# Wind turbine design for hybrid renewable energy systems

iea wind TEM#101

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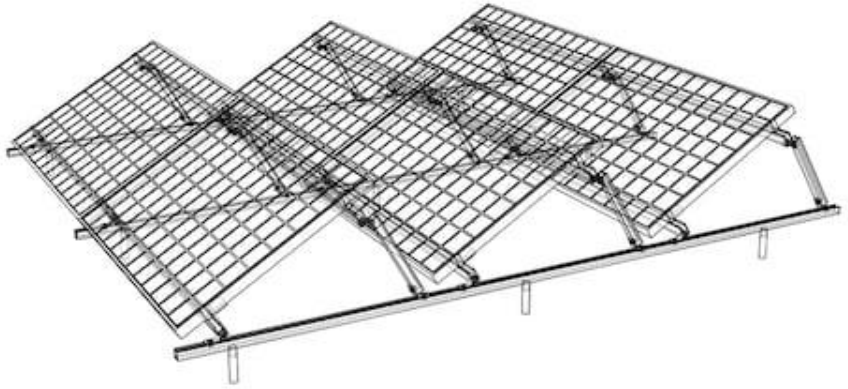

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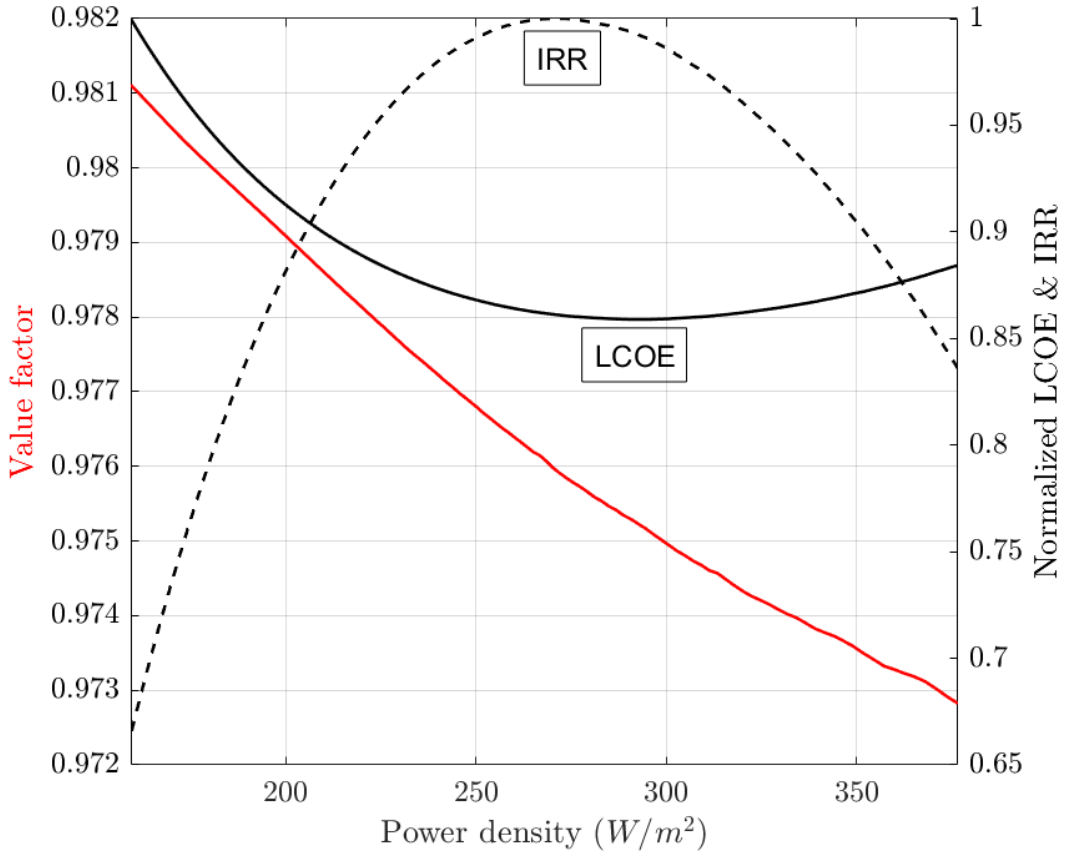
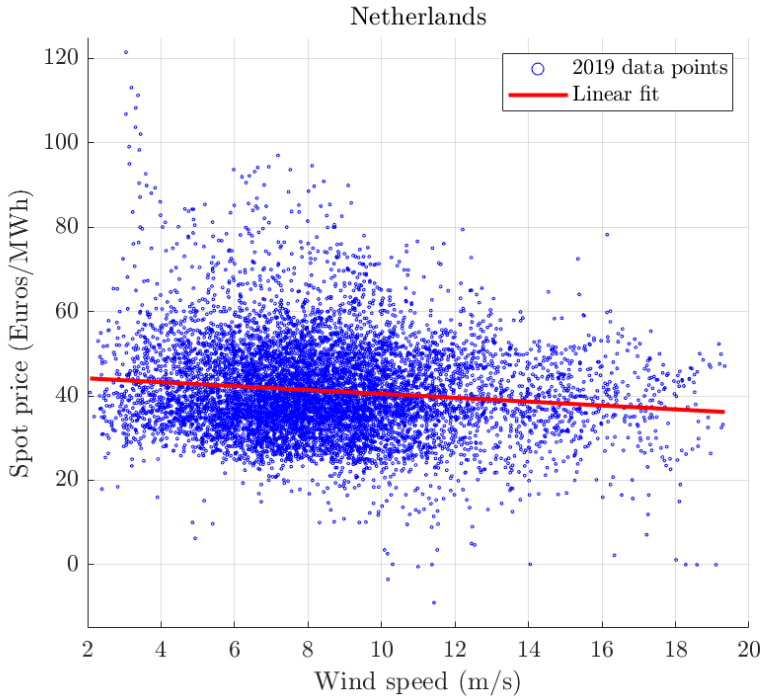
# Optimization beyond LCoE




