

# Large-scale Wind Power Integration: Challenges and Opportunities

Dr. Niamh Troy

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# ERC Industry Members



## Other stakeholders on ERC board:

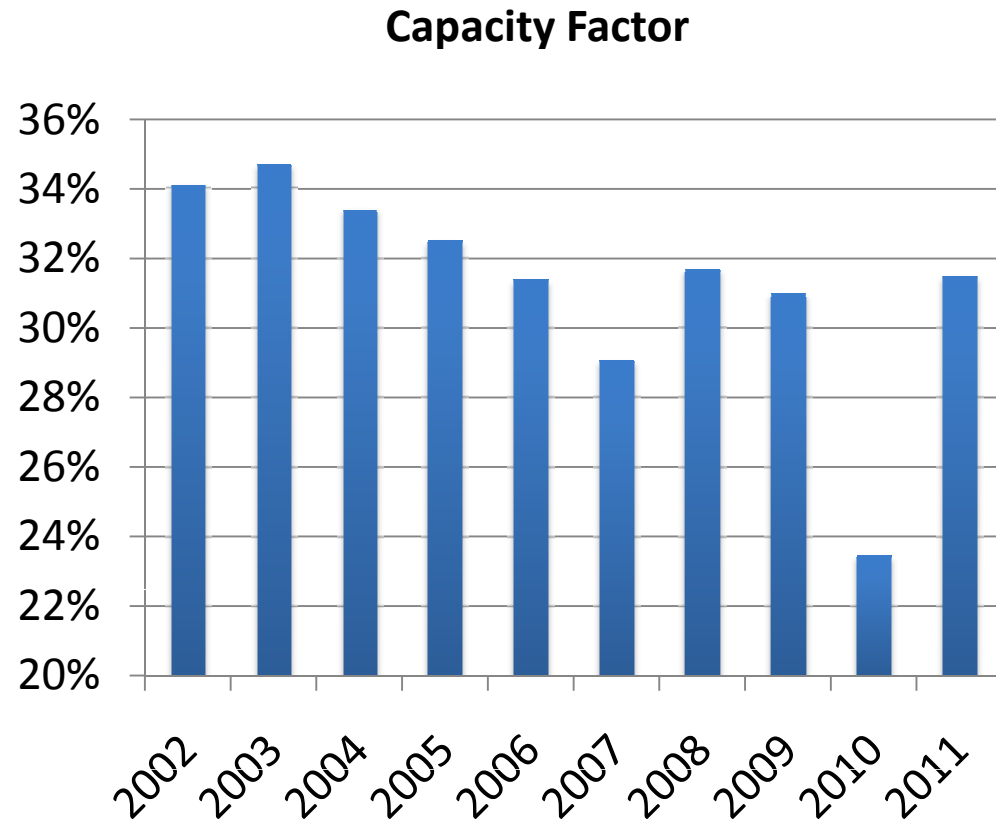


## Major Funding sources:

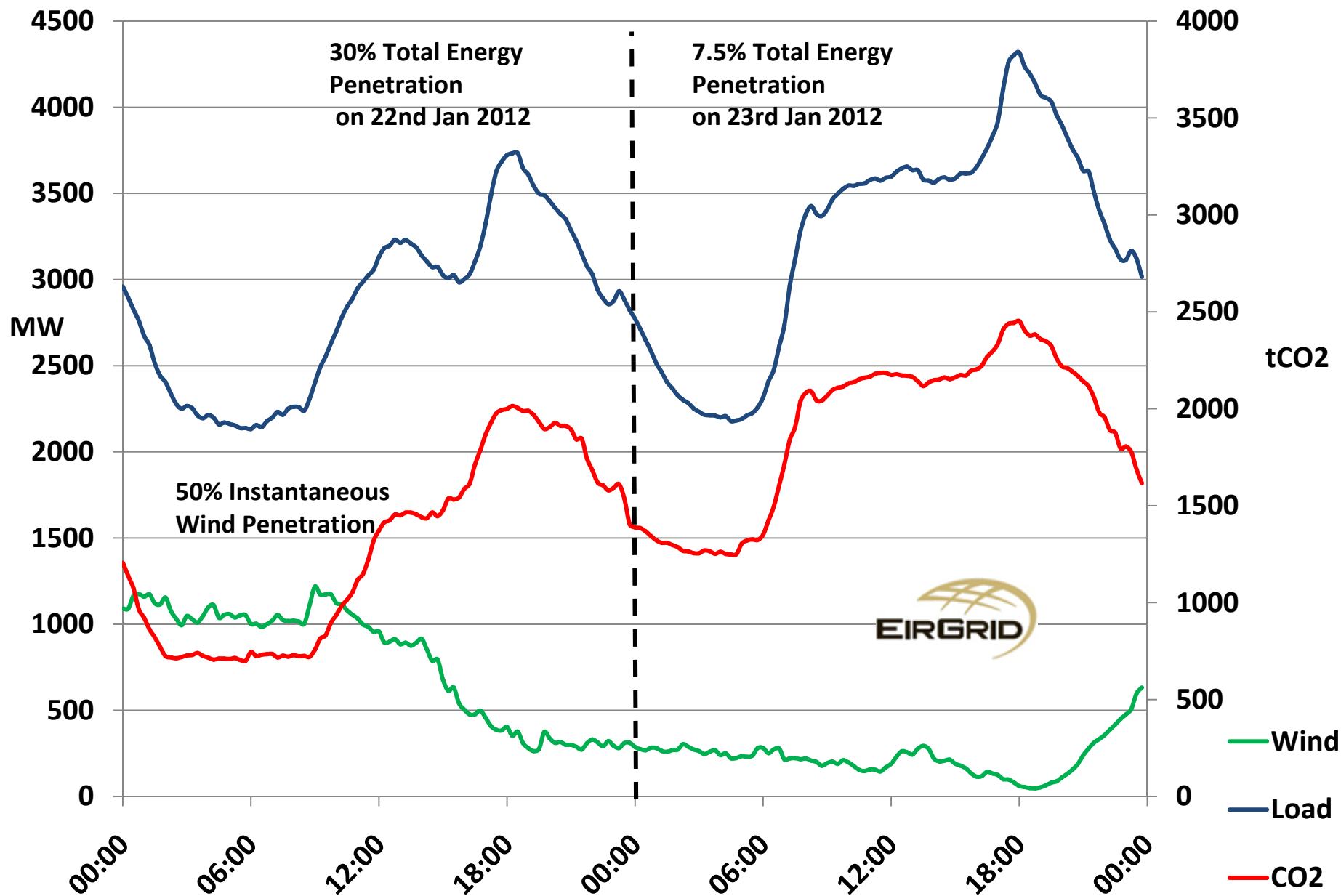


# Status of Wind in Ireland

- Total installed capacity is 2031.25 MW (Peak load 2011 = 6780 MW)
- Energy Penetration: >10%
- European 20/20/20 Target: 20% of energy consumption from renewable energy sources
- National Target: 40% electricity from renewables by 2020



# Load, Wind and CO<sub>2</sub> Ireland



# Challenges of Large-Scale Wind Integration...

Time Scale	Characteristic of Wind	Solution
Short (seconds)	Decoupled from the Grid (Asynchronous)	Control features/ Power electronics
Medium (Minutes, Hours)	Variable	Flexibility
	Uncertain	Flexibility, Reserve, Forecasting, Rolling Commitment
Long (Weeks, Months, Years)	Variable	Incentivize flexible generation/resources
	Uncertain	Robust Planning
	Distributed	Network Reinforcement

