Study of Using Energy Storage to Mitigate the Impact of High Renewable Energy Penetration to the Grid

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Taiwan Power Research Institute

Che-I Lin

Taiwan Power Research Institute (TPRI)

Taiwan Power Company

Outline

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- Introduction
- Development of Renewable Energy in Taiwan
- Issues Encountered with High RE Penetration
- Benefits of Energy Storage and Demo Projects
- Conclusion

Development of Renewable Energy in Taiwan

Generation Capacity in Taiwan by Generation Types in 2016

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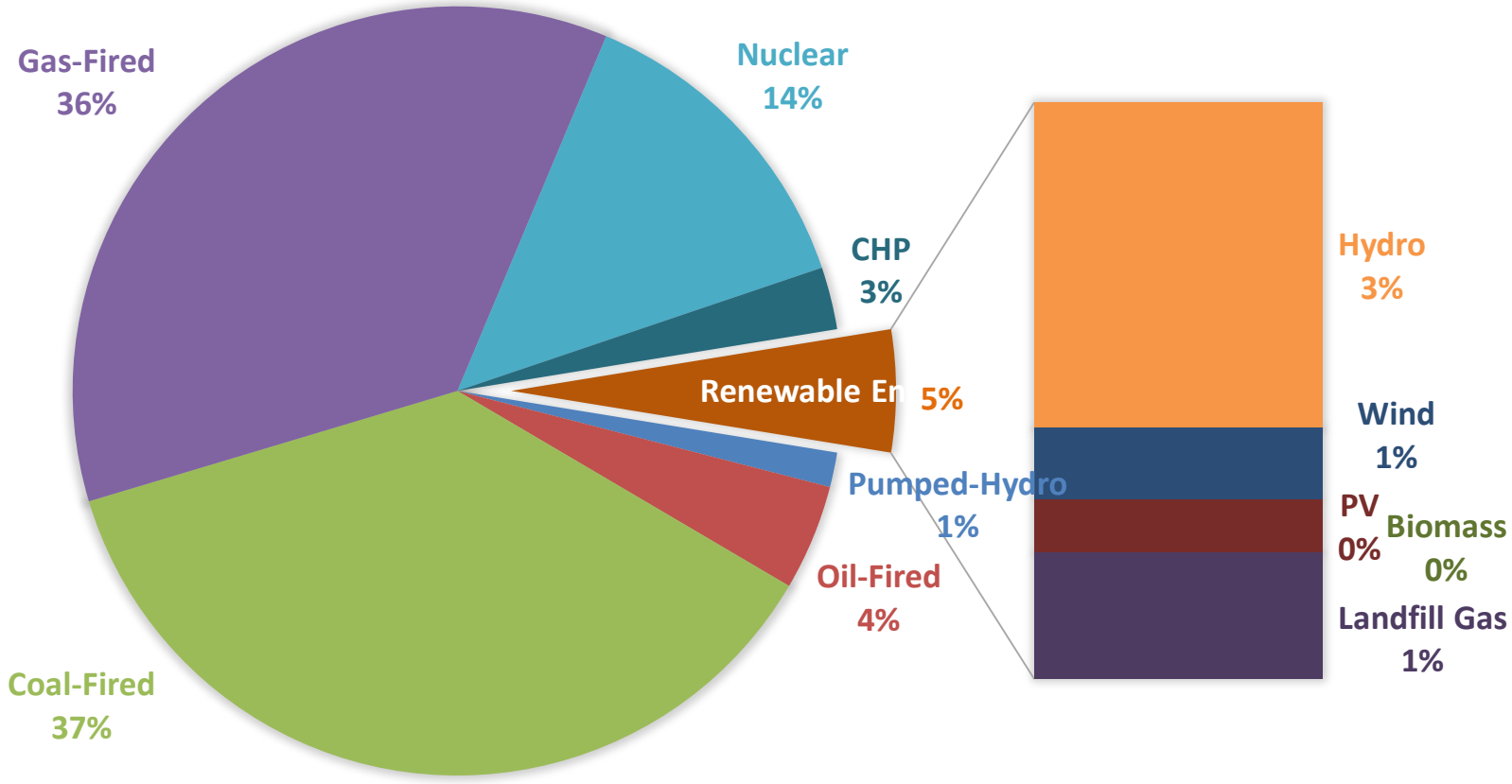

Installed Capacity in Taiwan by Generation Types in 2016

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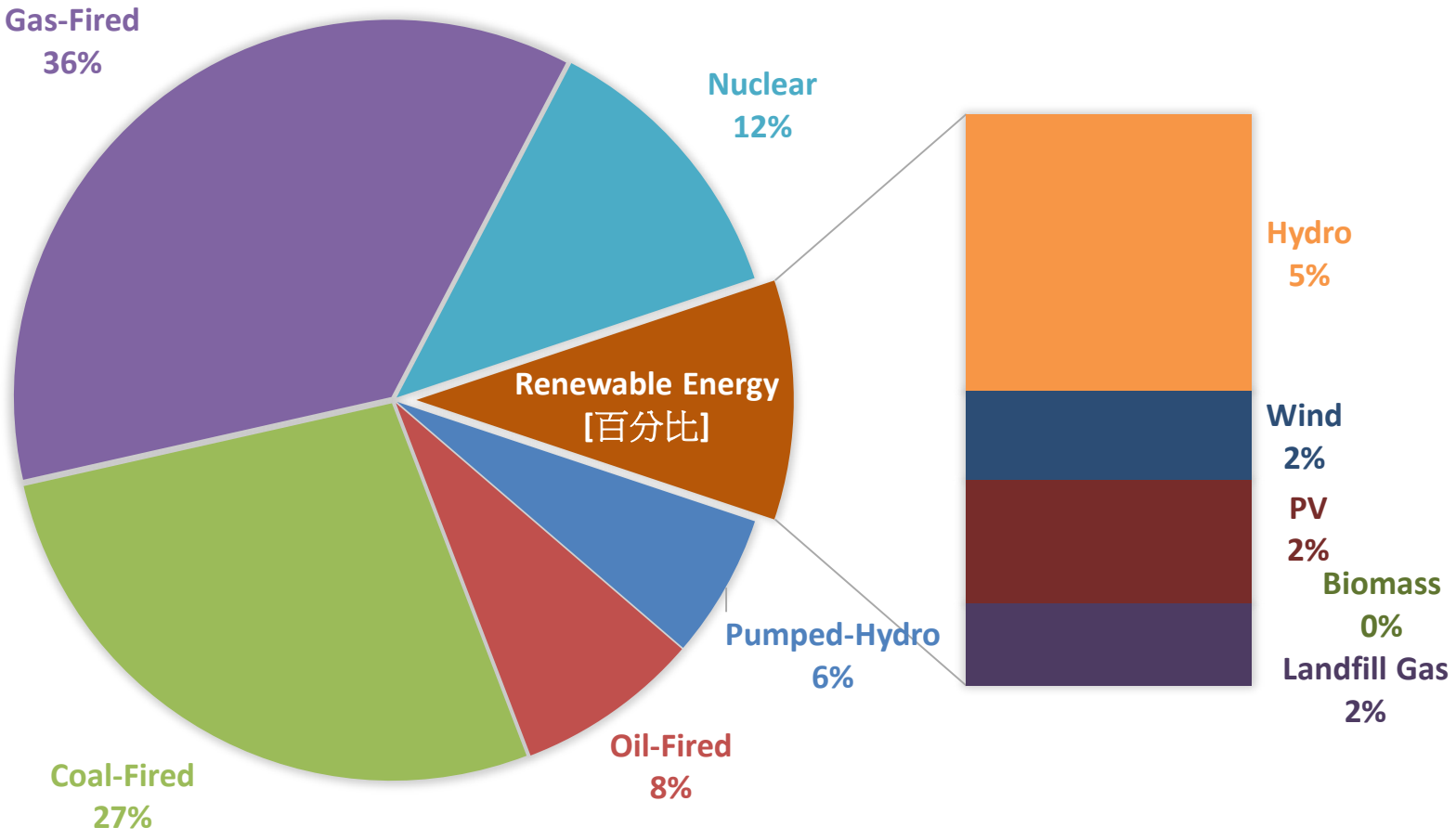

