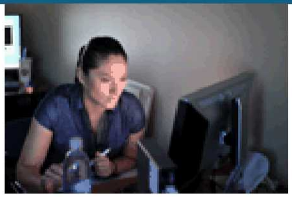
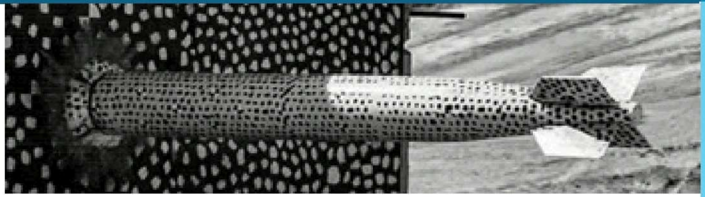
SAND2018-11752

Using Energy Storage to Support Puerto Rico's Transmission System





PRESENTED BY

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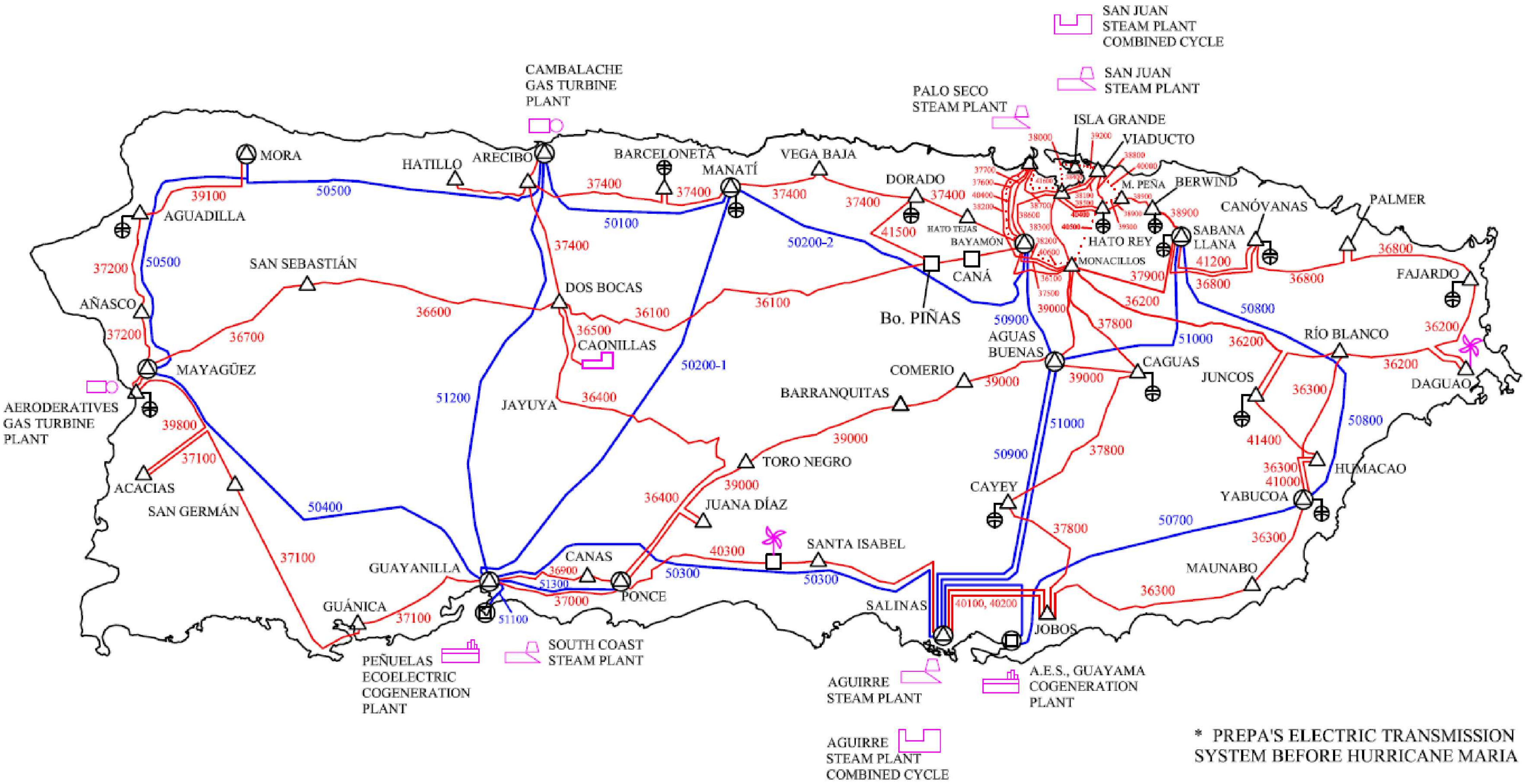
THE PUERTO RICO TRANSMISSION SYSTEM