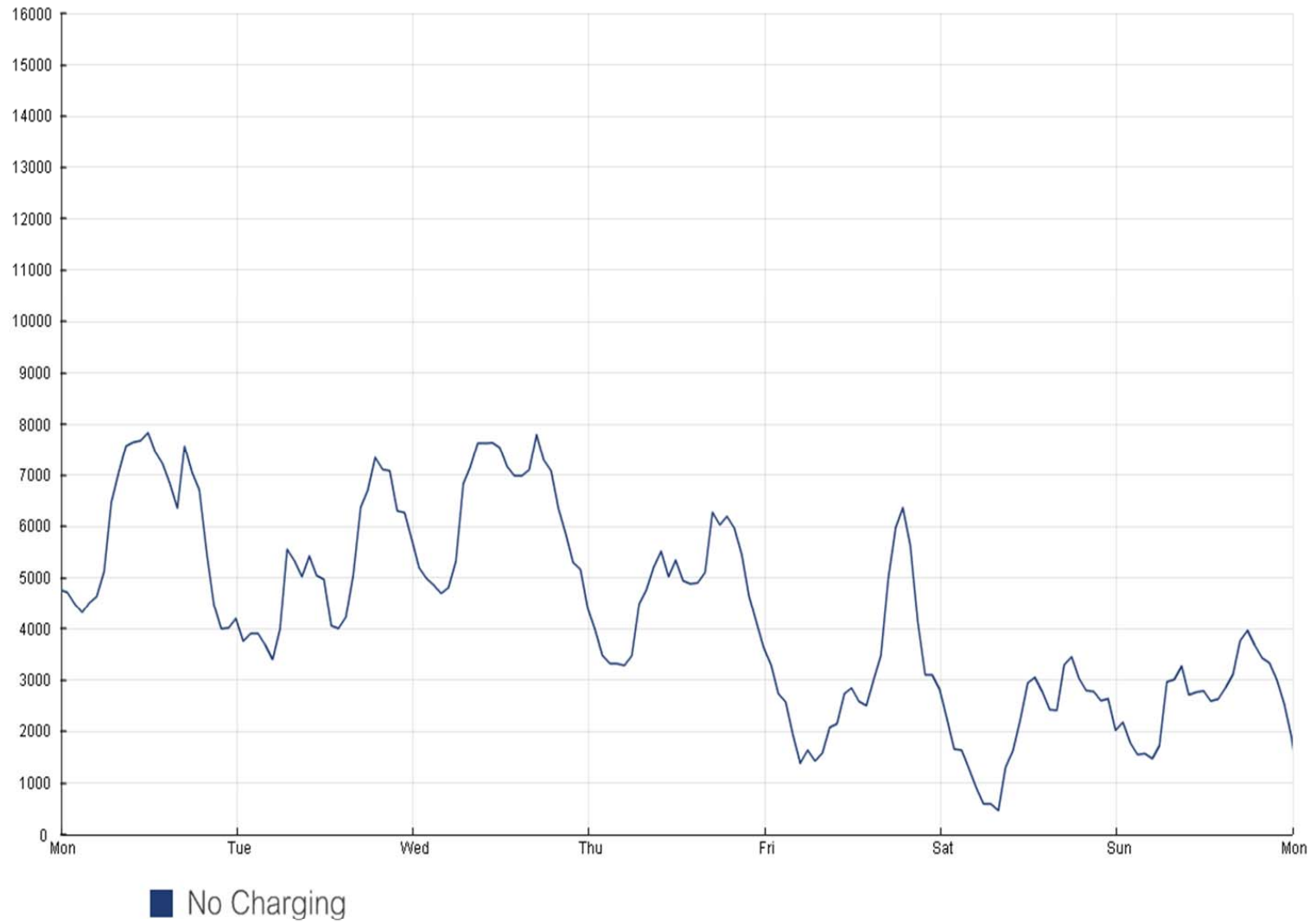
## ... and Opportunities

- Flexibility:
  - Demand Side Management
    - e.g. Electric Vehicles
  - Multi-mode operation of CCGTs
  - Stochastic Optimization

# Demand Side Management

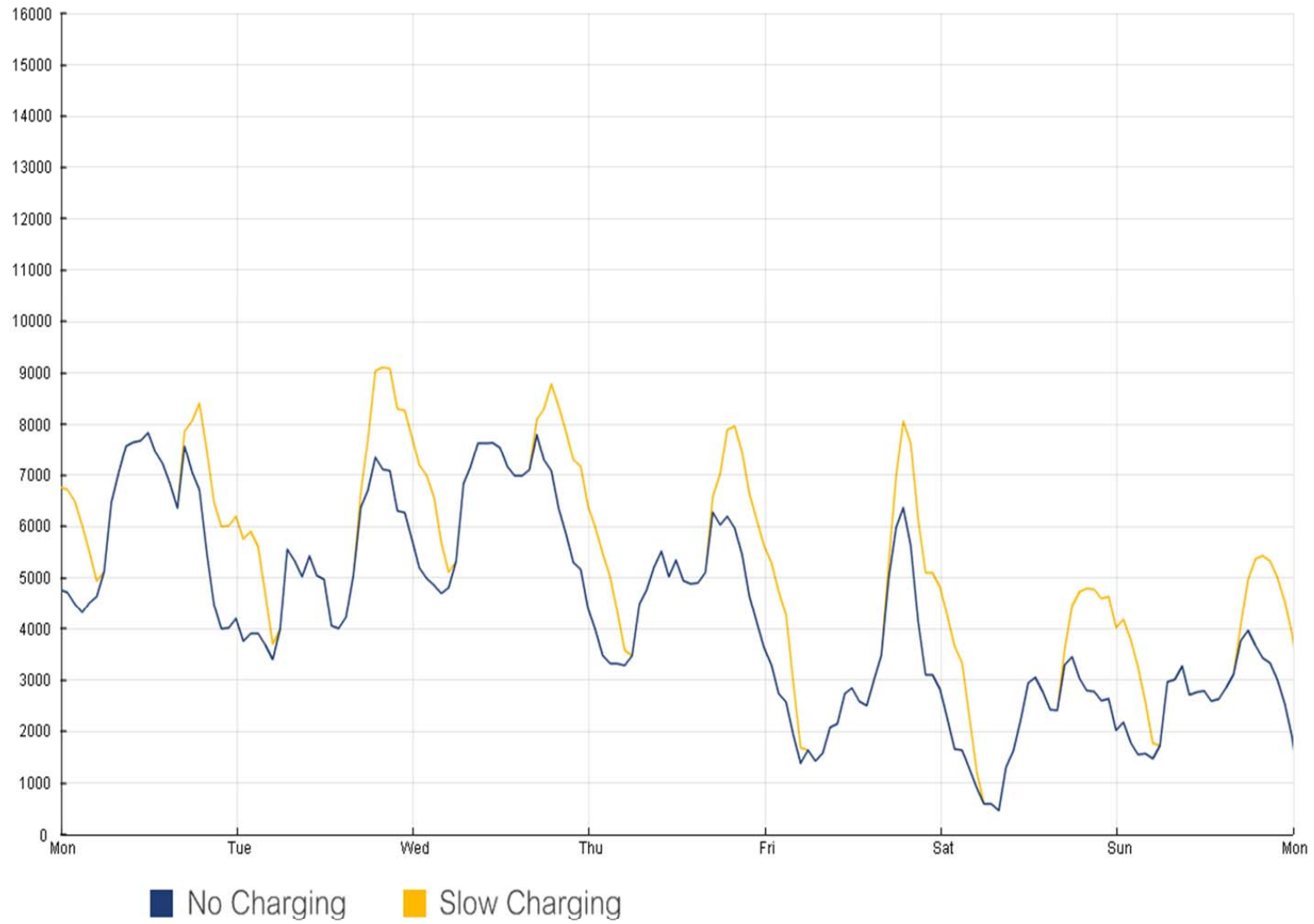
- Examples - electric vehicles, heat pumps, refrigeration
- Opportunities for Wind Power Integration:
  - Load shaping - smoothen the net load curve.
  - If controls are fast enough it can provide reserve (up and down).
  - Alleviate minimum generation issues
  - Centralised vs Local control?