OPTIMIZER

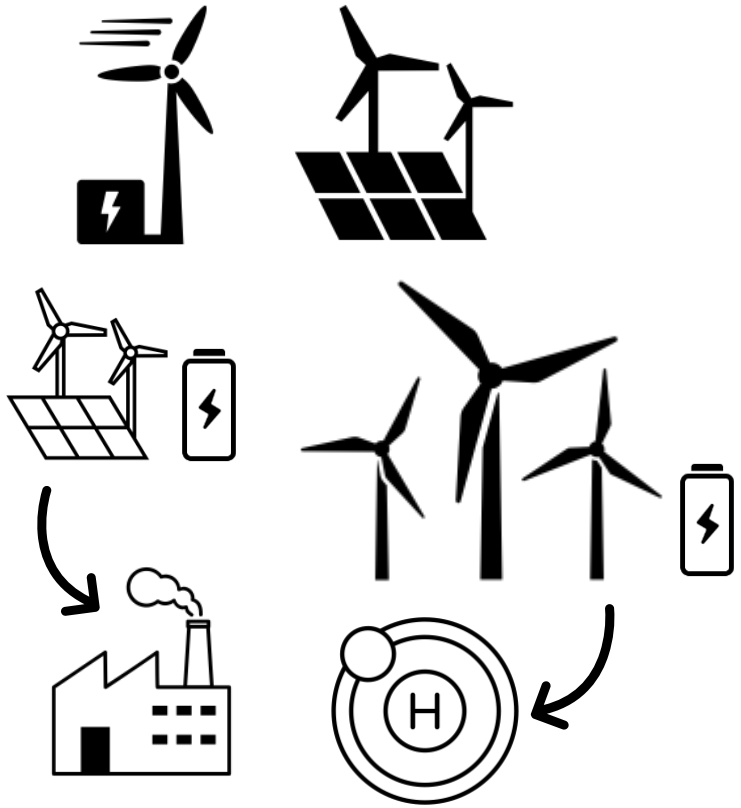
Lower power density turbines




Time varying price of wind

# Wind-based hybrids: Value and properties

**Systems**

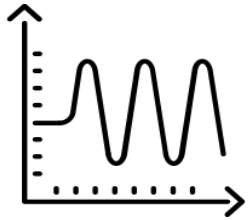



**Value & Properties**

*Value: Internal Rate of Return*

Day-ahead optimization
(Energy arbitrage + balancing)

Ancillary services
(Frequency support)