* PREPA'S ELECTRIC TRANSMISSION SYSTEM BEFORE HURRICANE MARIA

PUERTO RICO HAS *FUTURE* RENEWABLE ENERGY GOALS

In July 2010, Puerto Rico enacted the island's first Renewable Energy Portfolio Standard:

Targets:

2015 - 2019: 12%

2020 - 2027: 15%

Up to 20% by 2035

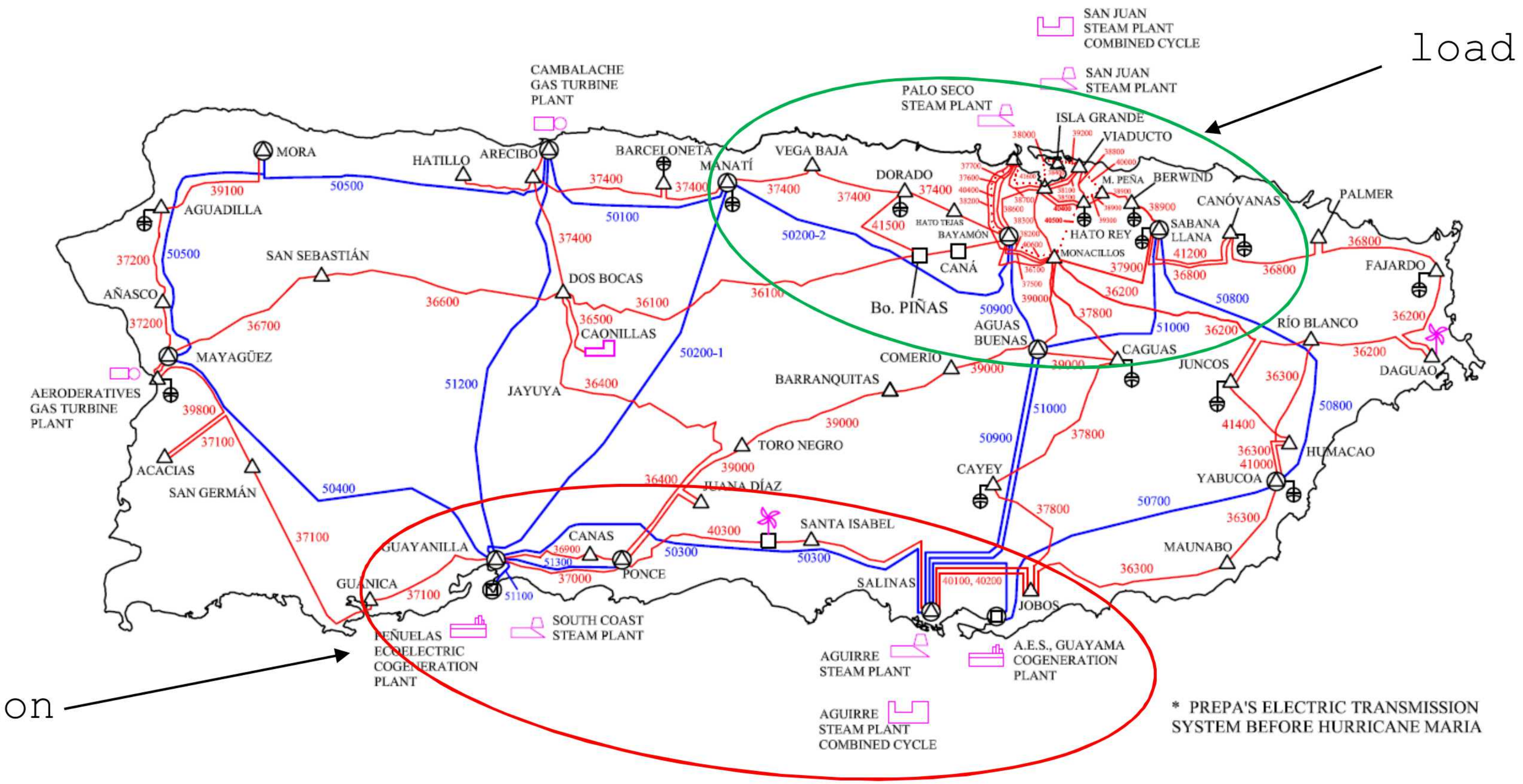
But renewable integration requires energy storage.