# Net Load Curves for Base, Slow, Fast & Smart Charge Cases

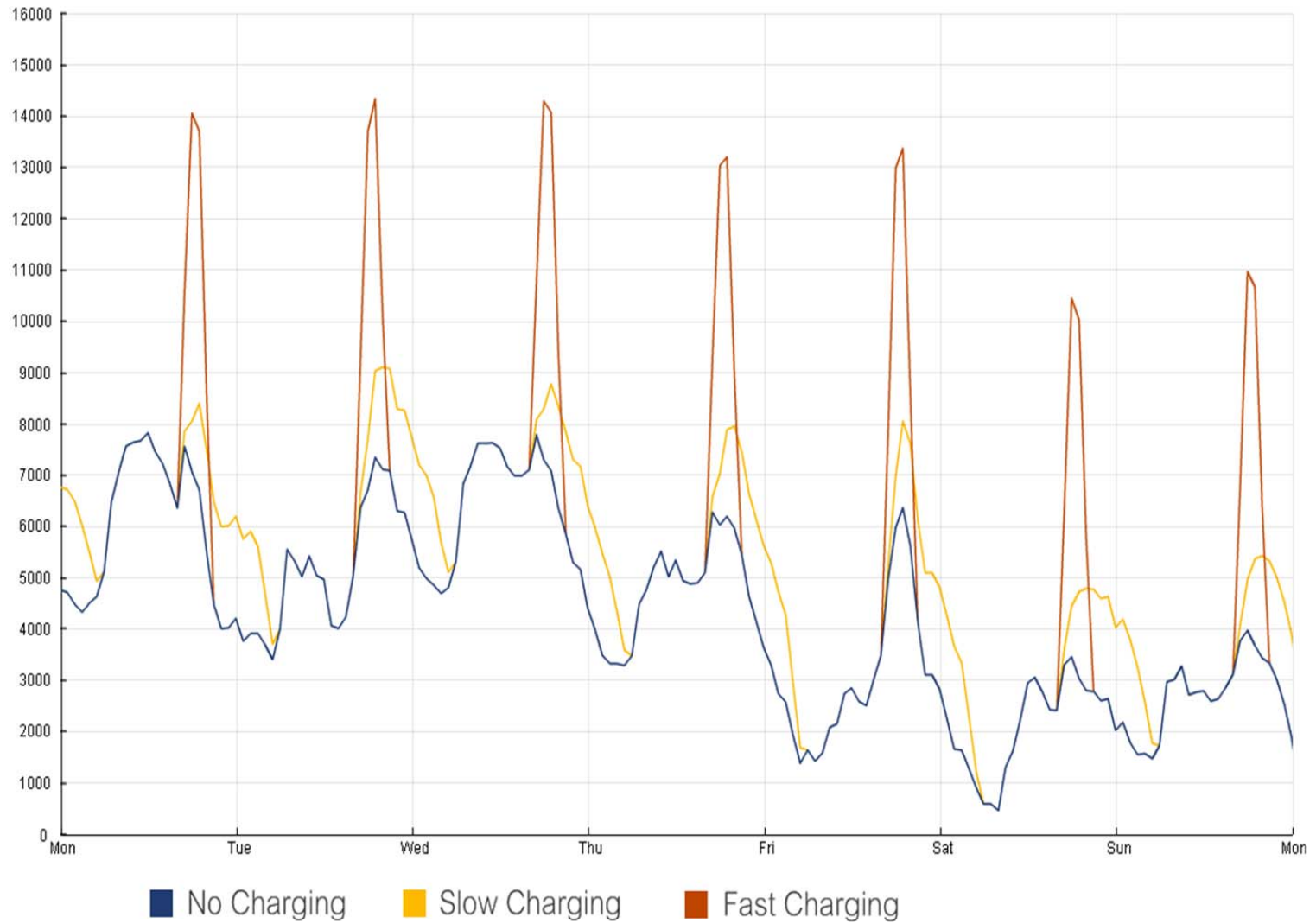




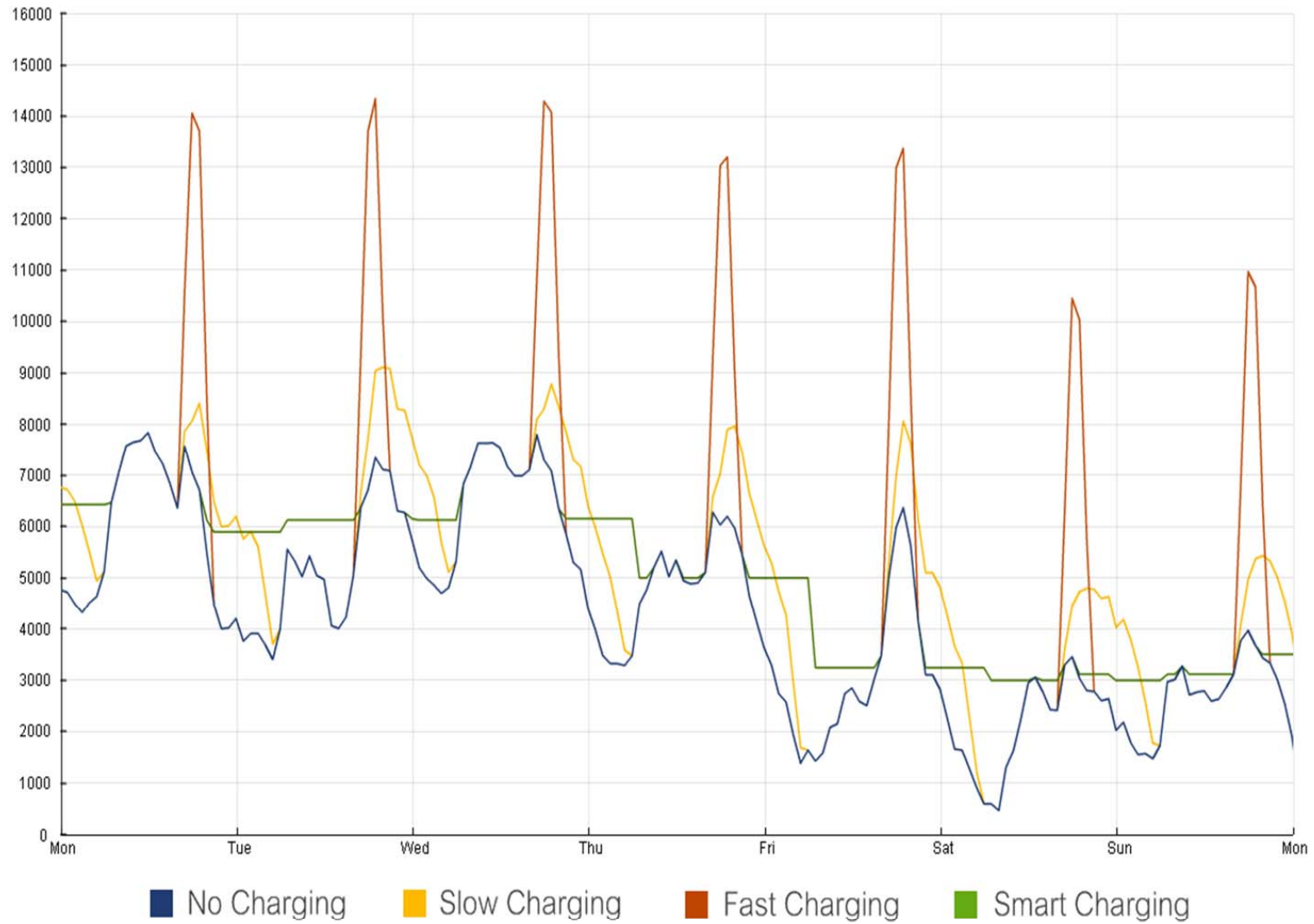
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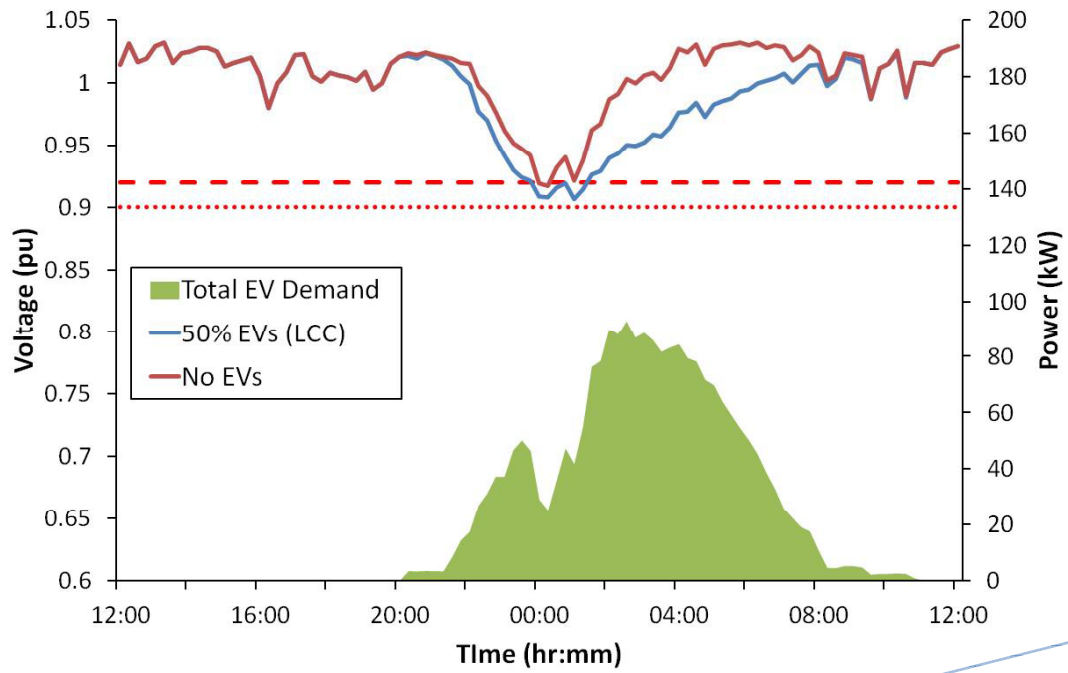