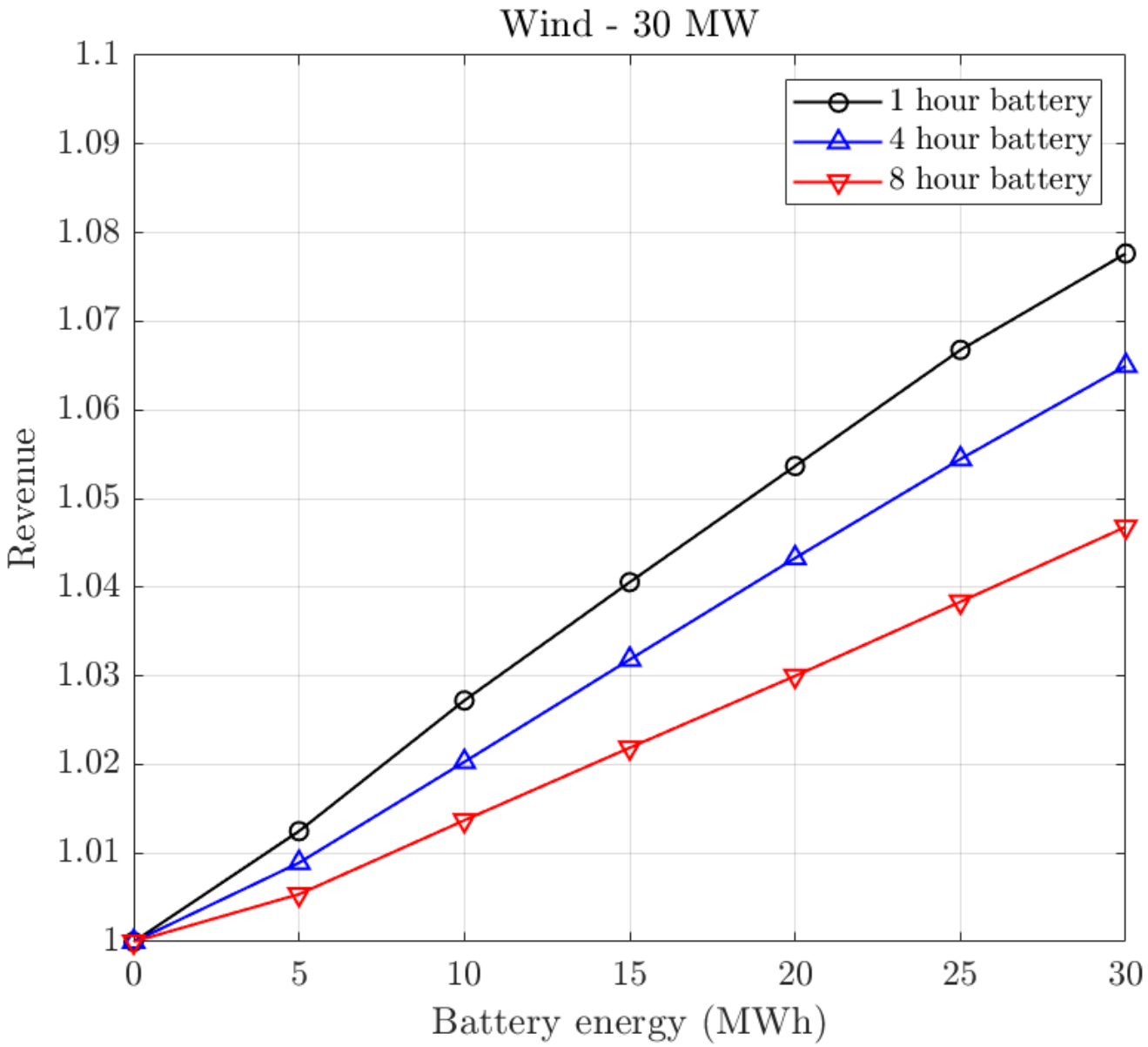


Smoothened power generation

# Example of a pitfall