Expected Renewable Energy Installed Capacity in Taiwan

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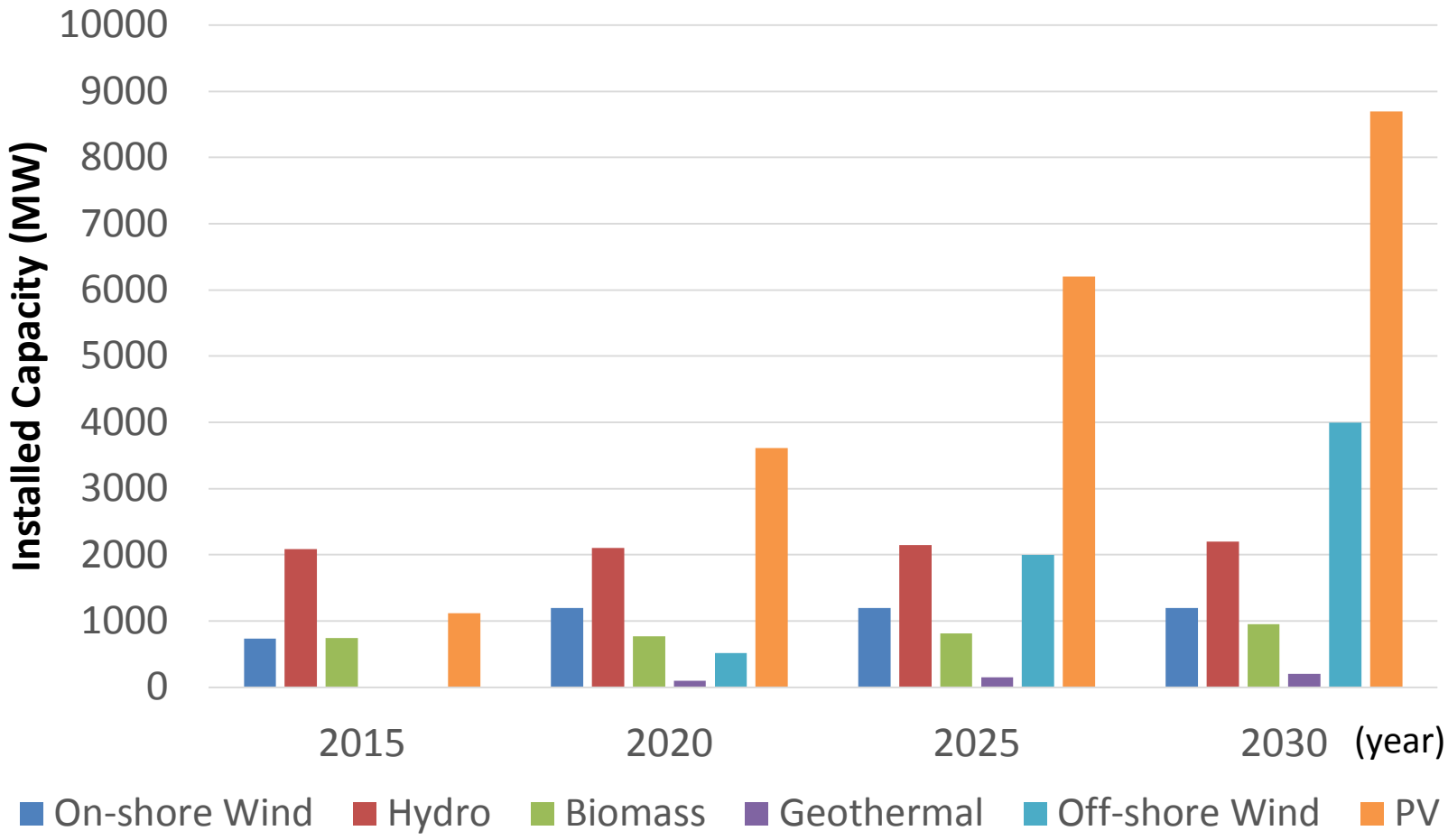

Issues Encountered with High RE Penetration

Monthly Wind Power Output

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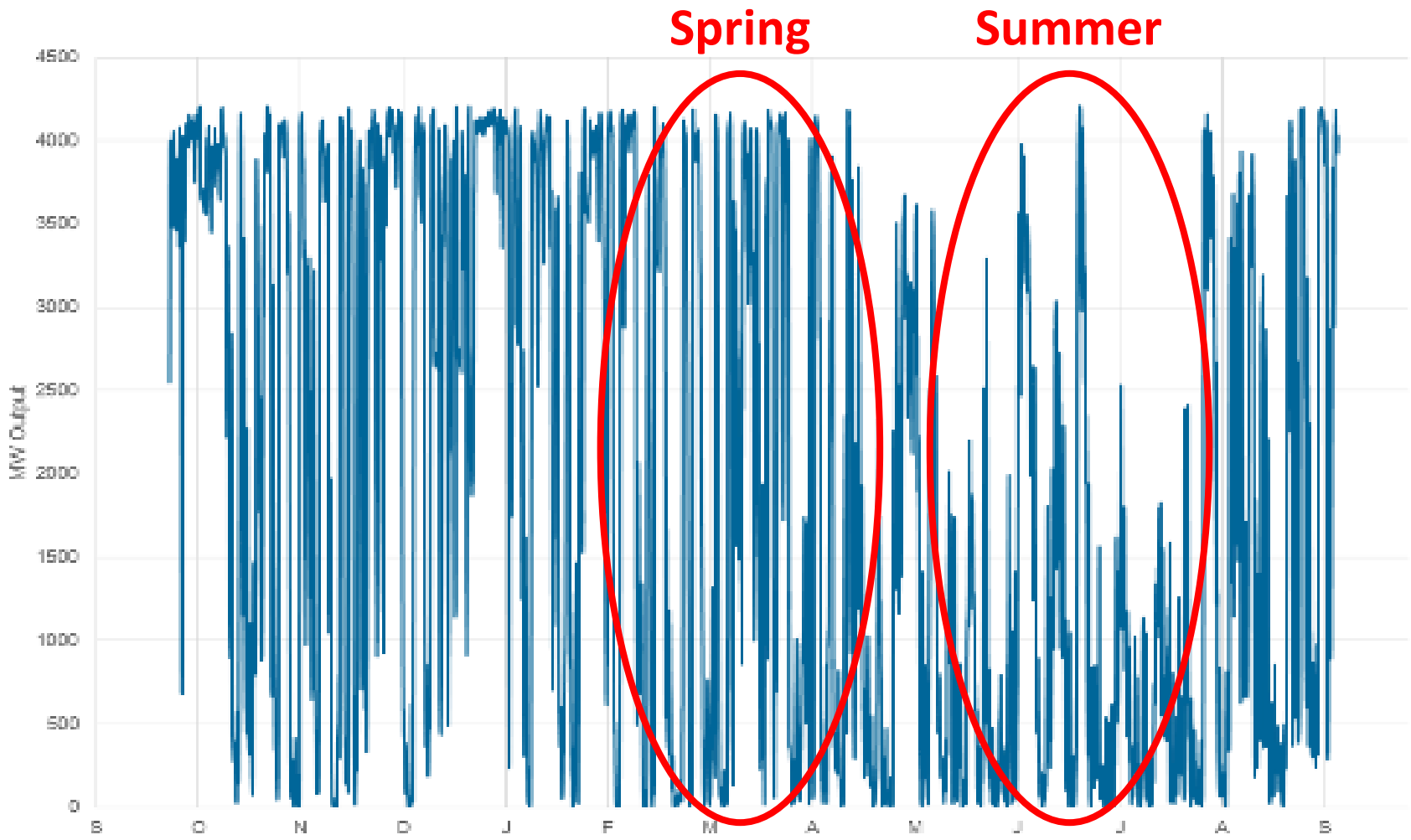