# Net Load Curves for Base, Slow, Fast & Smart Charge Cases



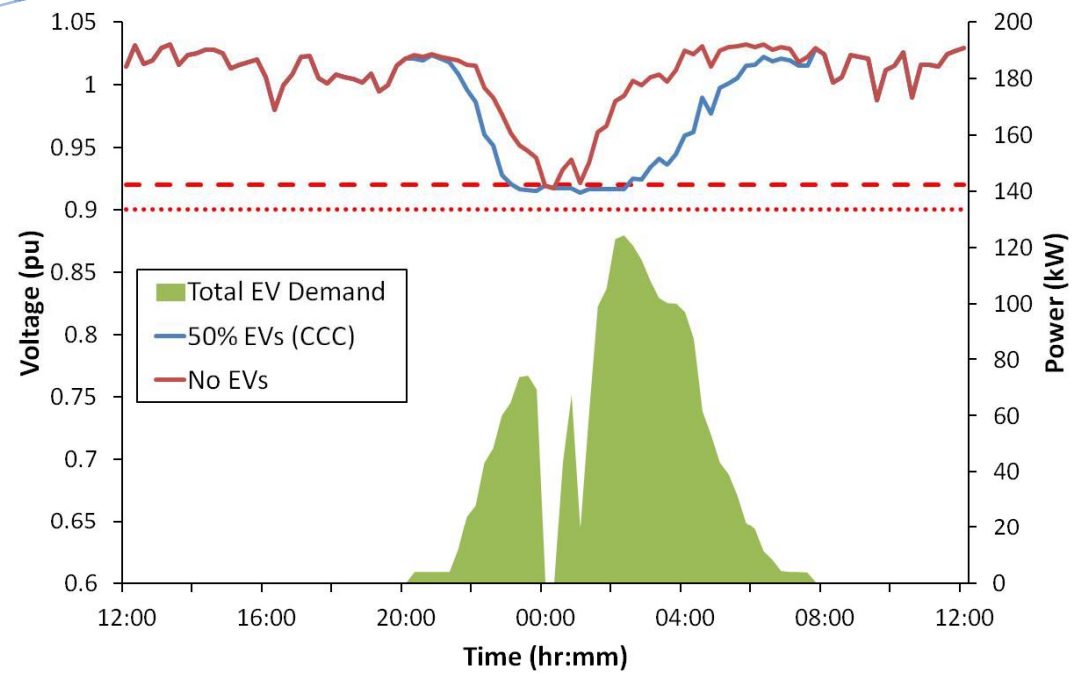
# Centralised vs. Local Control

- Centralised Control
  - Requires access to real-time operating conditions across entire network
  - Controller determines optimal charging rate for each EV based on network data
  - Charging signals sent to EV charger units
- Local Control
  - Each EV charger unit determines its own charging rate based on local network conditions only  
(i.e. voltage and loading at customer point of connection to network)