**Wind + storage**

*Arbitrage + Real-time balancing*



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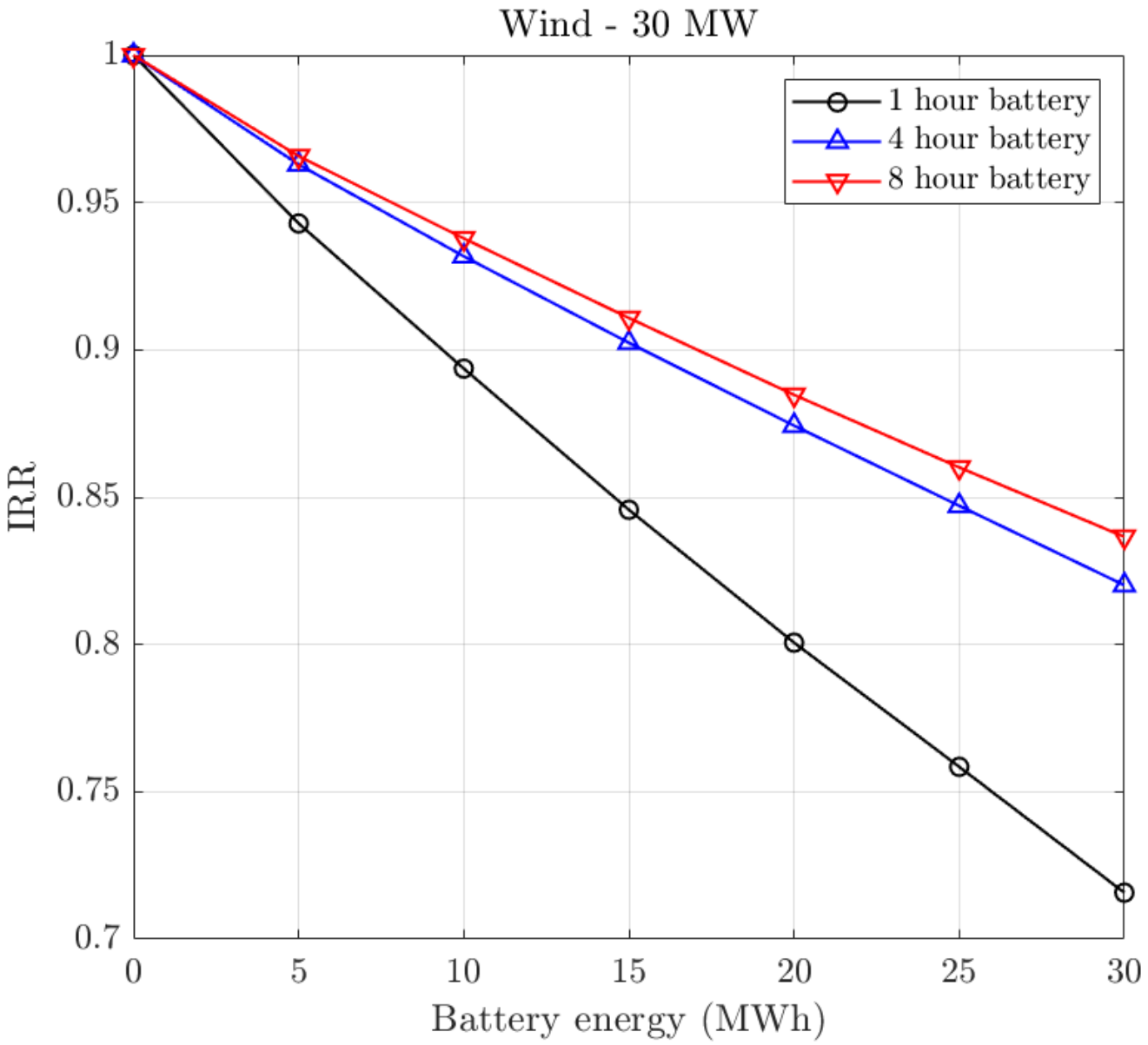
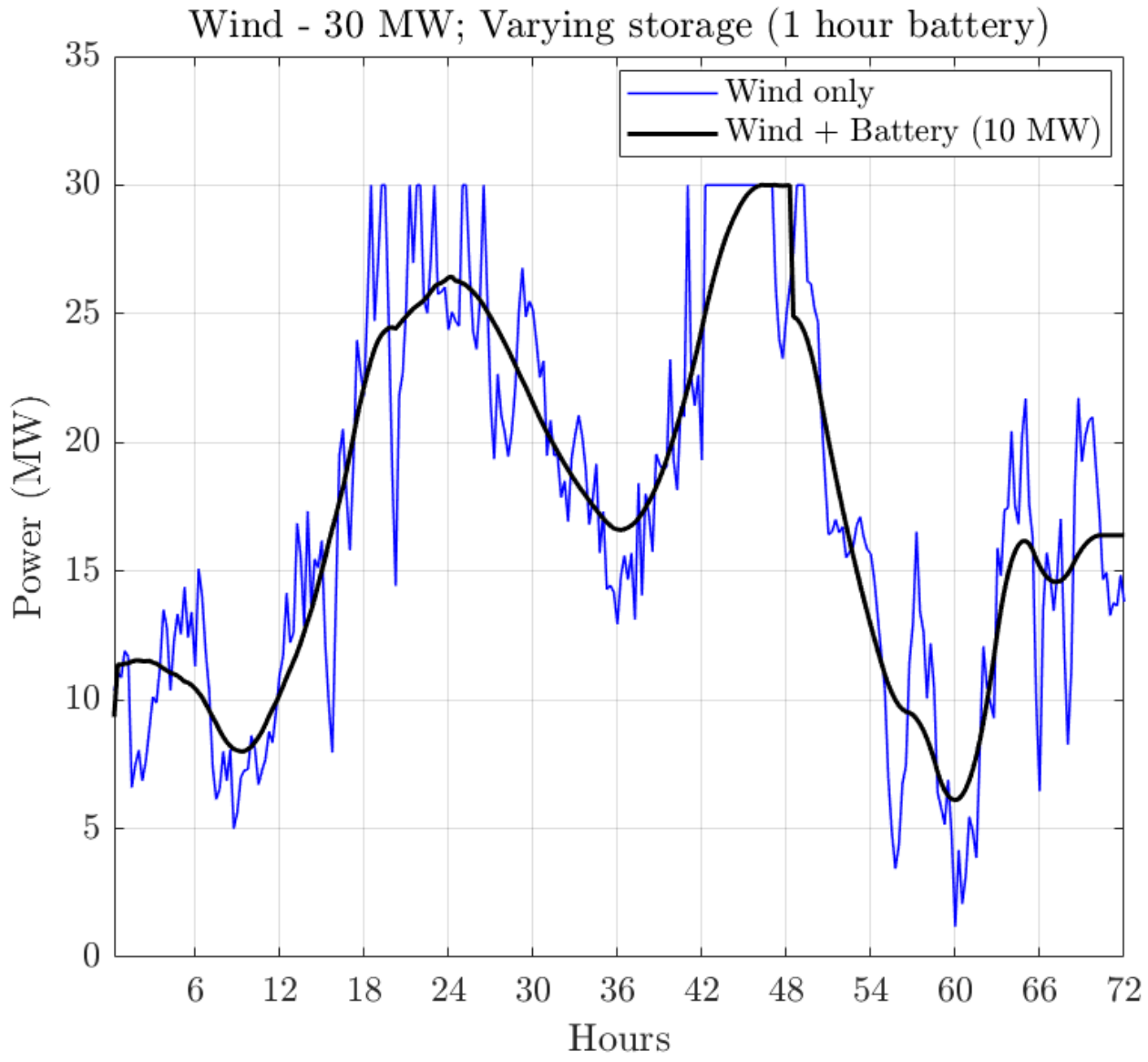