Monthly PV Output

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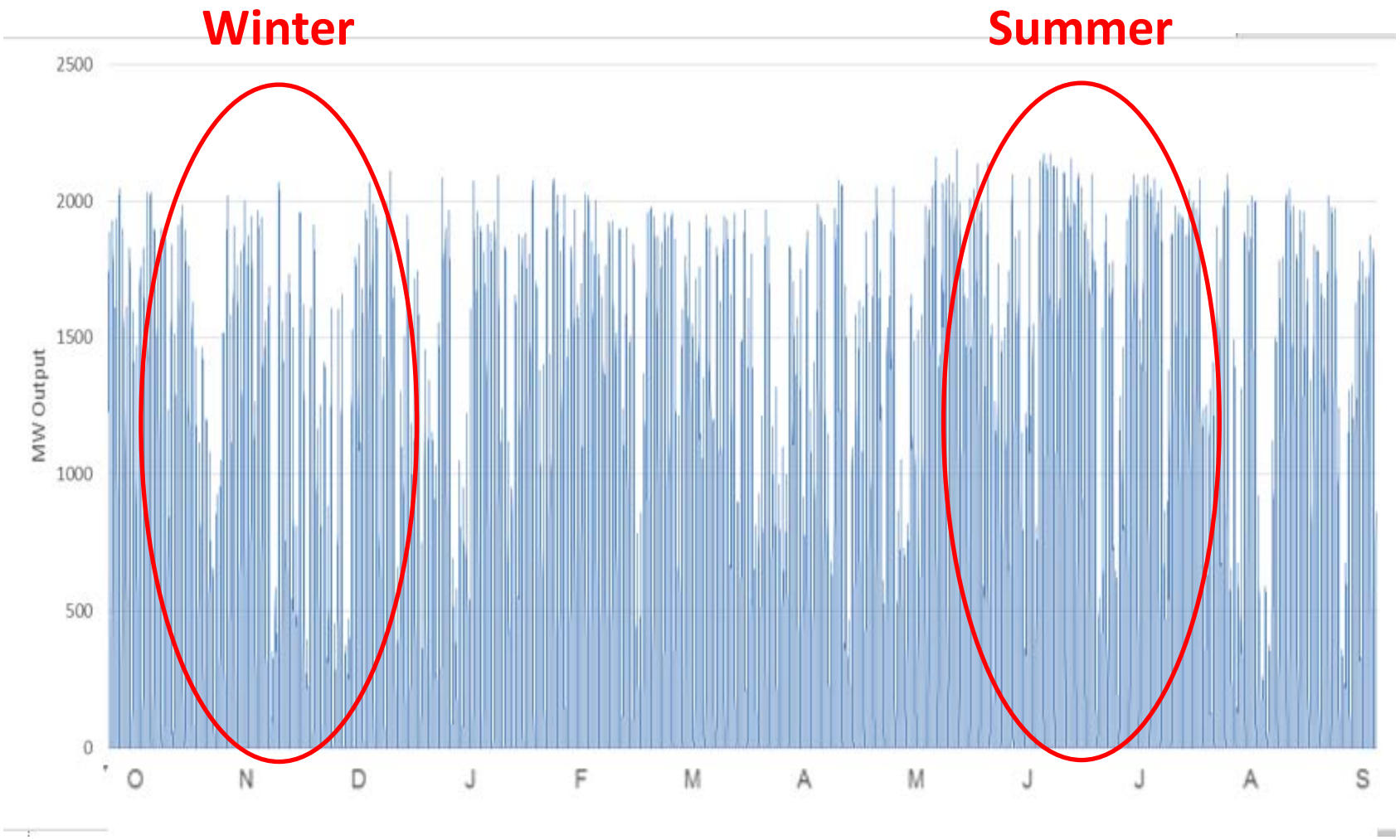

Monthly Variable Generation Output

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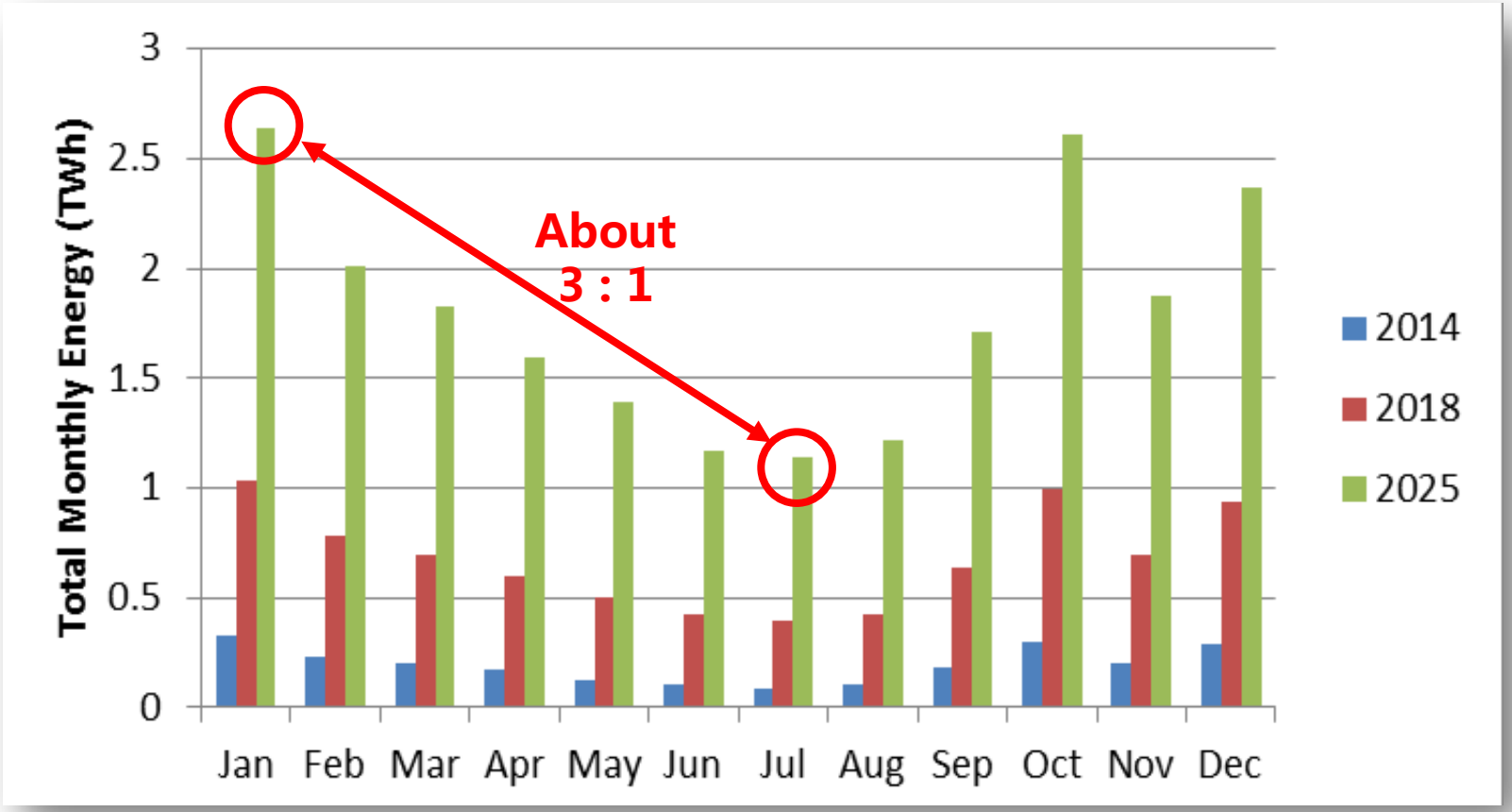