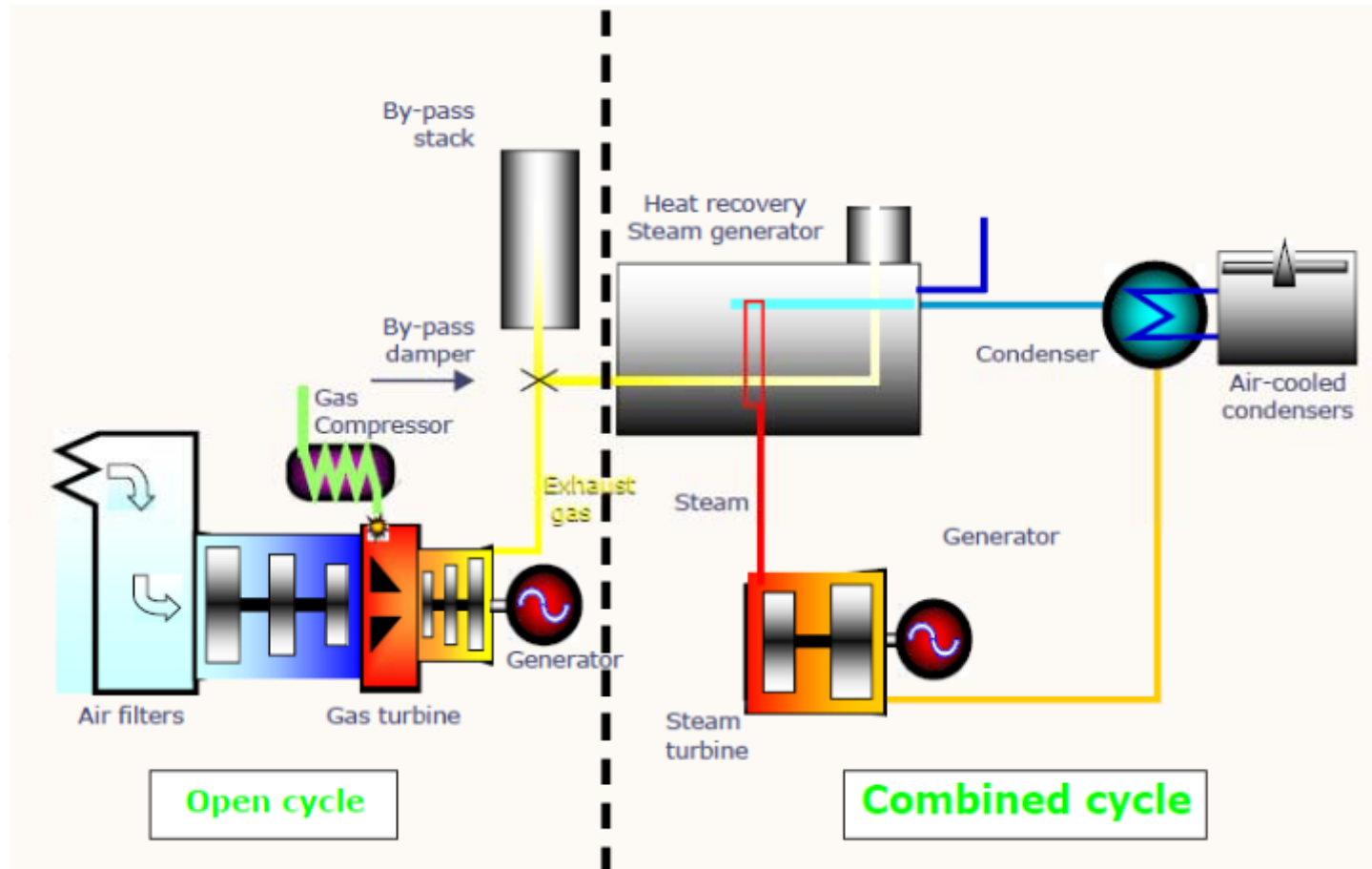
Local Control Charging

Centralised Control Charging

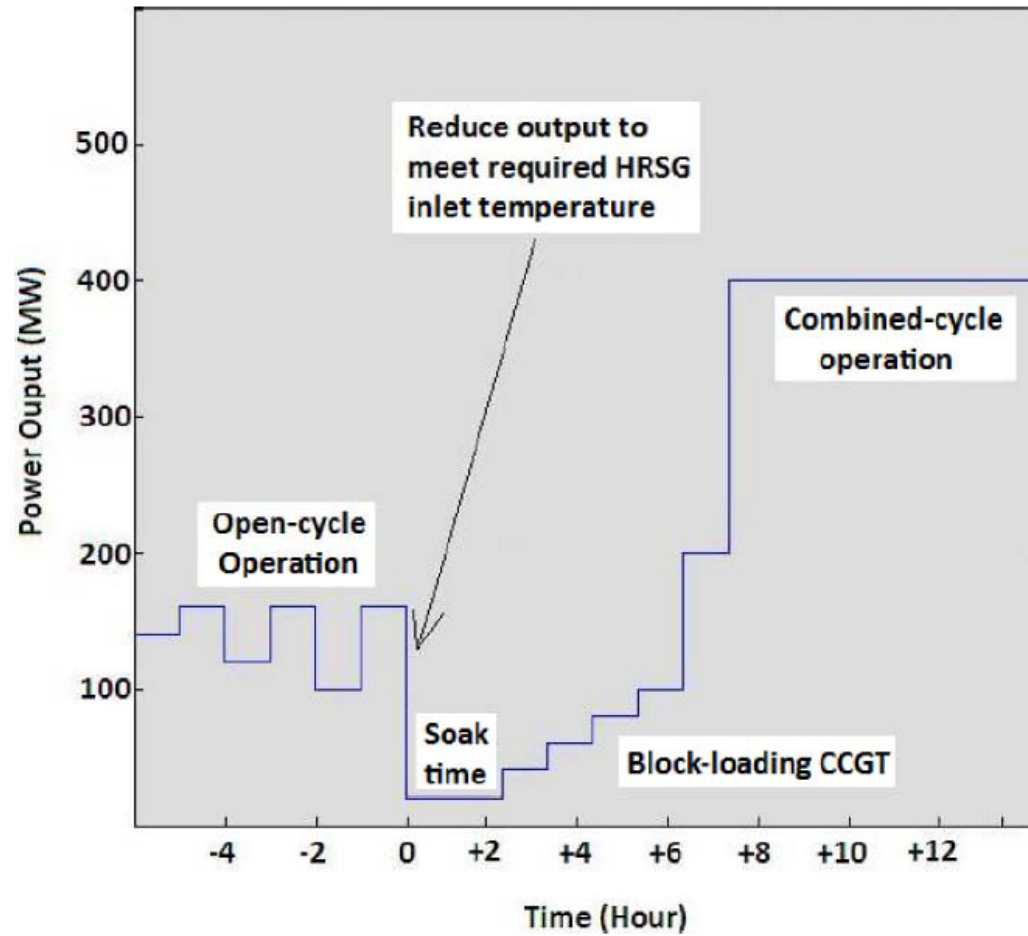


- Centralised control method
  - Significant communications infrastructure
  - Requires central controller
  - More efficient use of existing network capacity
  
- Local control method
  - Requires only local network information
  - Less communications infrastructure
  - Less accurate at maintaining network within acceptable operating limits
  - Increased charging time due to less efficient use of network capacity

