Operational Strategies for a Portfolio of Wind Farms in a Two-Price Balancing Market

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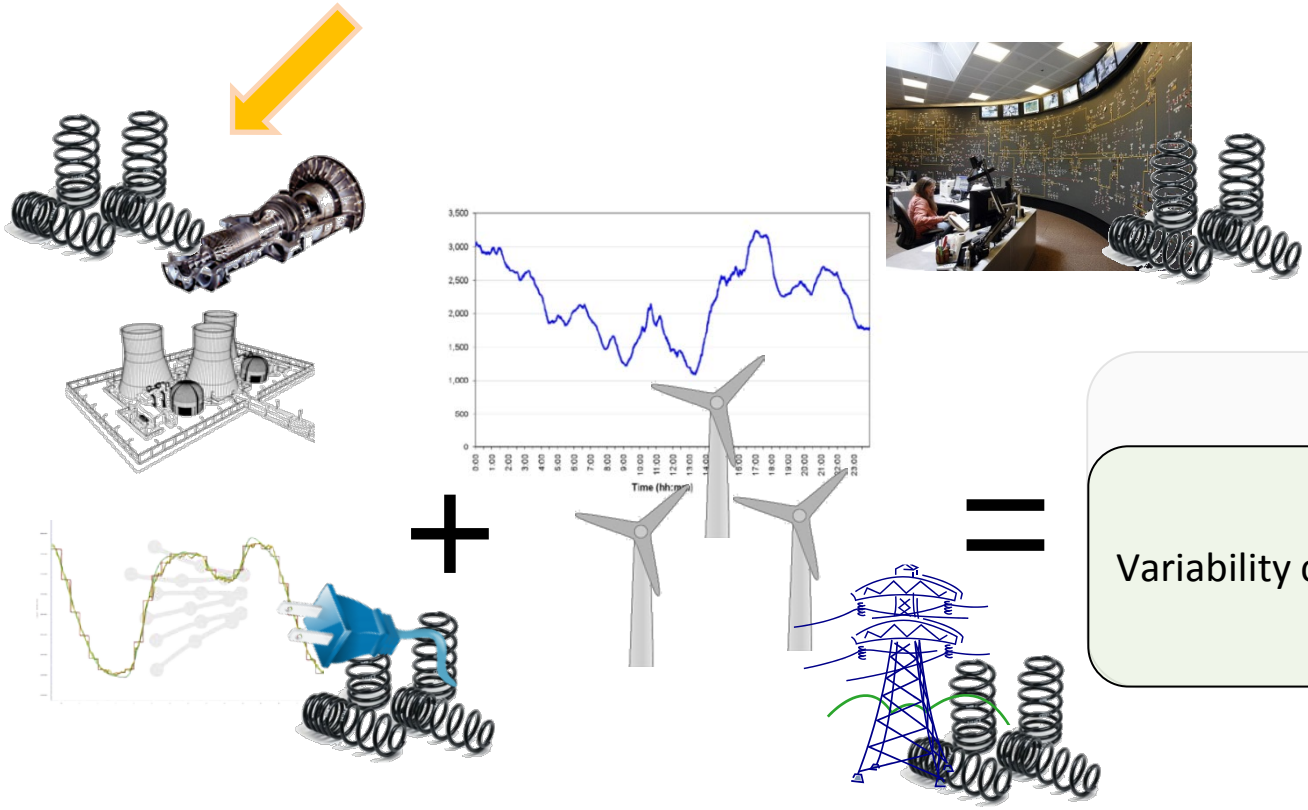
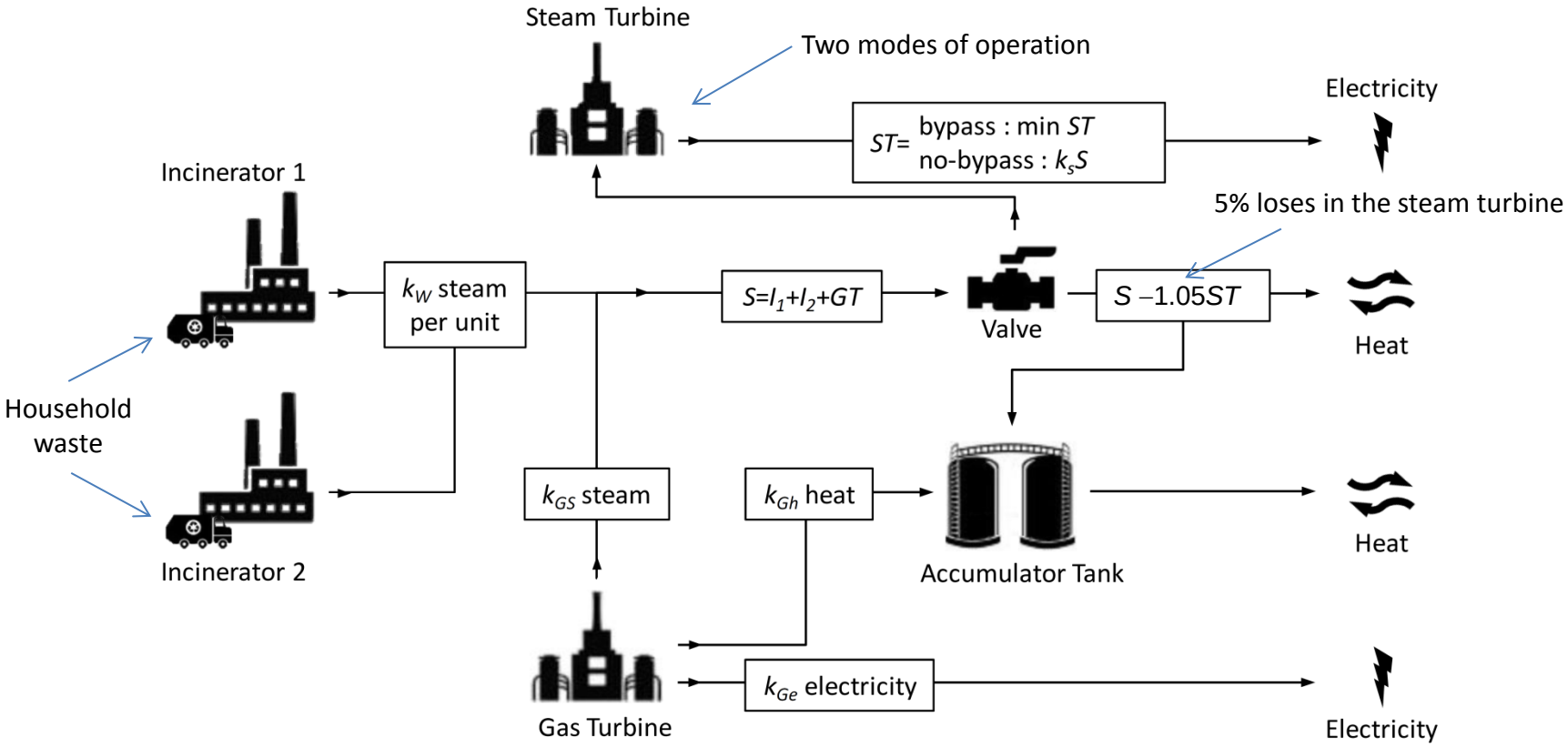
Motivation


