each technology was put through several simulations to measure how it responded to high DER
  - Tracked voltage violations, energy savings, peak demand reduction

Cases	Devices (Grid Edge or Smart Inverter)
(a) Base Case	Circuit A + 32% PV (Hosting Capacity)
(b) Higher PV	Circuit A + 43% PV + Devices
(c) Higher PV plus CVR	Circuit A + 43% PV + Devices +CVR

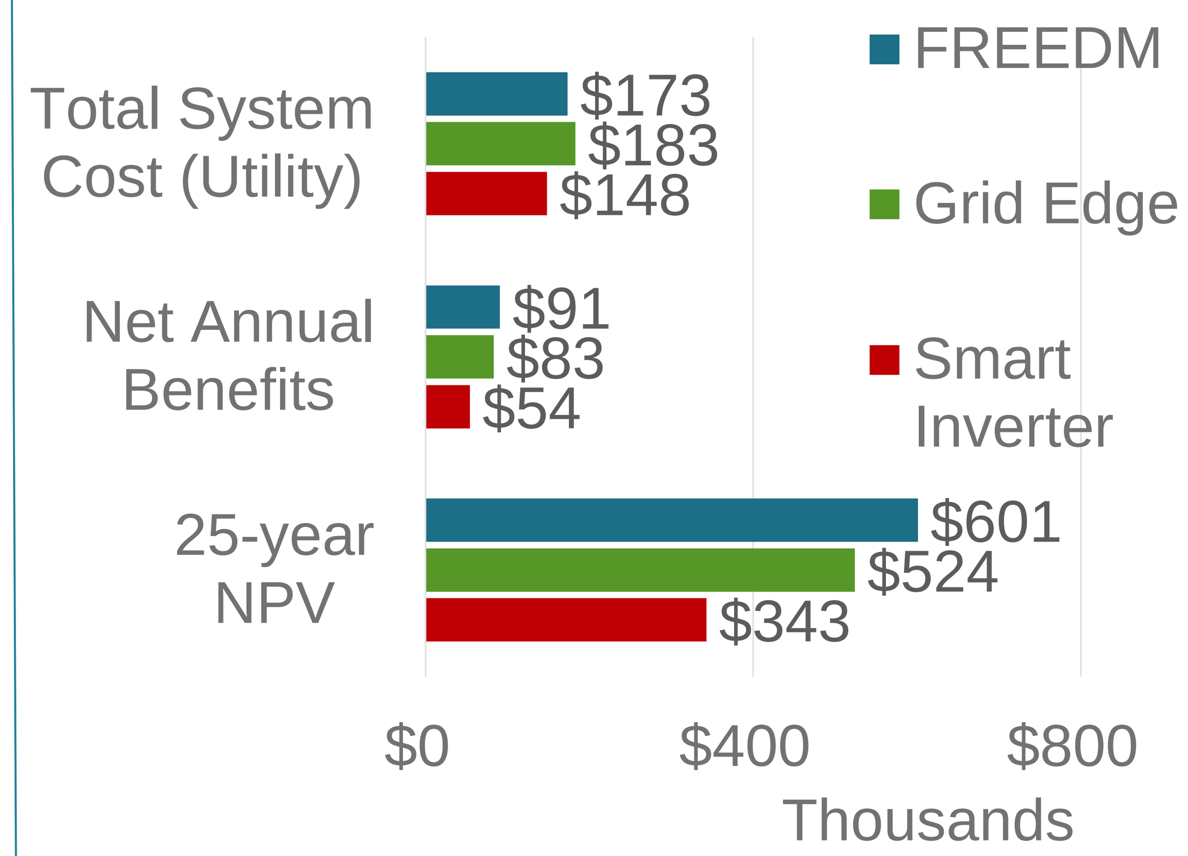
- Simulation results were monetized using representative electricity rates

#	Difference	Energy MWh/yr	Peak Demand kW	Losses MWh/yr
FREEDM SST	(b) – (a) Higher PV	-1,187	-2	15
	(c) – (b) CVR	-534	-146	-32
	(c) – (a) PV + CVR	**-1,721**	**-147**	**-17**
	Total %	**-8.7%**	**-2.2%**	**-0.09%**
Grid Edge Device	(b) – (a) Higher PV	-1,110	-3	0
	(c) – (b) CVR	-534	-146	-32
	(c) – (a) PV + CVR	**-1,644**	**-149**	**-31**
	Total %	**-8.3%**	**-2.2%**	**-0.16%**
Smart Inverter	(b) – (a) Higher PV	-1,082	-11	30
	(c) – (b) CVR	-153	-36	-22
	(c) – (a) PV + CVR	**-1,236**	**-46**	**8**
	Total %	**-6.2%**	**-0.7%**	**0.04%**

2. **Quantify the total system costs**

- **One-time costs considered:**
  - Per-unit cost of each technology
  - Required ancillary components
  - Installation of pole-mounted devices
  - Stranded assets
- **Recurring costs considered:**
  - Maintenance of grid upgrade devices
  - Replacement of residual DT

Results



- The **FREEDM SST** is still the most cost effective option from the utility's perspective.
- Net annual benefits calculation is from a specific Duke Energy circuit, and depends on feeder characteristics and existing and anticipated penetration levels of PV.
- **Results are robust** to large changes in device price
  - FREEDM SST price can increase by 56% before NPV falls below nearest competitor (Grid Edge device)

Conclusion

- The small difference between the grid-edge device and SST is not significant, based on the sensitivity of the results to key assumptions (such as discount rate, energy costs, and SST costs).
- Results indicate that the system has commercial viability, despite the numerous competing solutions already commercially available.

References

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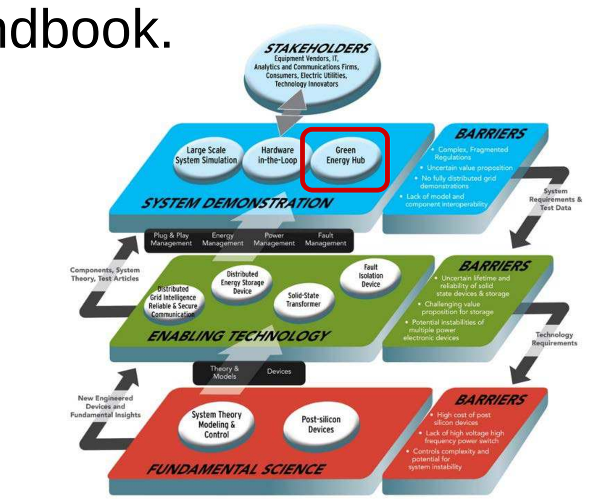

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