# Improved system behavior

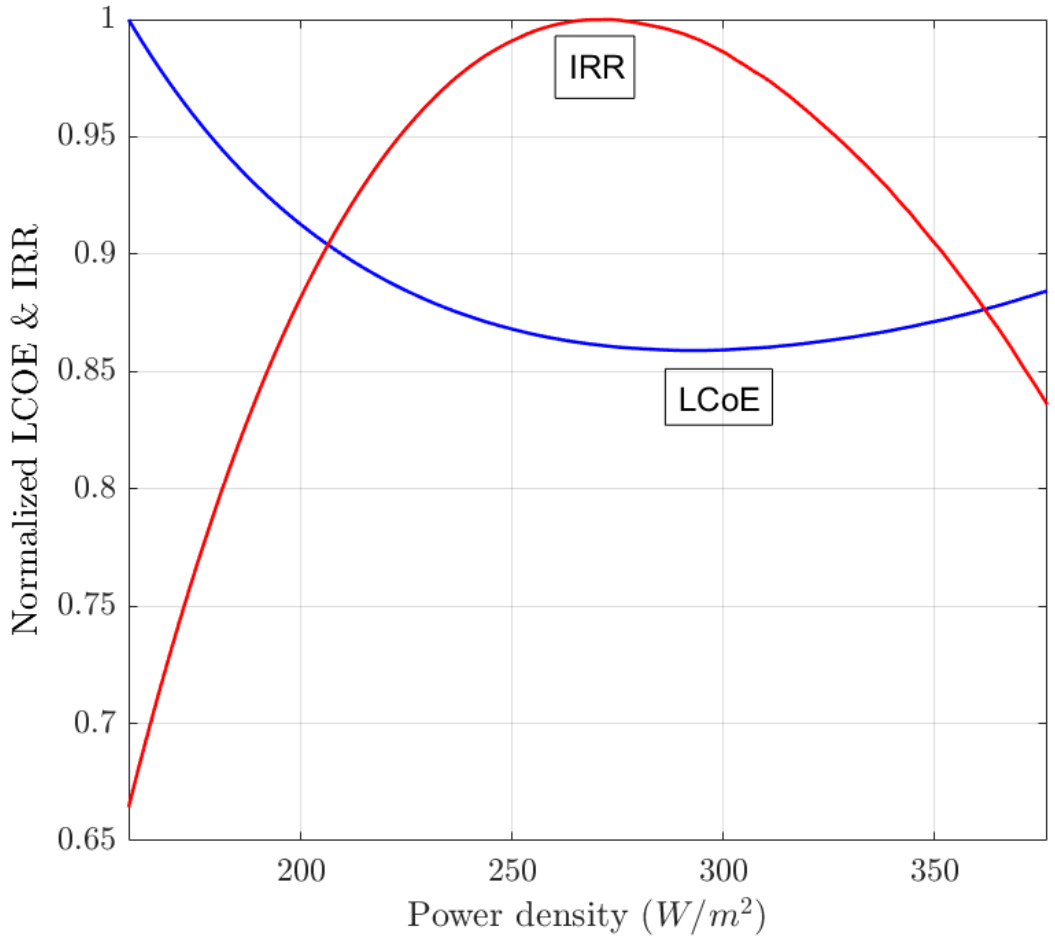
- Some technical advantages of a hybrid system
  (reduced ramp rates, higher c.f.)