- A 2015 renewable integration study estimated ~100 MW of storage to get to 12% penetration
- A more recent Siemens study suggested up to **243 MW** of storage to achieve 35% penetration of "a lower emission mix of generation resources with more energy storage, distributed solar, and small CCGT units…"

BUT THE TRANSMISSION SYSTEM HAS PROBLEMS *NOW*…

From rapid load changes to unpredictable protection schemes to right-of-way management shortfalls, PREPA Operators are more concerned with *getting to the next stable operating point* without under-frequency protection devices shedding load.

But generation *capacity* isn't the main problem – location is.



generation

POOR POWER QUALITY…

Within NERC reliability regions, frequencies below the 59.9's (Hz) are out of compliance…

Under-frequency line trip average settings

Fmin (Hz)	No. of Models	Average trip Setting (sec)
59.2	2	22.5
59	3	20
58.7	1	10
58.6	5	
58.6	6	
58.5	19	
58.4	2	
58.2	29	
58.1	19	
58	11	
57.9	11	
57.8	11	
57.7	7	

Fmin (Hz)	No. of Models	Average trip Setting (sec)
59.2	1	60
59.2	7	25
59	4	20
58.8	15	15
58.7	9	10
58.6	11	5
58.6	16	0.02
58.5	2	0.03
58.4	8	0.04
58.2	3	0.06
58.1	2	0.03
57.9	3	0.05
57.8	1	0.05
57.7	14	0.05

Under-frequency load trip average settings

ere $\varepsilon 1_I$ is the constant derived from a targeted frequency bound for each
erconnection as follows:

- Eastern Interconnection $\varepsilon 1_I$ = 0.018 Hz
- Western Interconnection $\varepsilon 1_I$ = 0.0228 Hz
- ERCOT Intercon
- Quebec Interco

ure that the average actual fr
entative of that time interval.

Table 6.1 Governor Deadband Settings

Generator Type	Max. Deadband
Steam and Hydro Turbines with Mechanical Governors	+/- 0.034 Hz
All Other Generating	+/- 0.017 Hz

Standard TPL-001-4 — Transmission System Planning Performance Requirements

Category	Initial Condition	Event [1]	Fault Type [2]	BES Level [3]	Interruption of Firm Transmission Service Allowed [4]	Non-Consequential Load Loss Allowed
P3 Multiple Contingency	Loss of generator unit followed by System adjustments[9]	Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer [5] 4. Shunt Device [6]	3Ø	EHV, HV	No[9]	No[12]
		5. Single pole of a DC line	SLG			
P4		Loss of multiple elements caused by a stuck breaker [10](non-Bus-tie Breaker) attempting to clear a Fault on one of the following: 1. Generator 2. Transmission Circuit	SLG	EHV	No[9]	No

FROM NOW TO THEN WITH ENERGY STORAGE…

Modern Energy Storage can help bridge the gap…
But how much?