Average Daily Wind Production Profiles by Season - 2025

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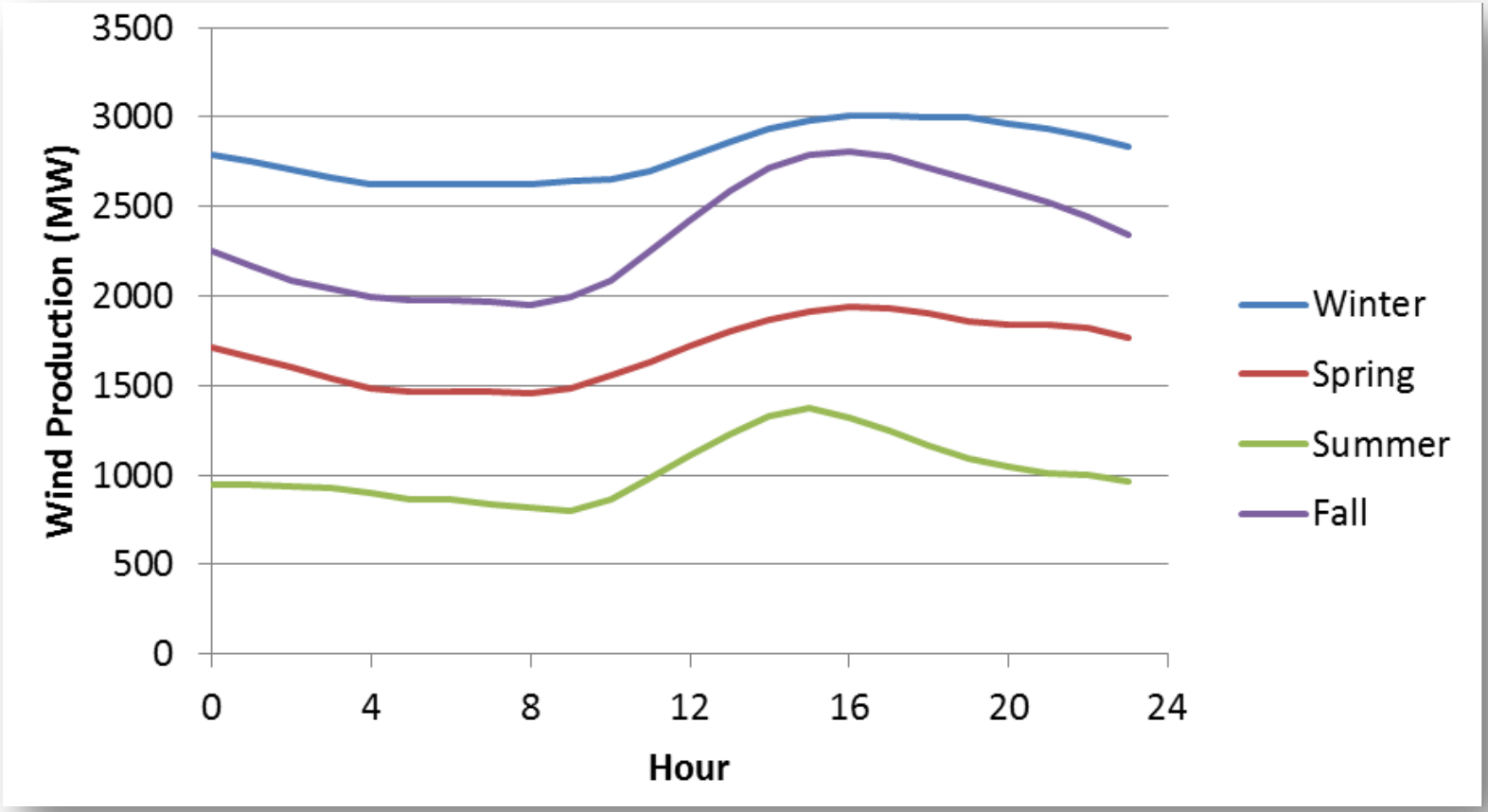

Average Daily PV Production Profiles by Season - 2025

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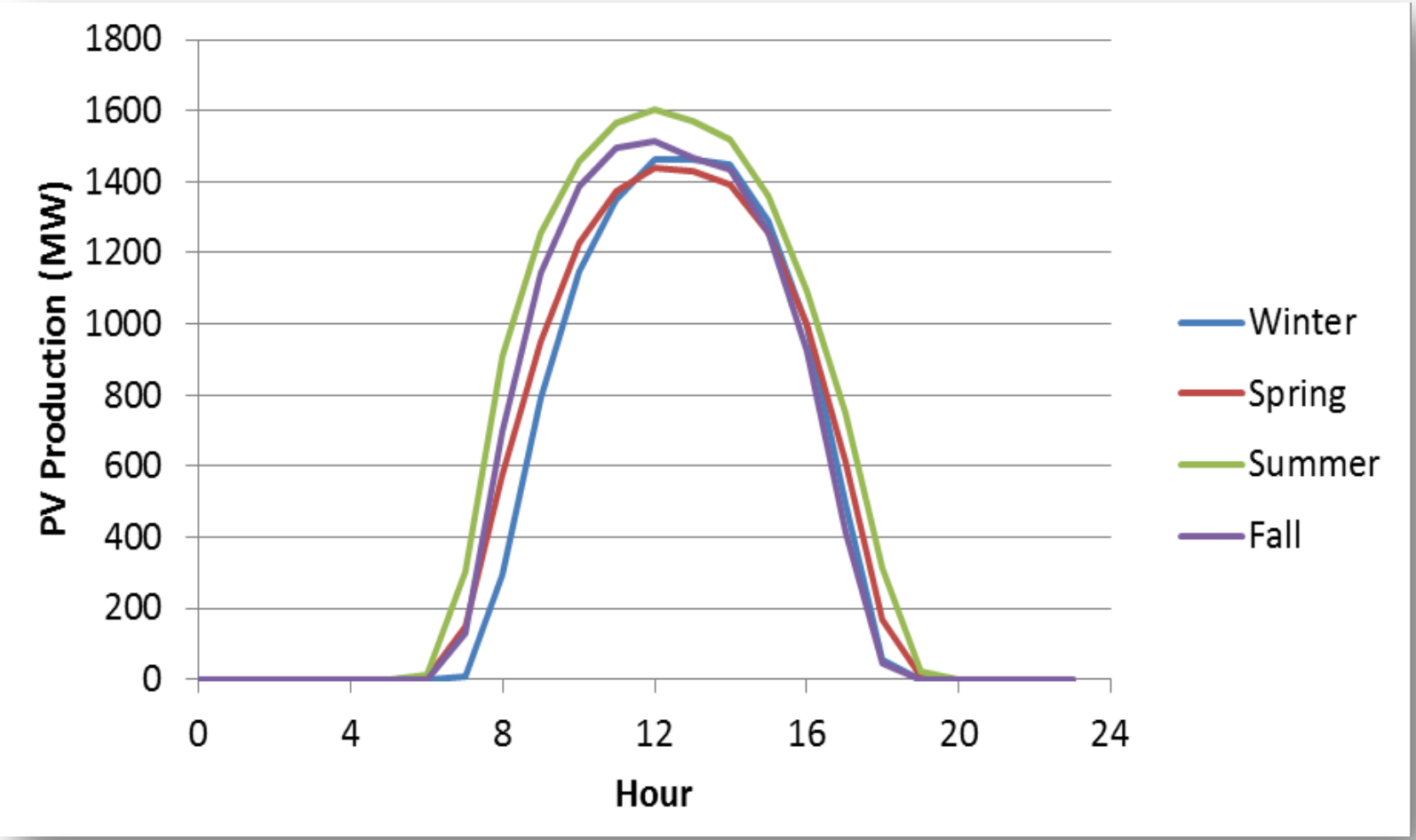

