# Small Modular Reactor Based Microgrid Cost Optimization

U.S.NRC

Western Carolina University
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## Problem Statement

- Renewable power generation is inherently intermittent which can cause significant issues for grid stability. To combat this, many power system designers are using battery storage systems (BSS) to be able to load follow and consistently meet the load despite significant cost [6]
- Recently, an increase in generation ramp rates for small modular reactors (SMR) has been implemented with an increase from 2% to 5% ramp up/down of total capacity per every 10 minutes. There now exists a potential decrease in the cost of implementing clean microgrid system by using the SMR as the load follower [7]

## Objectives and Components

- Model a clean hybrid microgrid power system using NuScale Small Modular Reactors (SMR), solar, and wind farms, with a battery storage system
- Perform an optimization to determine the sizes of generations sites which will result in the smallest levelized cost of electricity
- Analyze the effect on the cost of changing the ramp rate of the SMR from 2% to 5%

**Solar**
- Provides supplemental support for load fluctuations
- Excess generation charges the battery
- Output dependent on location's temperature & solar irradiance

**Wind**
- Provides supplemental support for load fluctuations
- Excess generation charges the battery
- Output dependent on the location's wind speed conditions & geography

**Nuclear**
- Provides bulk of power demand
- Can ramp up or down 20% of total capacity over a 10-minute interval to load follow

**Battery**
- Used for load following
- Most costly component
- Depends on excess power being generated to be charged

## Methodology

### Data Collection

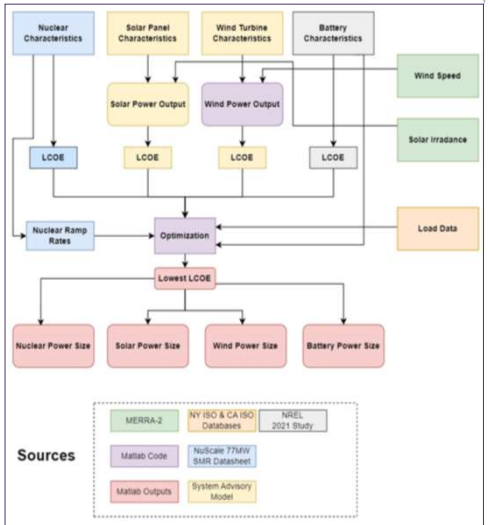
The input data was acquired in 5-minute intervals for August, April, and December 2020 for the 4 test locations: Owyhee ID, Rochester NY, Shelter Island NY, and Brookings OR.

Load Data (Power Consumption):
- New York Independent Service Operator (NY ISO)[3],
- California Independent Service Operator (CA ISO) [3]

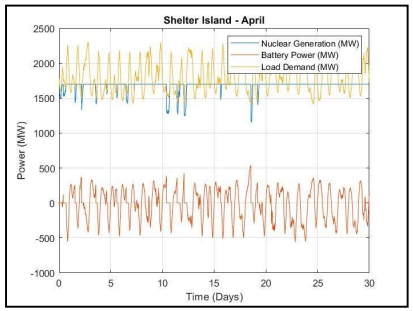
Solar Power:
- System Advisory Model (SAM).
- Shell Solar SM10 panel [4]

Wind Power:
- MERRA-2 weather satellite

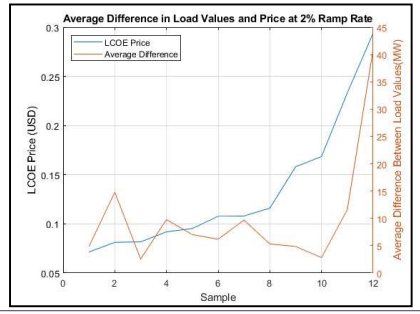
### Design

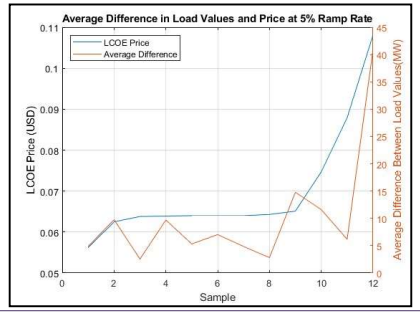



## Results: Load Following and Cost Correlation




| Month | Percent Decrease in Cost from 2% to 5% SMR Ramp Rate | | | |
|---|---|---|---|---|
| | Rochester NY | Shelter Island NY | Owyhee ID | Brooking OR |
| April | 10.42 | 31.89 | 64.46 | 32.88 |
| August | 18.41 | 61.82 | 63.23 | 40.79 |
| December | 44.83 | 67.71 | 19.90 | 21.97 |




## Statistical Analysis

| Method | Correlation Coefficient | |
|---|---|---|
| | 2% Ramp Rate | 5% Ramp Rate |
| Range Difference | .715 | .818 |
| Average Difference | .657 | .761 |
| Average Percent Change | .582 | .738 |

0.5<Coefficient<0.7=Moderate, 0.7<Coefficient<1 =High (3)

**High Correlation Trends**
- Analysis based about rapid change between load points

**Low Correlation Trends**
- Analysis based about load size, standard deviation and variance

## Conclusion

The levelized cost exhibited a strong correlation with the rate of change between load points, indicating that a steeper slope led to a higher cost. However, no significant correlation was observed between the cost and the total size or distribution of load values.

The results suggest that the increase in ramp rate for the selected test locations can drastically reduce the cost of an HGS system as it significantly lowers the need for battery capacity.

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## References

## Sponsor


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