We examined how much energy storage would be necessary to avoid triggering under-frequency trip schemes for events up to loss of the single largest generating unit:

Aguirre Unit 1

Nameplate: 450 MW

Dispatch: 380 MW

This G-1 contingency bounds the level of frequency deviation that any lesser event might trigger

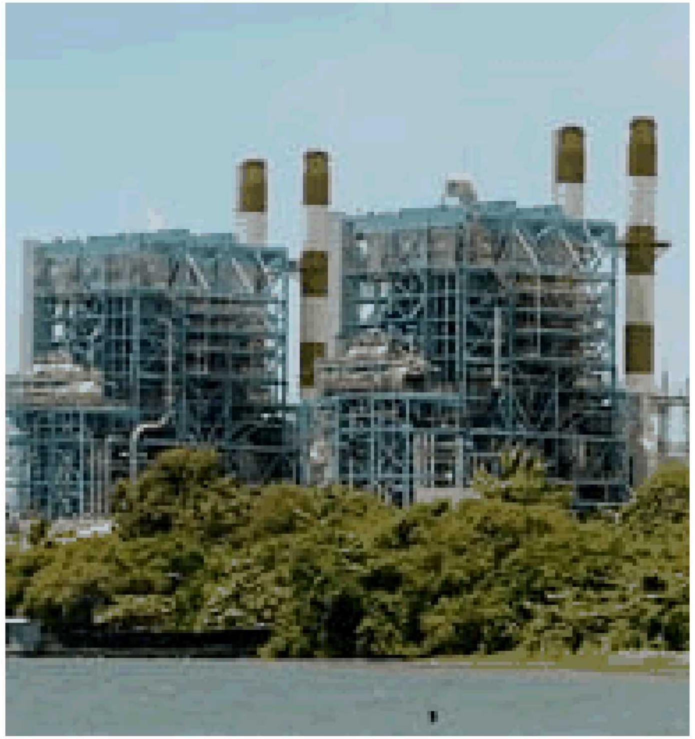


Image from pr.gov

RESULTS

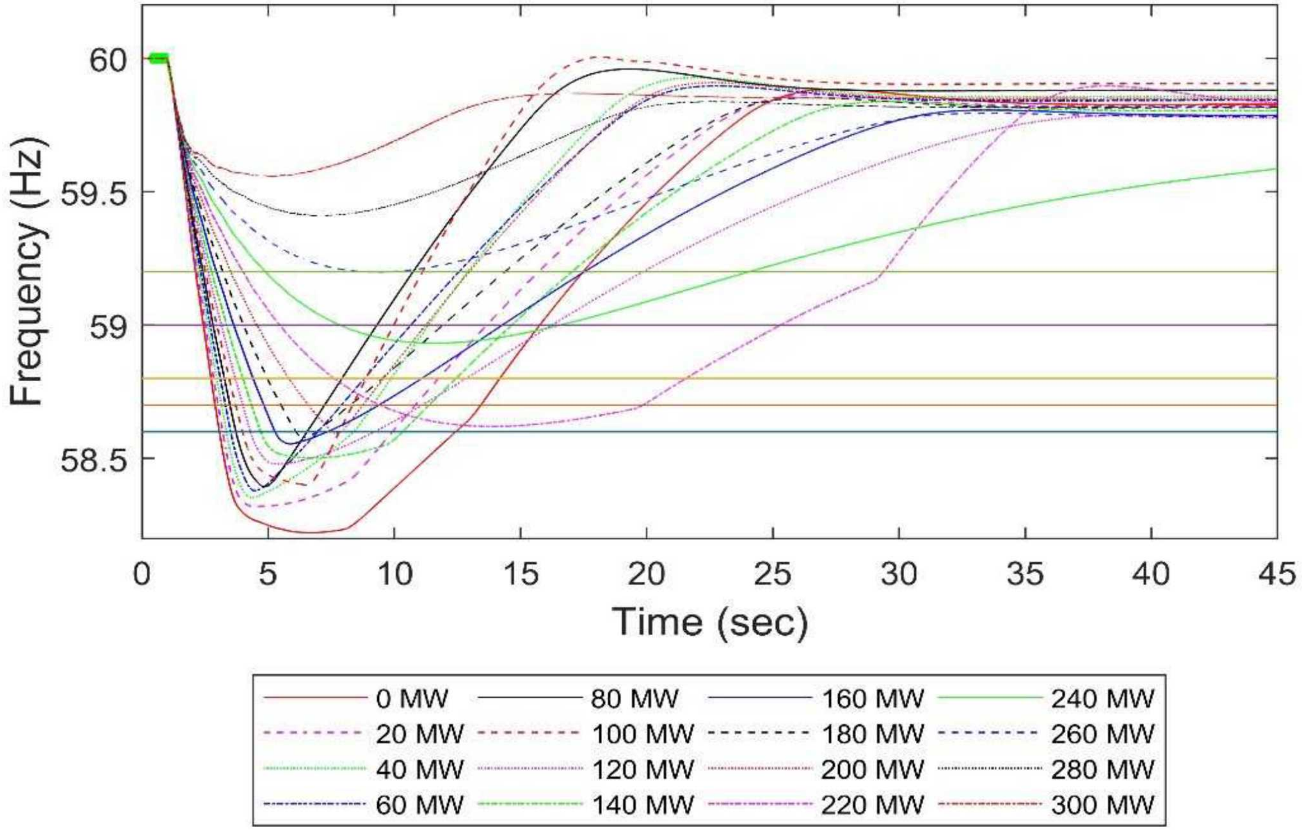


Figure 4-1. Frequency response of 20 MW energy storage power increments for loss of Aguirre Unit 1 showing settling times