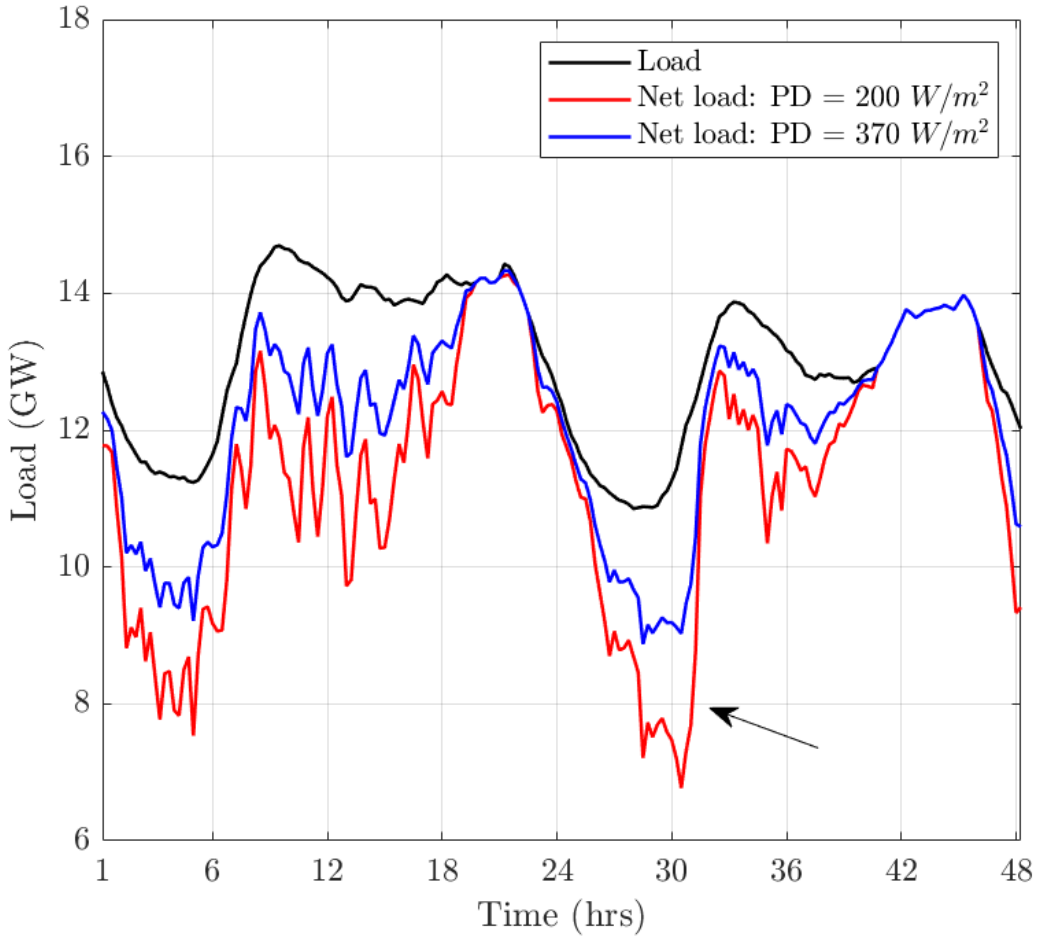
**Wind + storage**

*Ramp rate reduction*

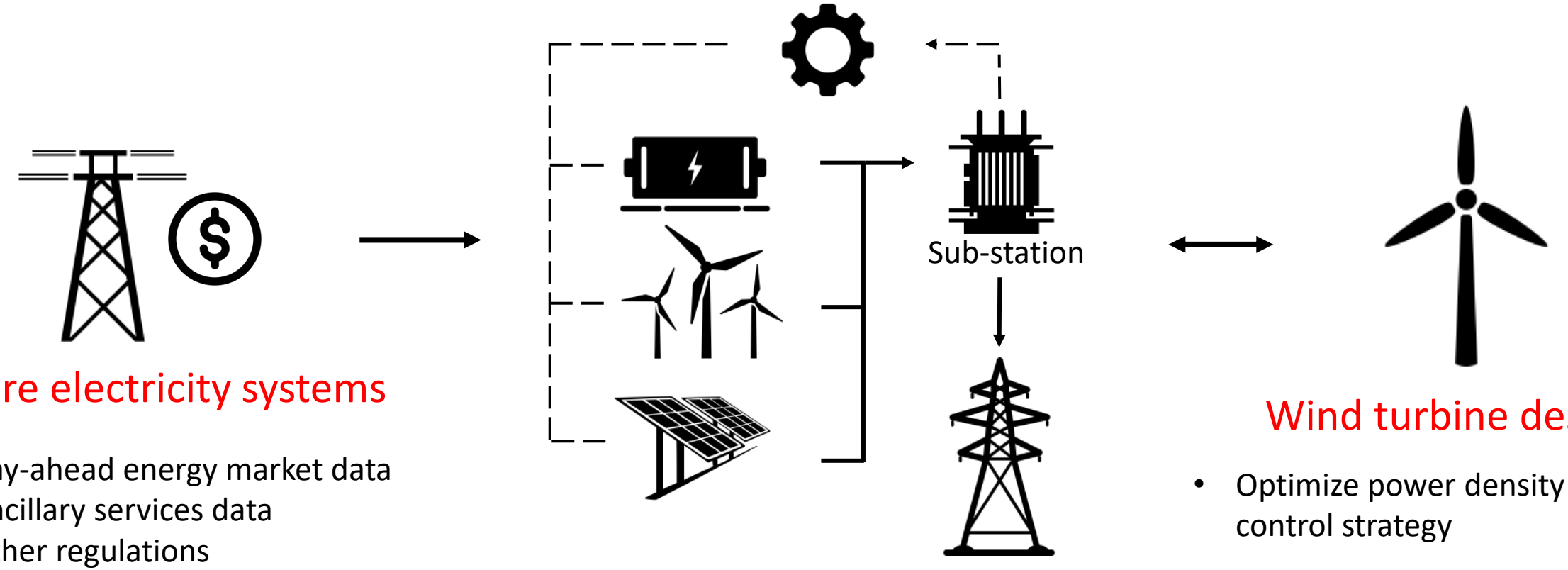


# Impact on wind turbine design



# Needed modelling framework




## Future electricity systems

- Day-ahead energy market data
- Ancillary services data
- Other regulations

## System sizing

- Determine components
- Determine size of storage/solar for the given wind farm

## Wind turbine design

- Optimize power density and control strategy

# Major takeaways

- *Design and optimize hybrid systems for goals other than LCoE (IRR, ramp rates, correlation with demand)*

- *Design wind turbines for target hybrid systems*

- *A new IEA task to facilitate a unified framework to:*
  - *Simulate market conditions*
  - *Size hybrid systems*
  - *Design of wind turbines*