# Multi-mode Operation of CCGTs

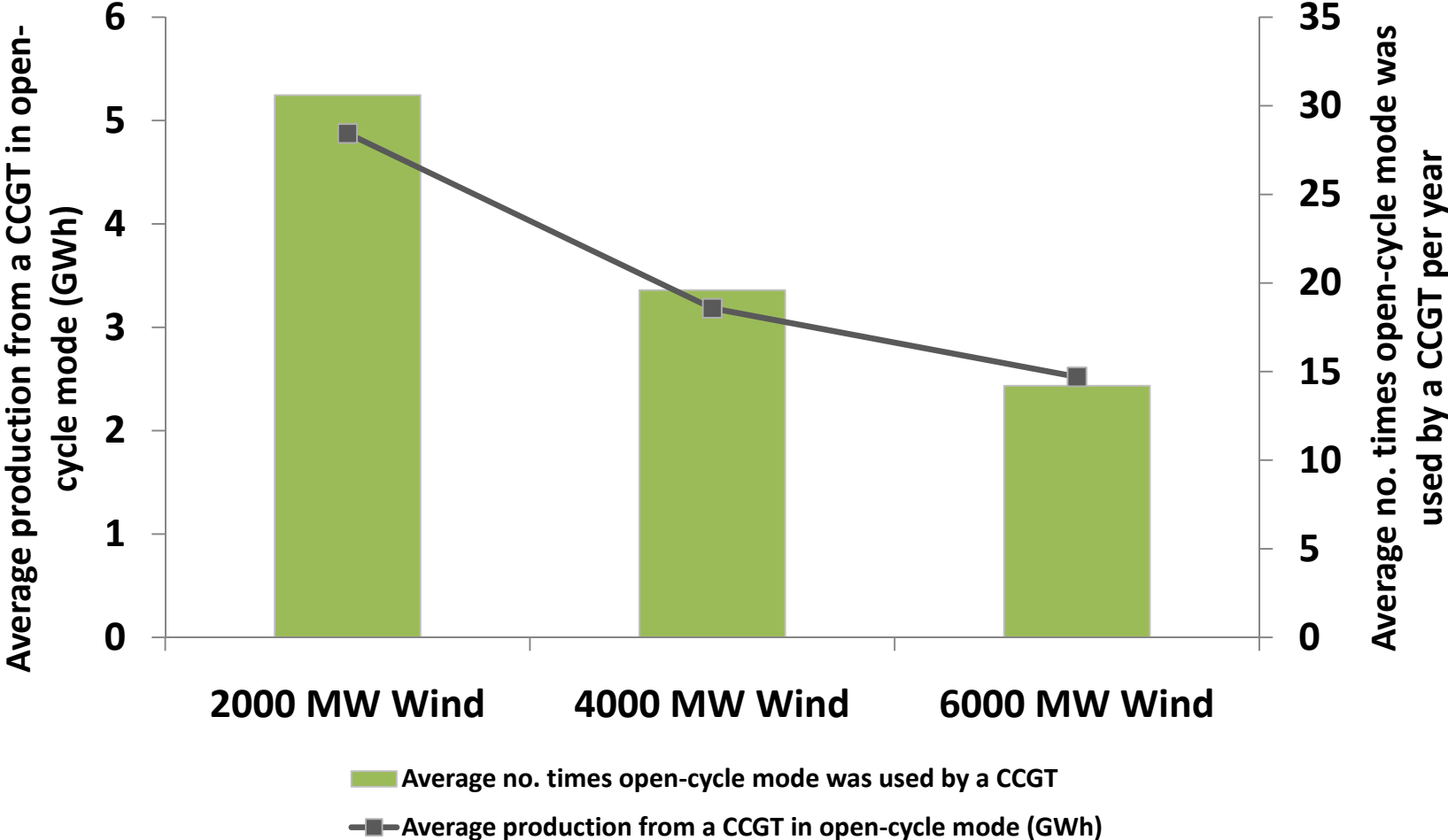


# Modelling multi-mode operation of CCGTs

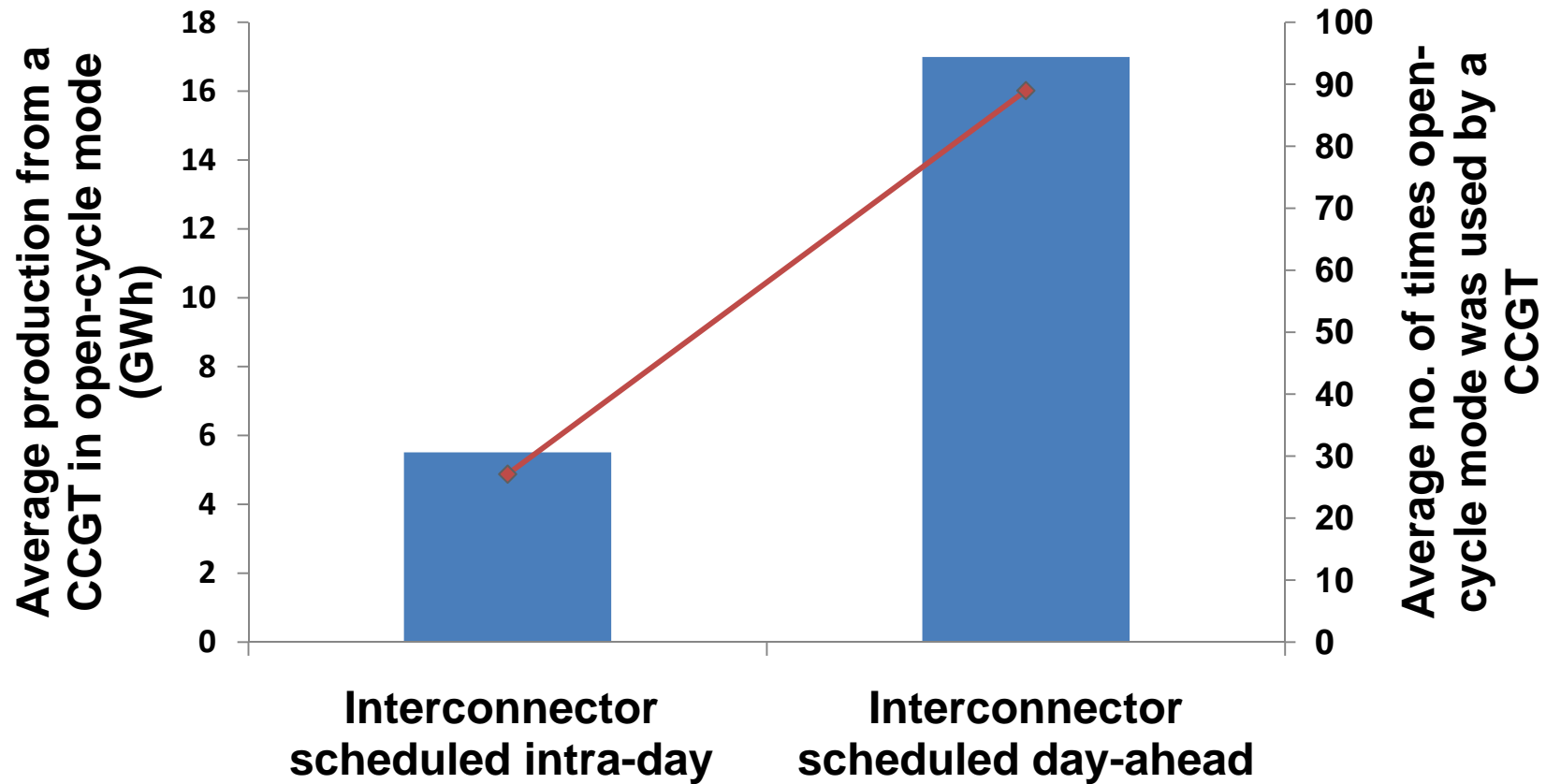




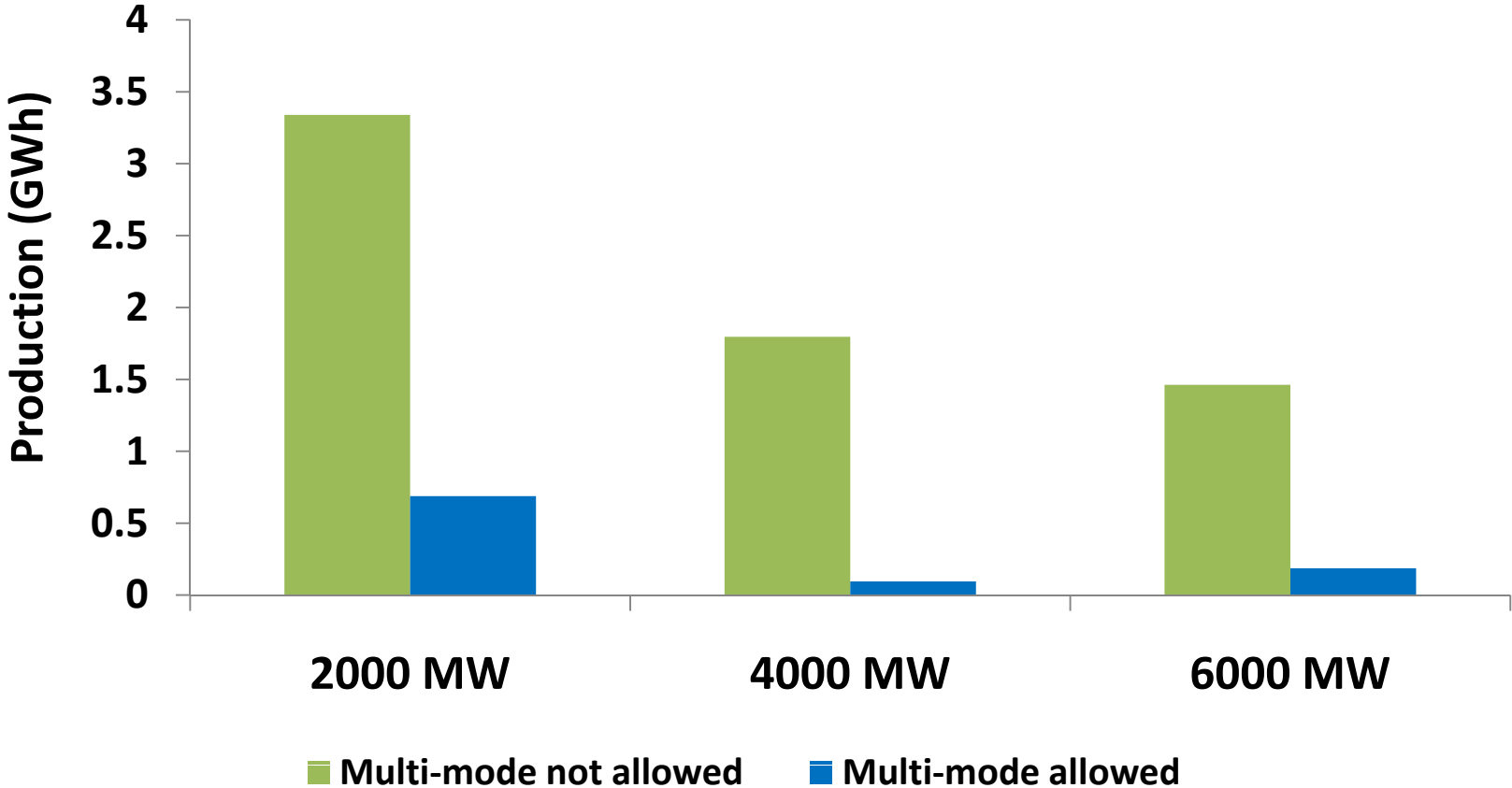