Average Daily VG Production Profiles by Season - 2025

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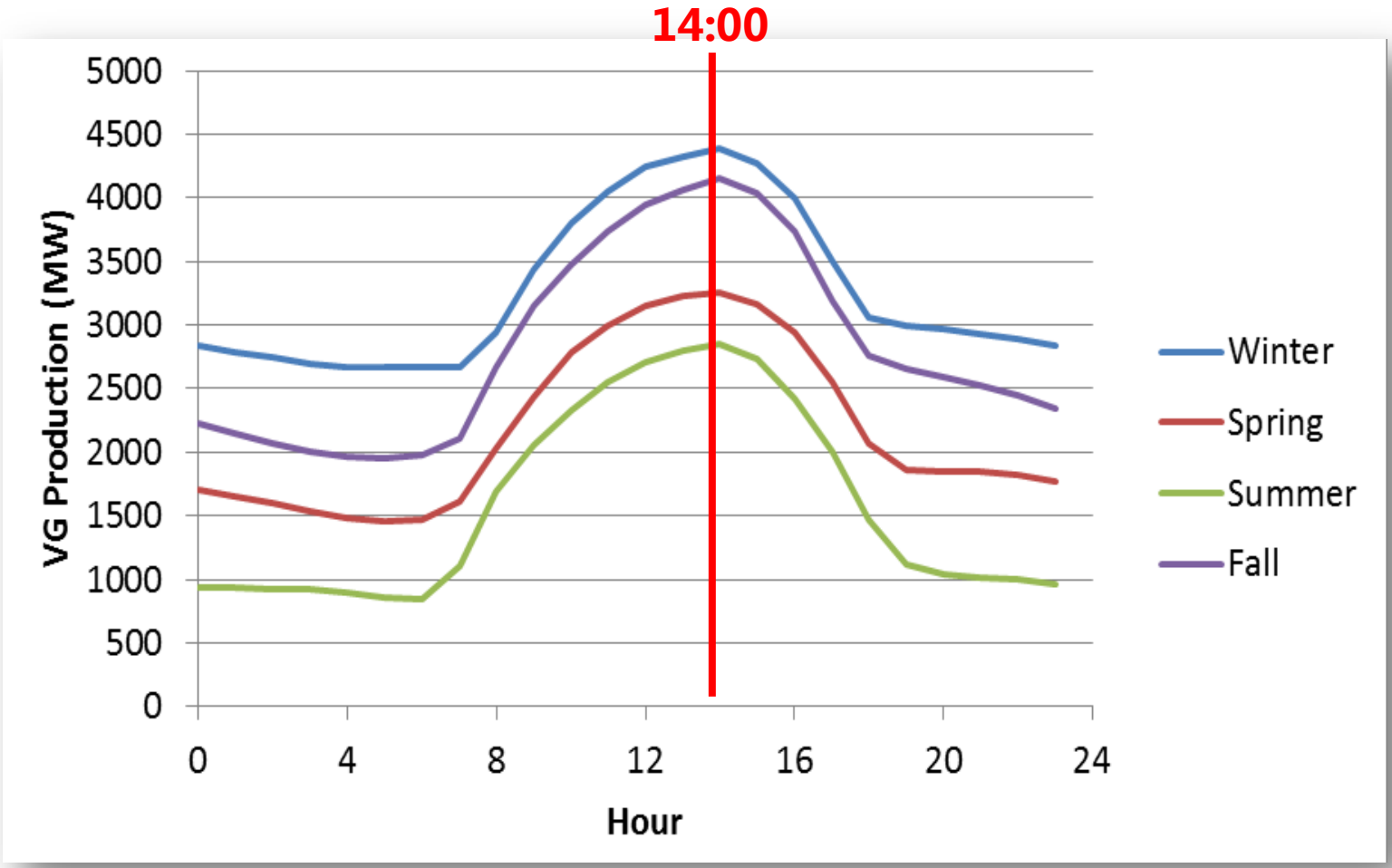

Normalized RE Production 60 Min Variability by Day

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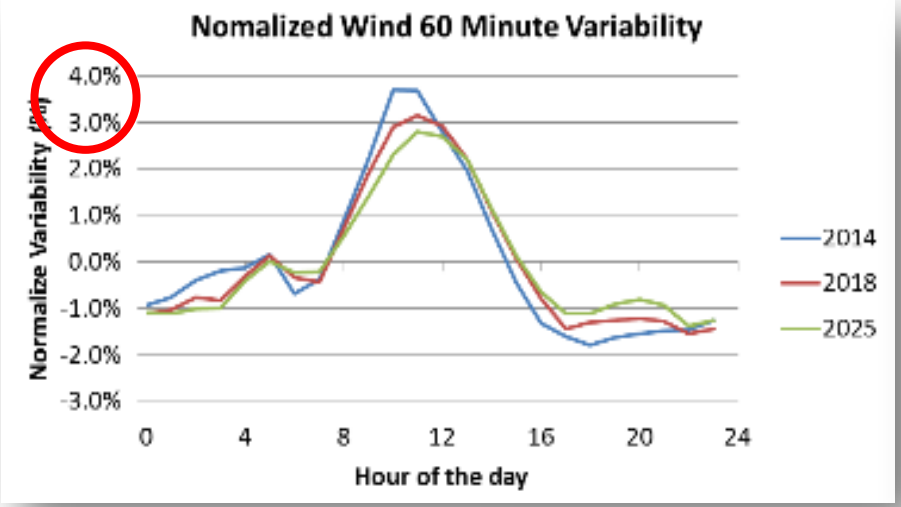

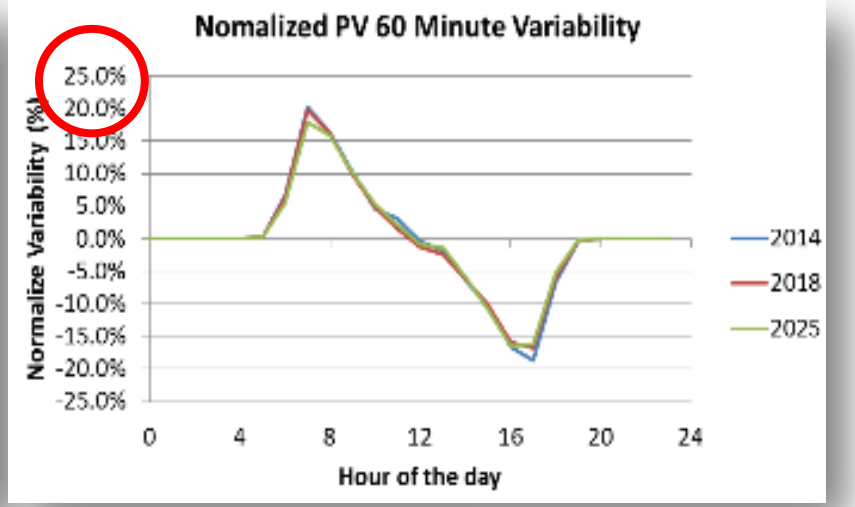

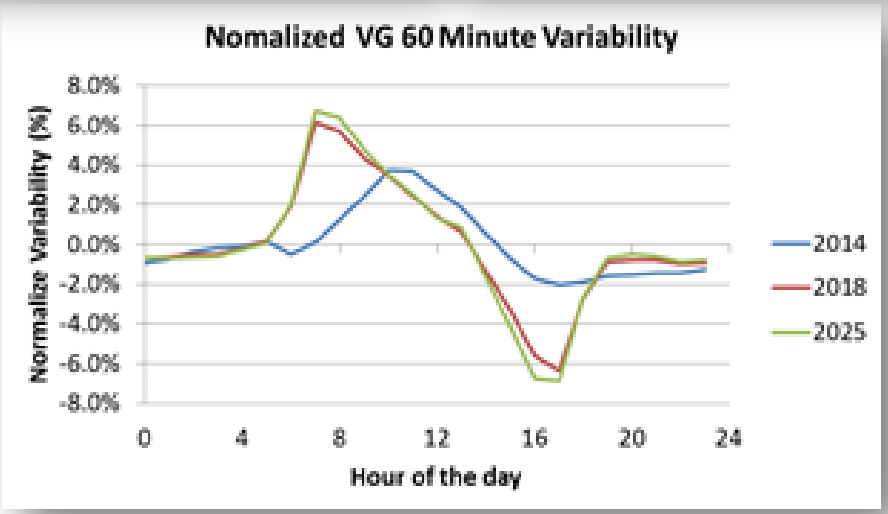

Normalized RE Production 10 Min Variability by Day

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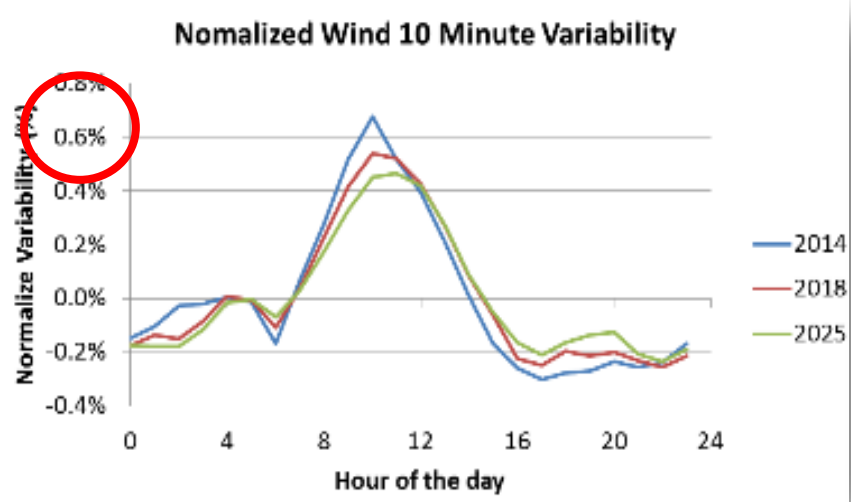