RESULTS

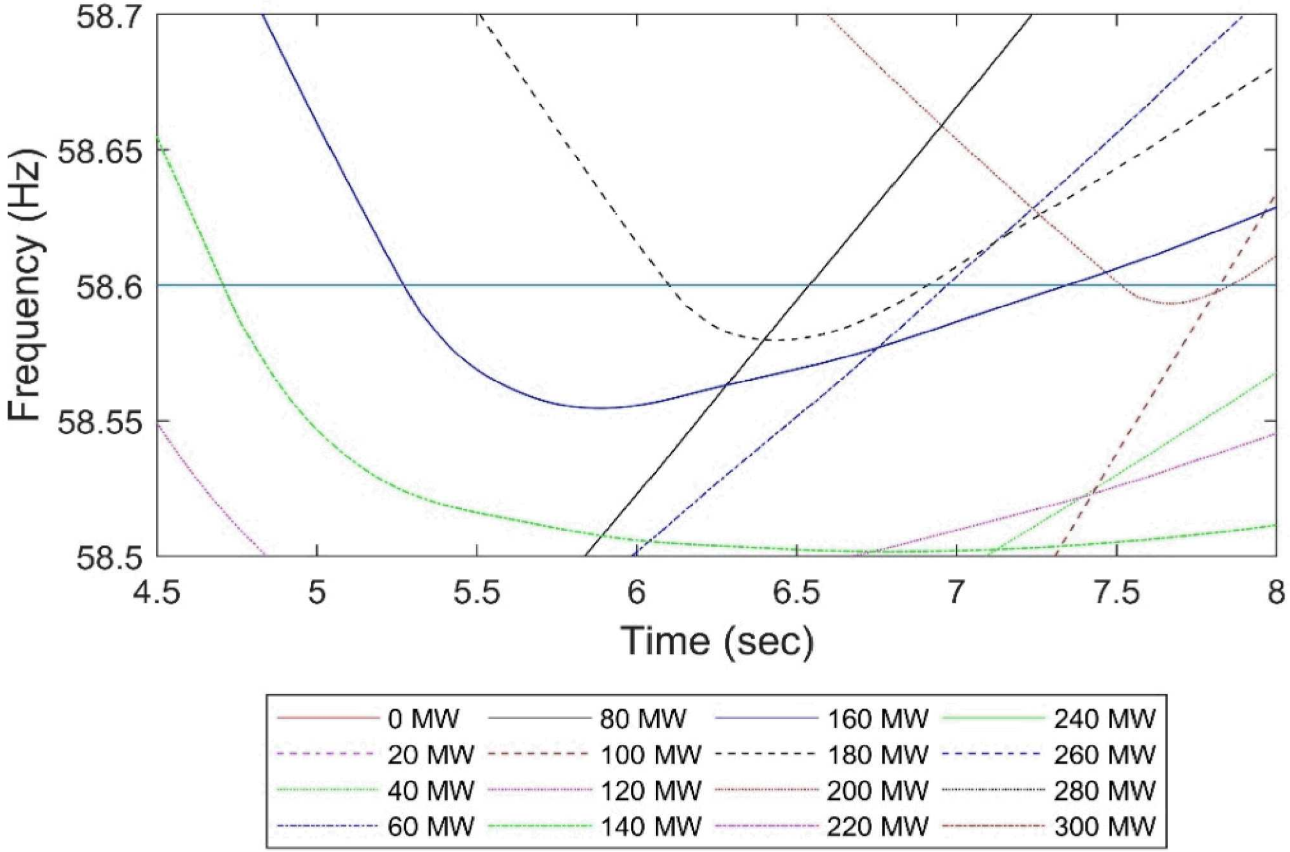


Figure 4-3. Frequency response of 20 MW energy storage power increments for loss of Aguirre Unit 1 near the 58.6 Hz minimum trip threshold