# Utilization of Multi-mode Function with Increasing Wind Penetration



# Utilization of Multi-mode Function - Sensitivity



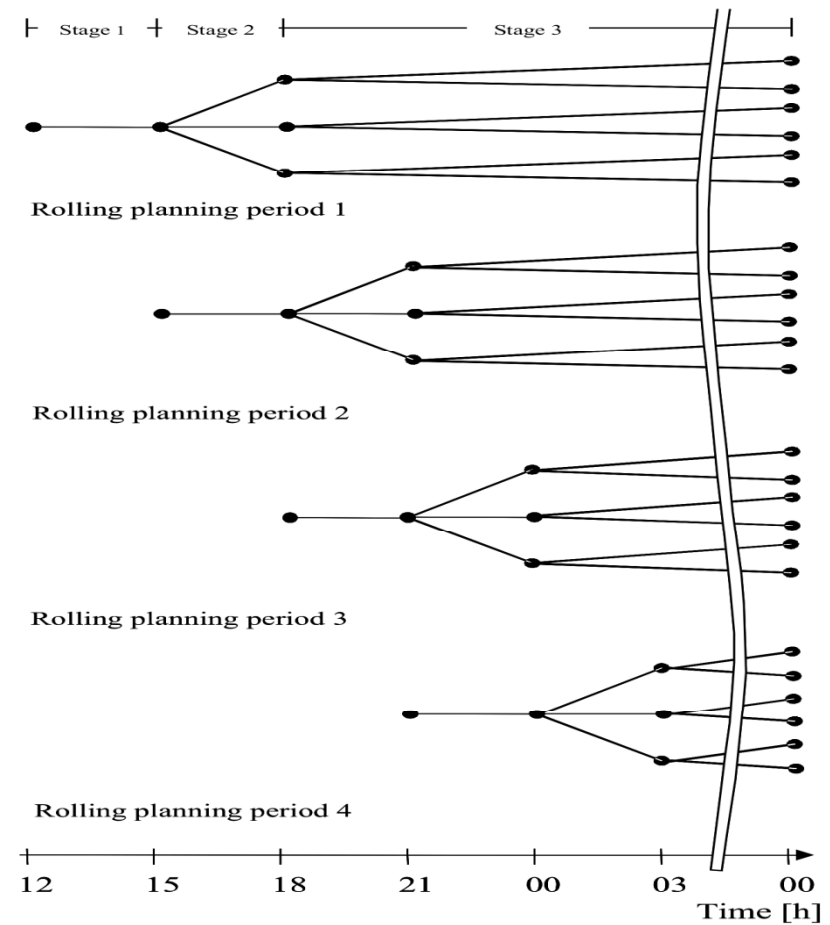
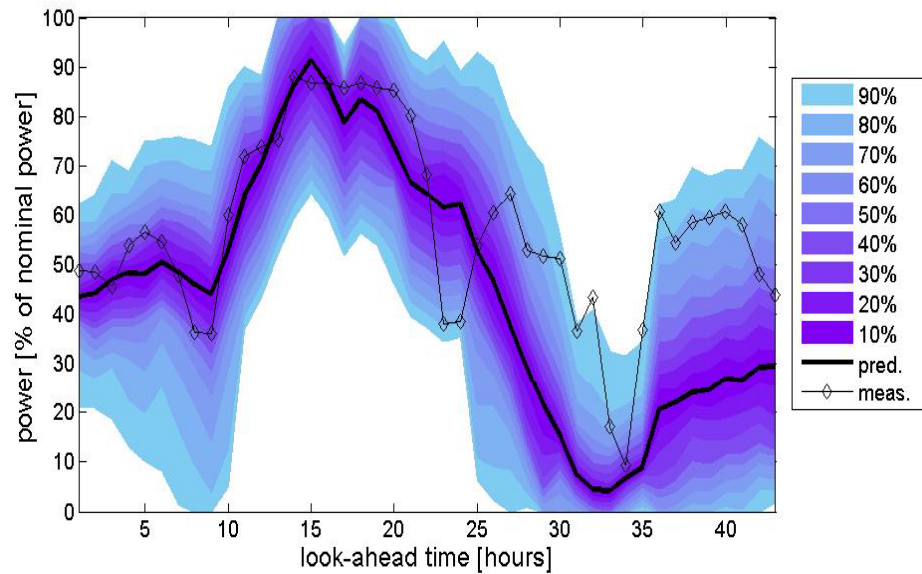
# Production from Peaking Units with Increasing Wind Penetration