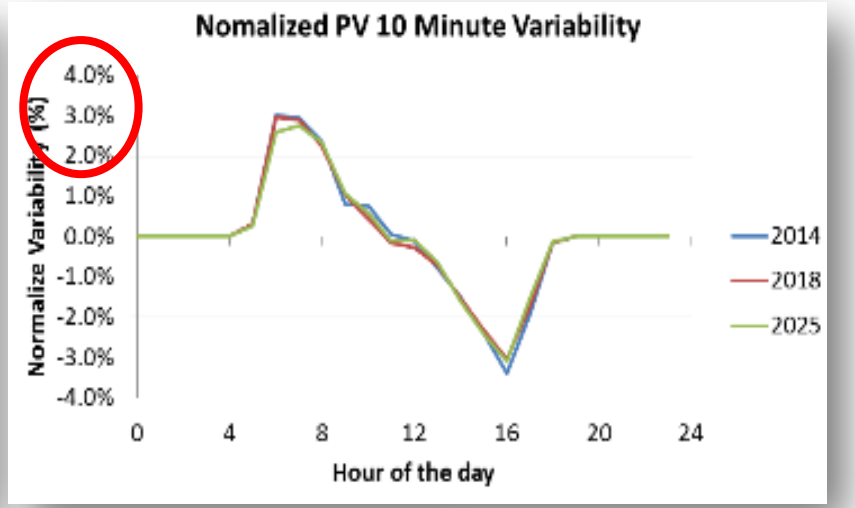

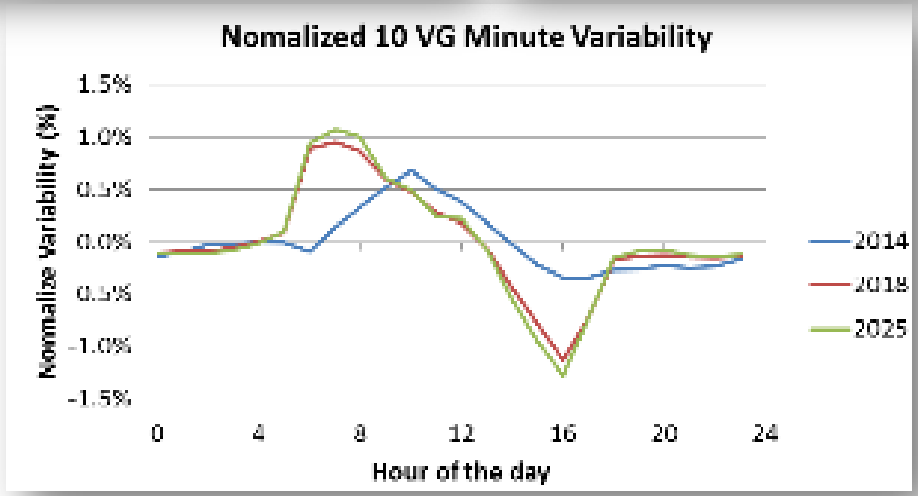

Expected "Duck Curve" Effect in Taiwan

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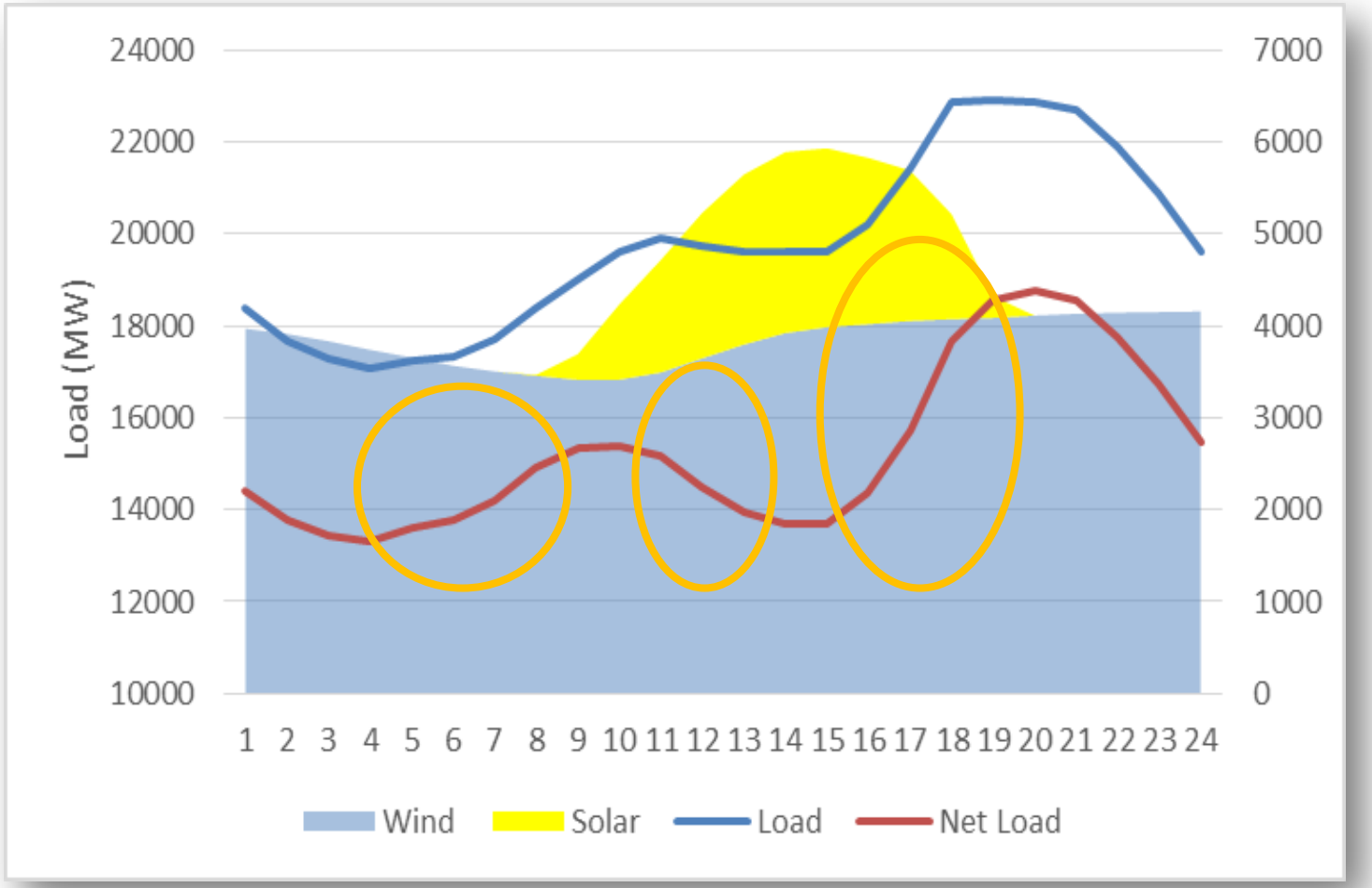