RESULTS

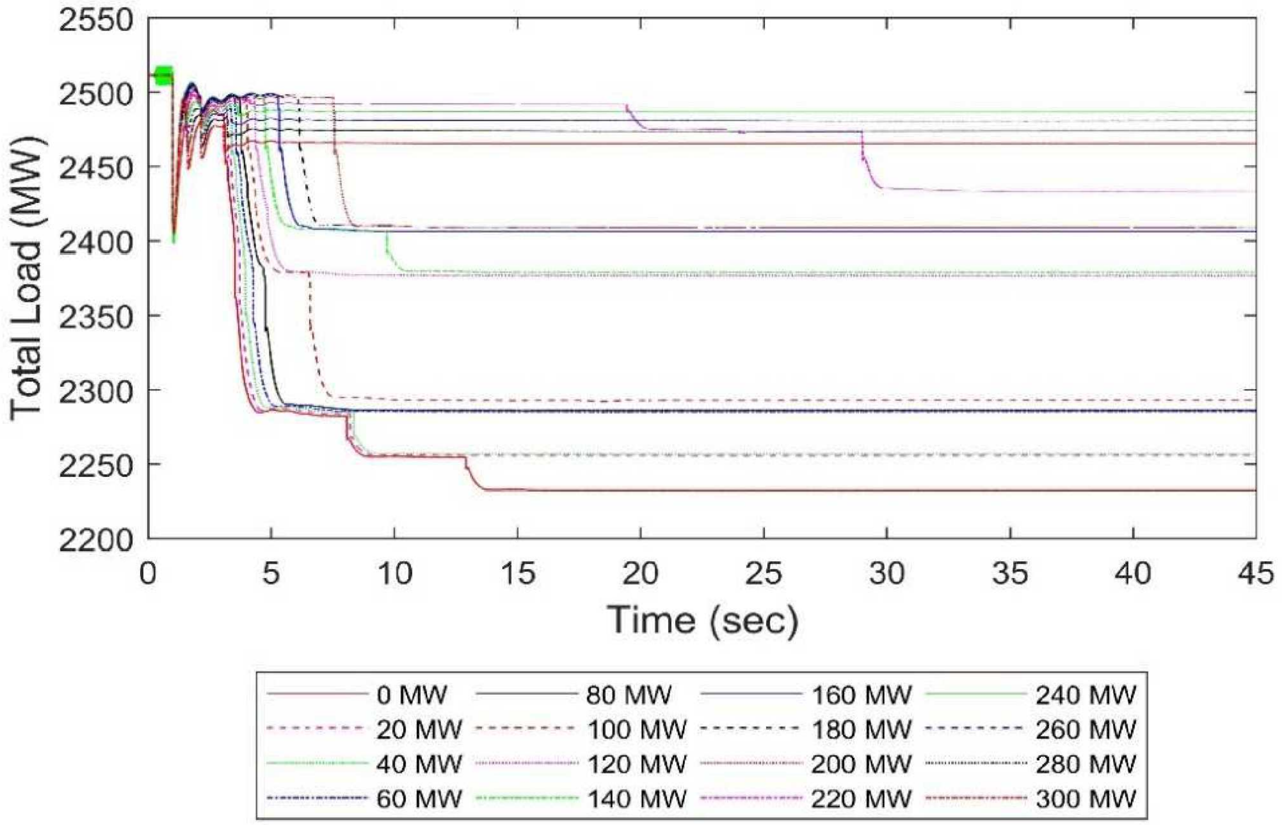


Figure 4-4. Post-disturbance system load as a function of energy storage increment

RESULTS

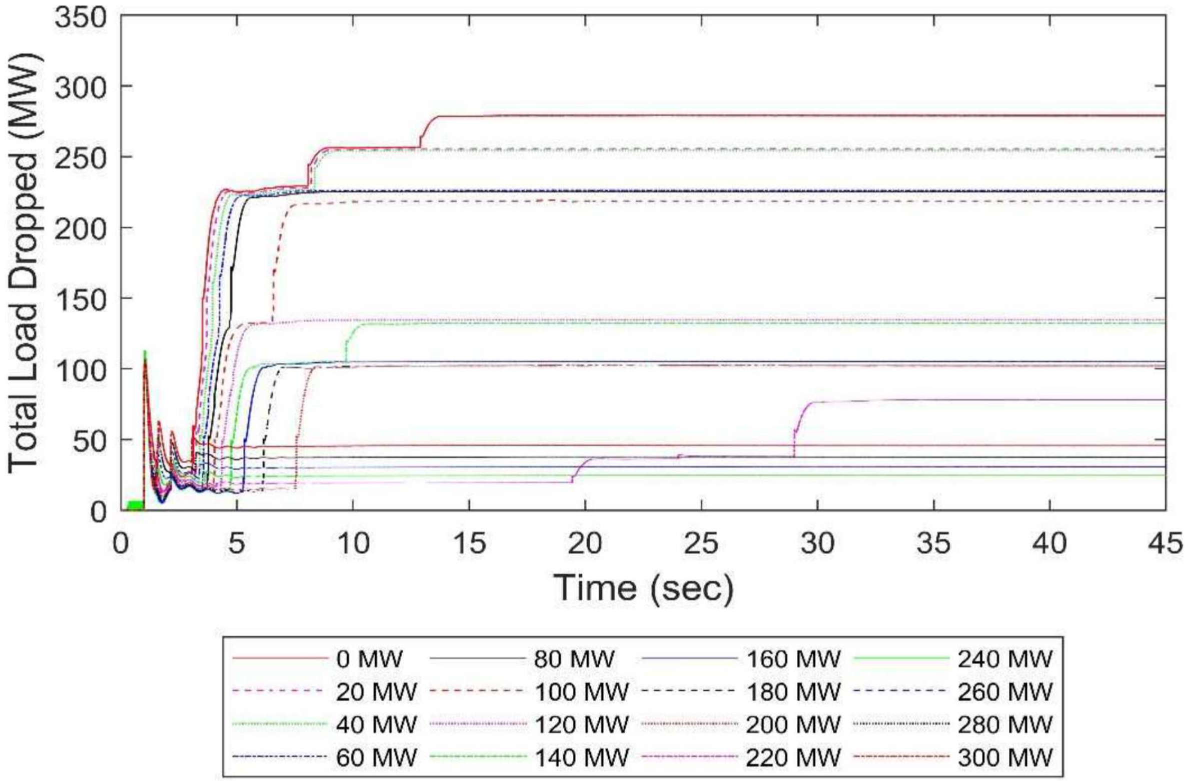


Figure **4**-**5**. Post disturbance load shed as a function of energy storage increment

CONCLUSIONS

- Focus initial investment on power
- Minimum size recommendation of 240 MW/60 MWh
- Budgetary cost to implement the initial power-focused energy storage capacity is estimated to be $100-125 million