# Shortfall in Replacement Reserve Target with Increasing Wind Penetration

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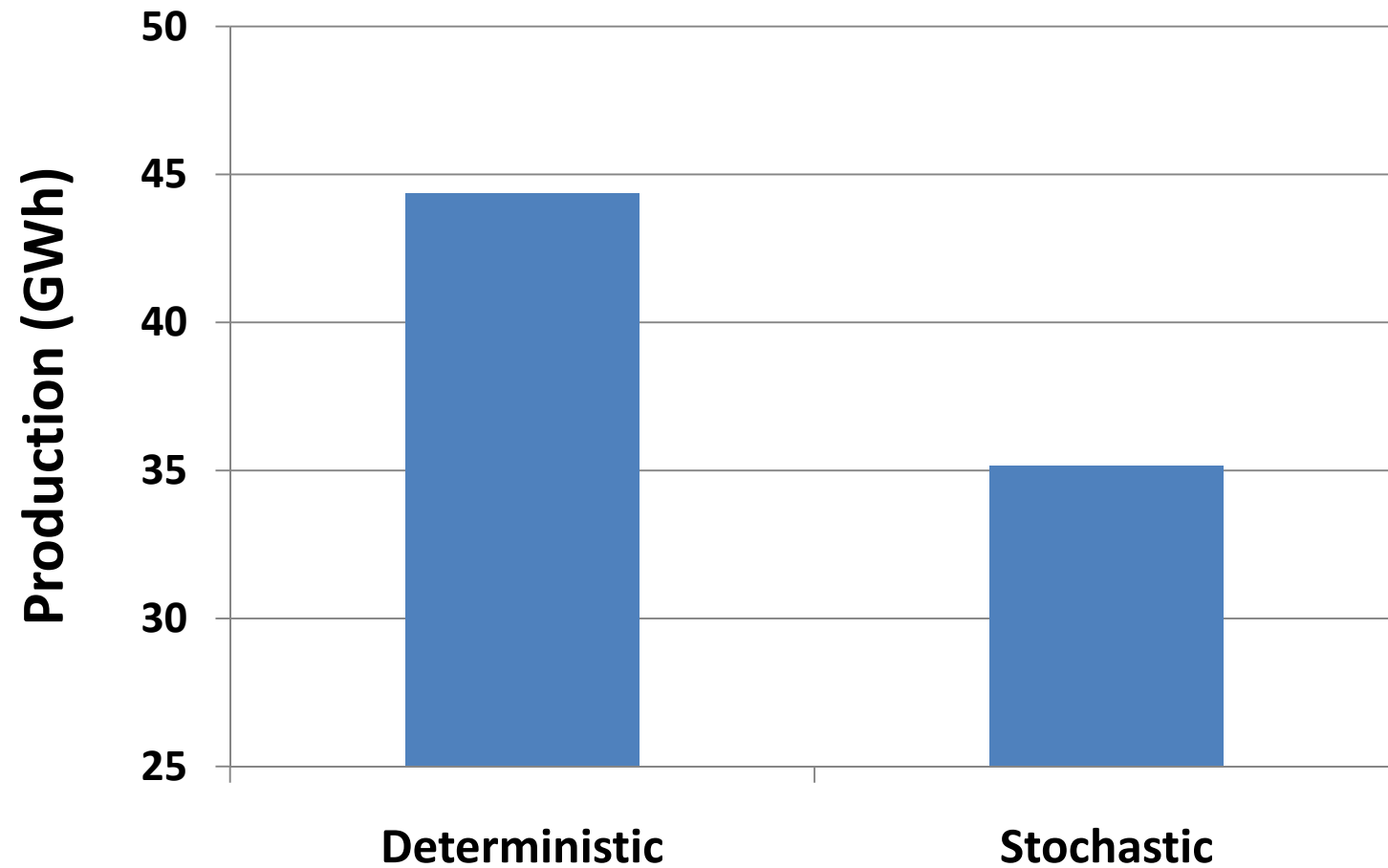
Installed Wind	Multi-mode Not Allowed		Multi-mode Allowed	
	MWh	No. Hours	MWh	No. Hours
2000	1688.7	13	861.4	3
4000	2972.9	17	880.2	5
6000	609.9	13	7.6	1



Meibom, P., Barth, R., Hasche, B., Brand, H., Weber, C. and O'Malley, M.J., "Stochastic optimisation model to study the operational impacts of high wind penetrations in Ireland", *IEEE Transactions on Power Systems*, Vol. 26, pp. 1367 - 1379, 2011.

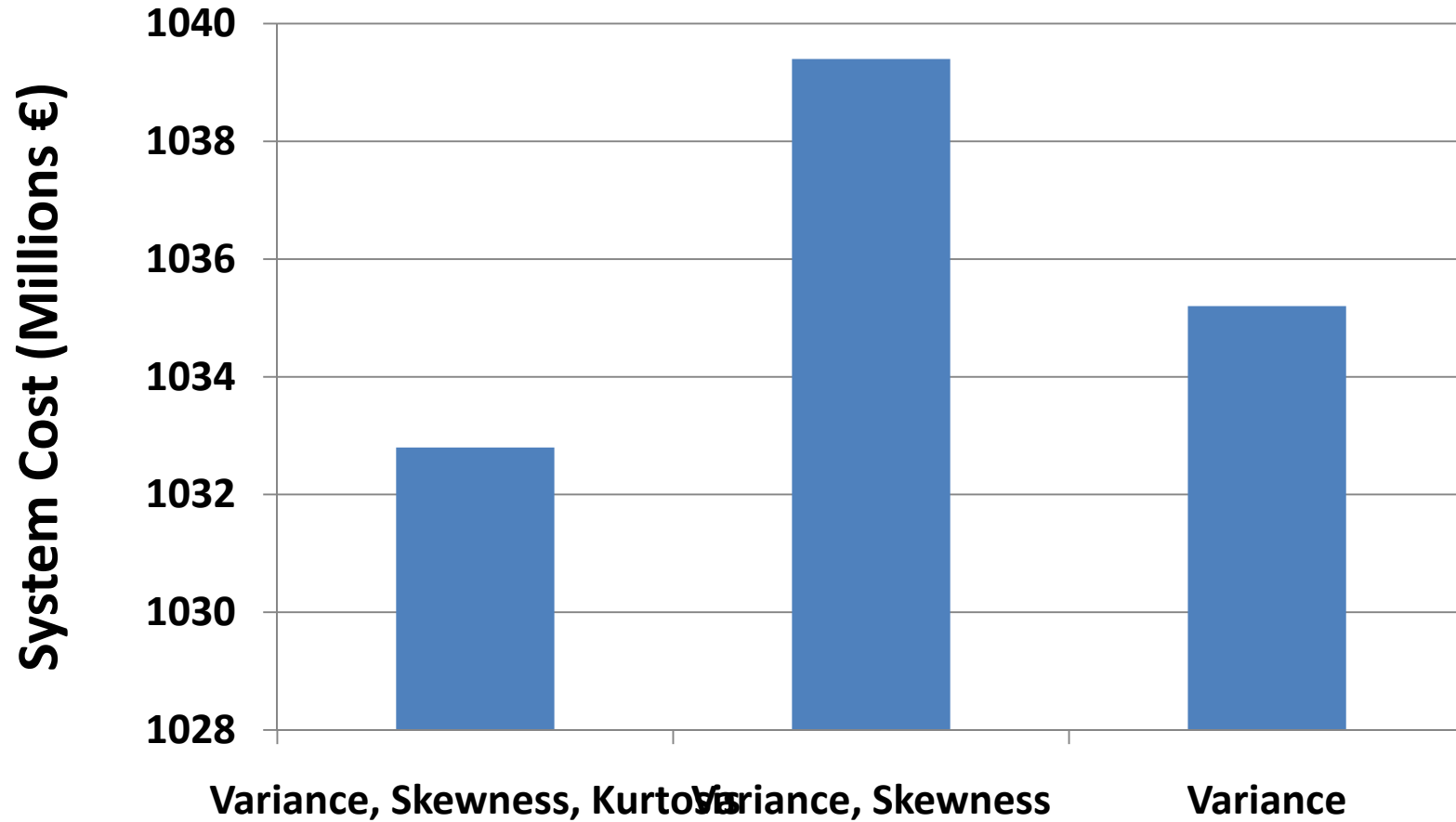
# Annual Production from Peaking Plants

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# Impact of excluding statistical information

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# Thank you!

Questions/Comments: [niamh.troy@ucd.ie](mailto:niamh.troy@ucd.ie)

Electric Vehicles: [peter.richardson@ucd.ie](mailto:peter.richardson@ucd.ie)

Scenario Trees: [colm.lowery@ucdconnect.ie](mailto:colm.lowery@ucdconnect.ie)