Expected Duck Curve Effect in the State of California of the USA

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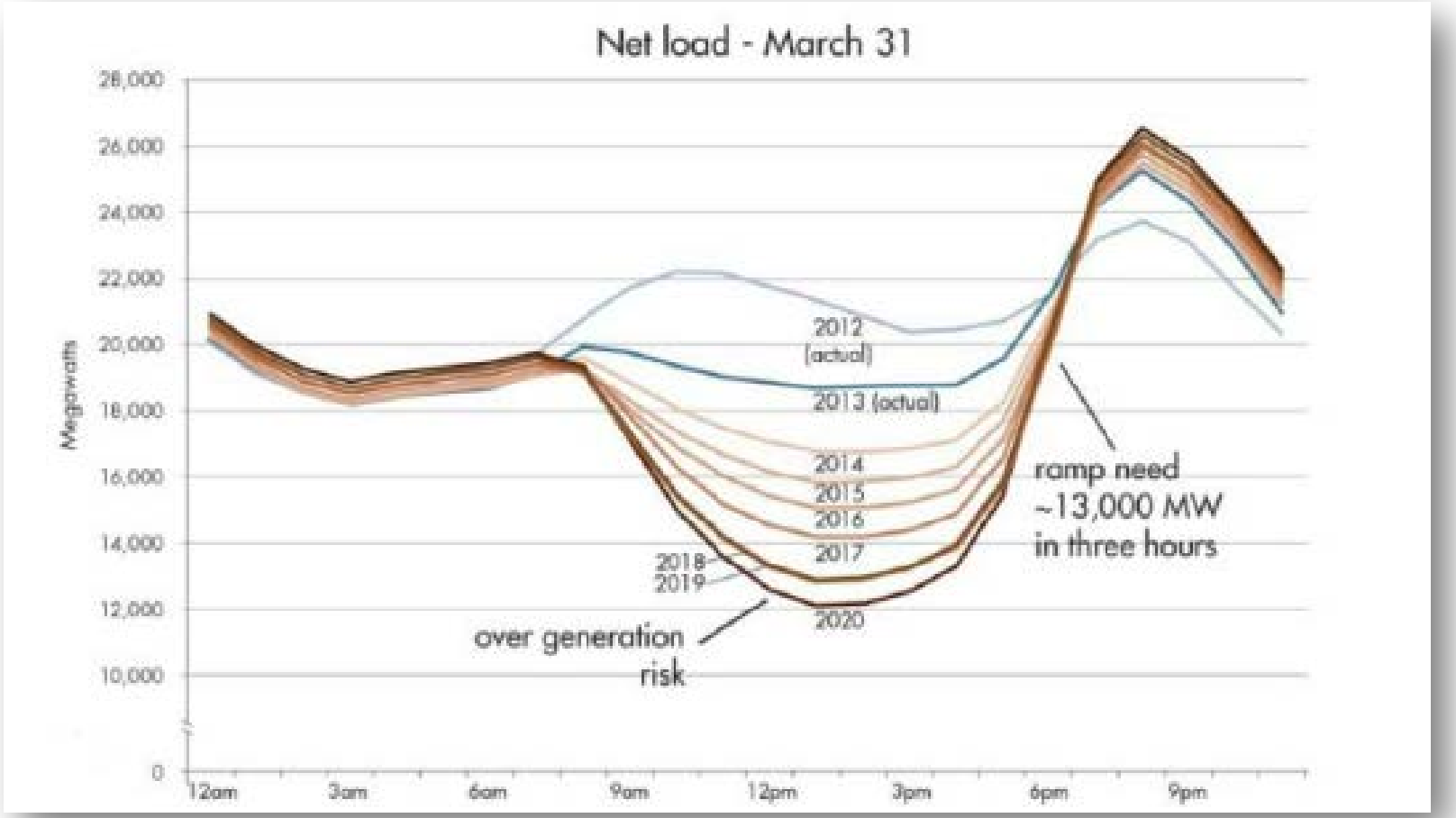

Reserve Power

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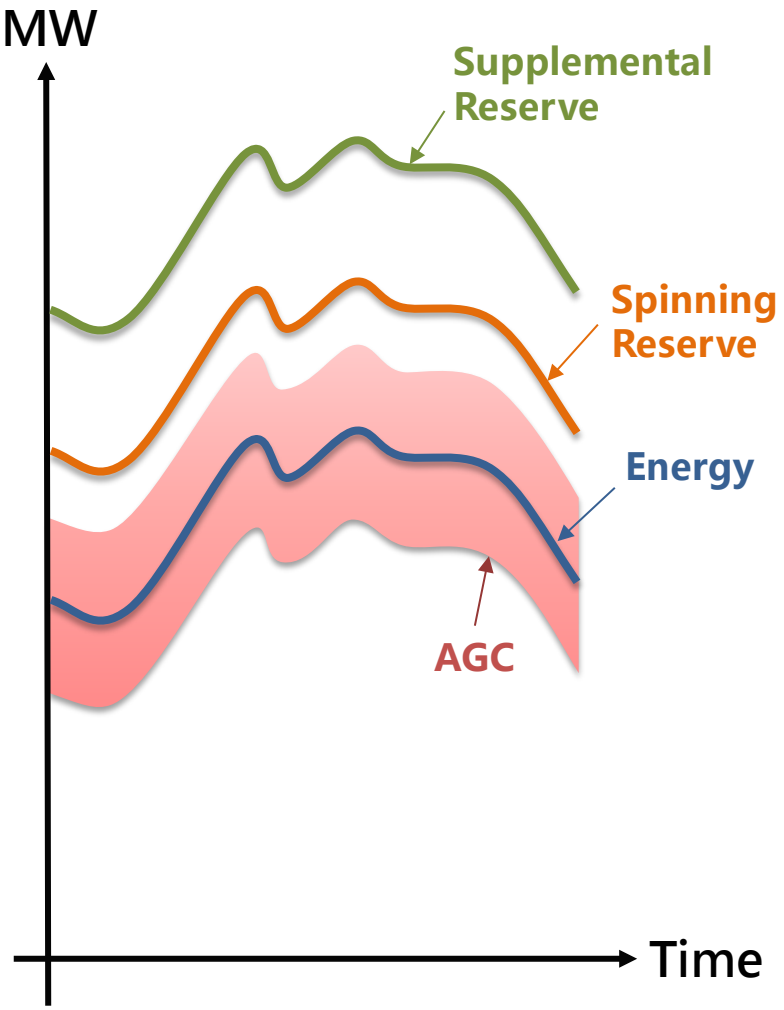
Taipower's Reserve Power Category	EPRI's Reserve Power Category
Automatic Generation Control (AGC)	Reg(Regulation)
Spinning Reserve	Flex
Supplemental Reserve	



Average Reserve Power by Coverage Confidence Interval

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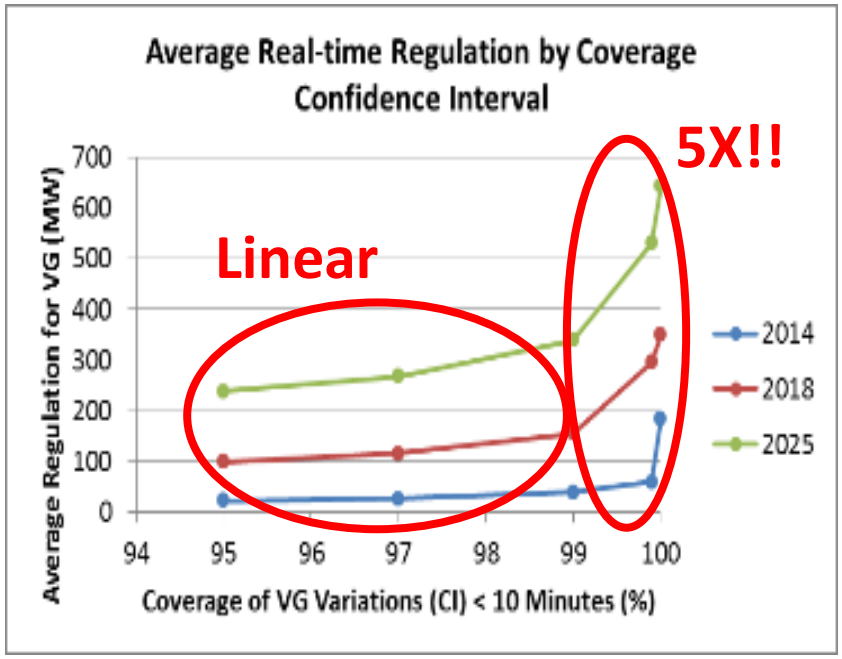

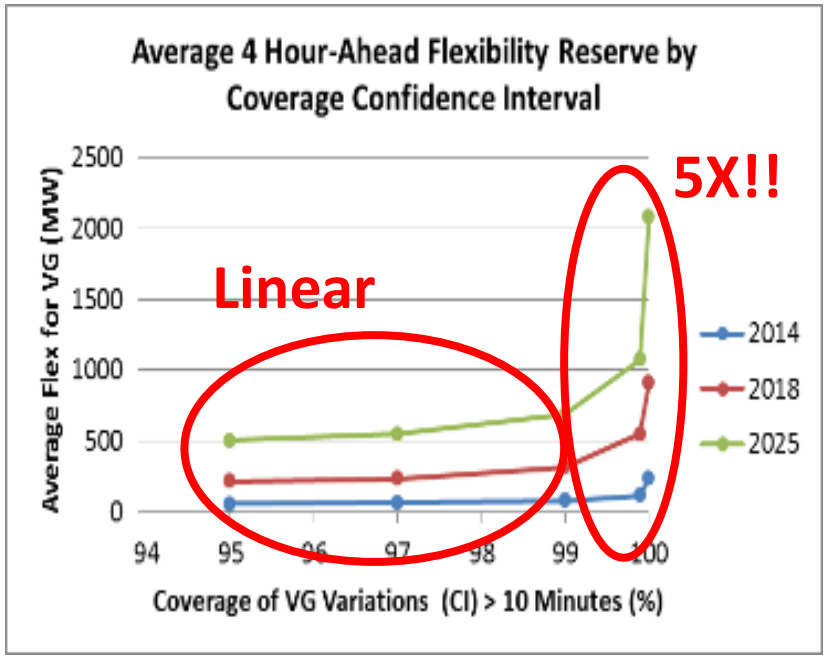

Benefits of Energy Storage and Demo Projects

Load Leveling and Peak Shaving with Energy Storage

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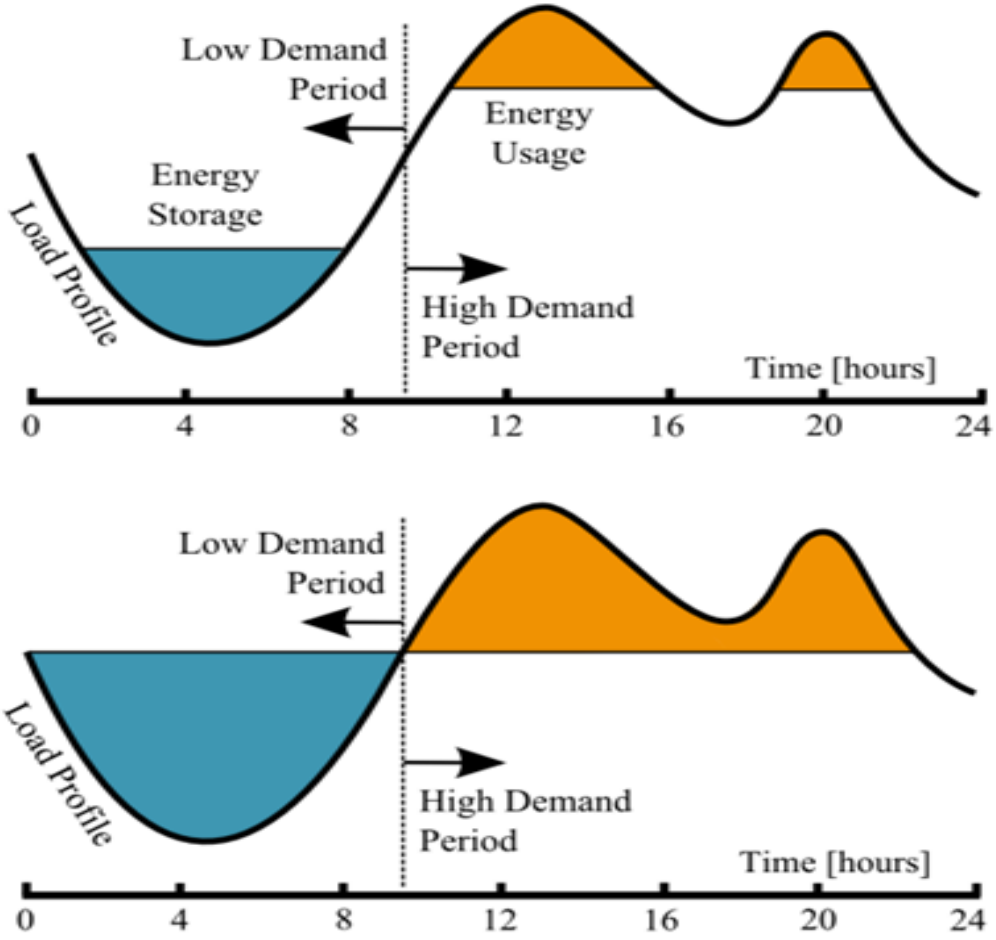

Other Potential Benefits of Energy Storage

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Dispatch

- -Energy Management
- -Peak Shaving and Load Leveling
- -Load Dispatching

Generation

- -Decrease Power Reserve
- -Delay the Need for New Power Plant

User

- -Increase Power Quality
- -Lower Contract Capacity
- -Decrease Electricity Payment

Transmission Distribution

- -Grid Connection Energy Management
- -Mitigate Transmission Congestion
- -Delay Transmission Investment

Energy Storage Demonstration Sites in Taiwan

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KimMen

Energy Storage:

- 50kW/150kWh (Lithium iron phosphate)

Testing Functions:

- Centralized Community Energy Storage System
- Power Flow Management and Control
- Distributed Grid Business Model Demonstration

PengHu

Energy Storage :

- 100kW/40kWh (Li)

Testing Functions:

- Renewable Energy

Smoothening

- Load Leveling and Peak Shaving

LongTan

Energy Storage:

- 100kW/60kWh (Lithium iron phosphate)

Testing Functions:

- Continuous Islanding Operation
- Seamless Grid-Connected/Islanding Operation
- Remote Demand Response

TPRI

Energy Storage:

- 30kW/63.3kWh (Lithium iron phosphate)

Testing Functions:

- Voltage Dip Compensation
- Demand Response
- Grid-Connected/Islanding Operation

Evaluation of ESS on 161 kV Congested Transmission Line

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Items \ Scenarios	Scenario 1 : Replacing Transmission Lines	Scenario 2 : Installing Transmission Level Energy Storage System		
		Scenario 2-A	Scenario 2-B	Scenario 2-C
Demands to be satisfied	Year 2031 (To start construction now)	Year 2021 (Delaying the construction for 5 years)	Year 2024 (Delaying the construction for 8 years)	Year 2031 (Delaying the construction for 15 years)
Energy Capacity	440MVA → 778MVA	115MW 410MWH	150MW 811MWH	300MW 1,590MWH
Installation Price	~USD$ 20M	~USD$ 163M	~USD$ 324M	~USD$ 636M
Land space Requirement	None	~0.56km^2	~1.11km^2	~4.92km^2
Energy Lose Rate	0%	25%		
Note	• Can last for over 30 years	• Take Sodium- sulfur battery as example - each unit is about 1MW x 6hr • Discharging time is set at 6 hr for each scenario • Average 4,500 cycles can last for about 15 years		

Conclusion

Transmission Level Energy Storage System

- **Requirement:** at least MW-level capacity
- **Condition:** Low Cost, High Safety, No Environmental Impact
- **Technology Maturity:**
  - No commercially matured transmission level ESS on the market internationally
  - Only a few demonstration products that supports dozens of MW output
  - Hard to evaluate the lifetime and costs
  - **Not economical**
- **Future Development:**
  - Incorporate with renewable energy with the development of transmission level energy storage system to strengthen the grid's **reliability, safety, security, environmental impact, energy efficiency, and financial benefits**