Variability cost
Uncertainty cost


Flexible production
Uncertain production
Firm production

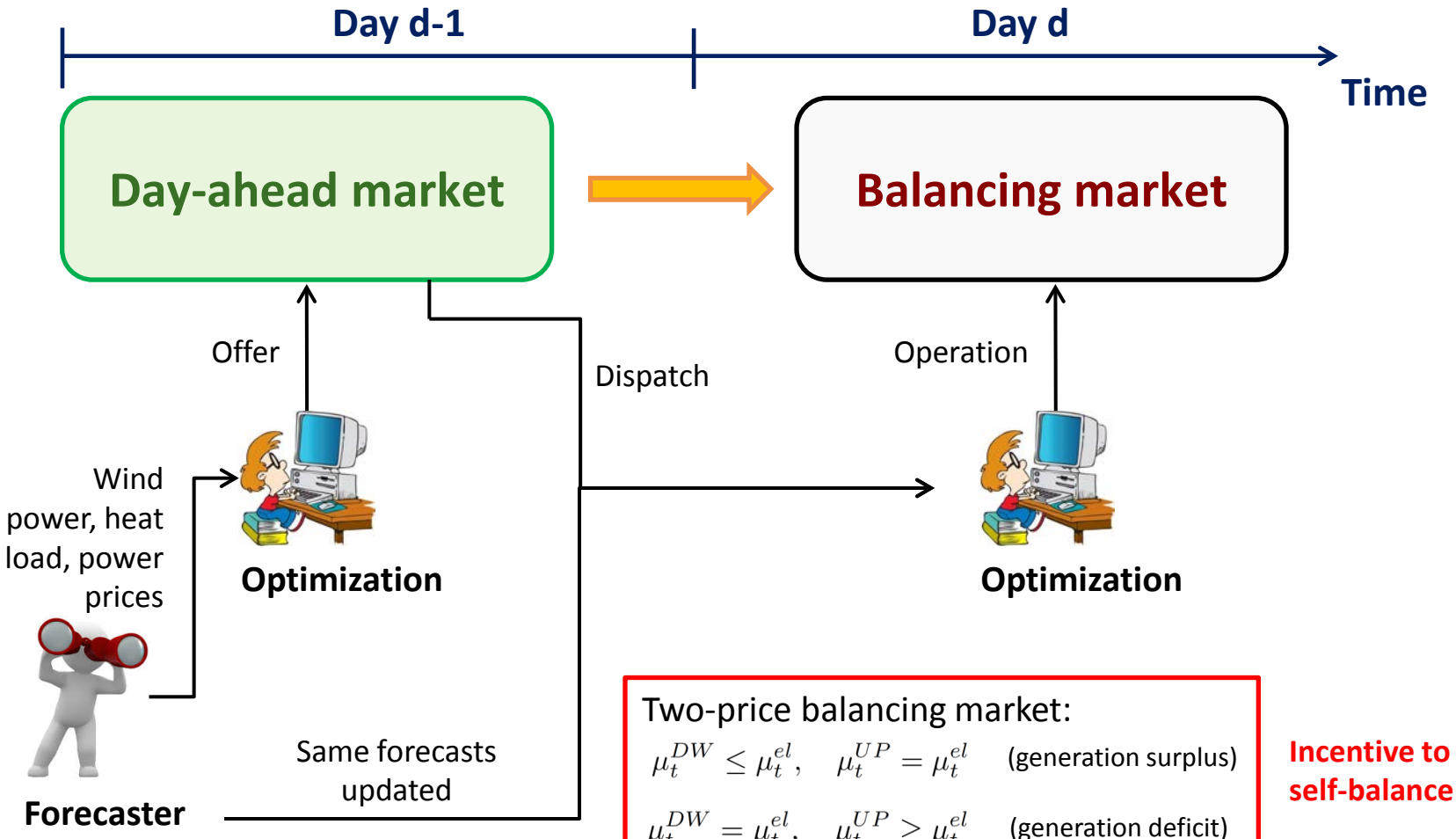
Combined Heat-and-Power System



Mixed-integer programming problem (capacity limits, modes of operation, start-up/shut-down costs …)

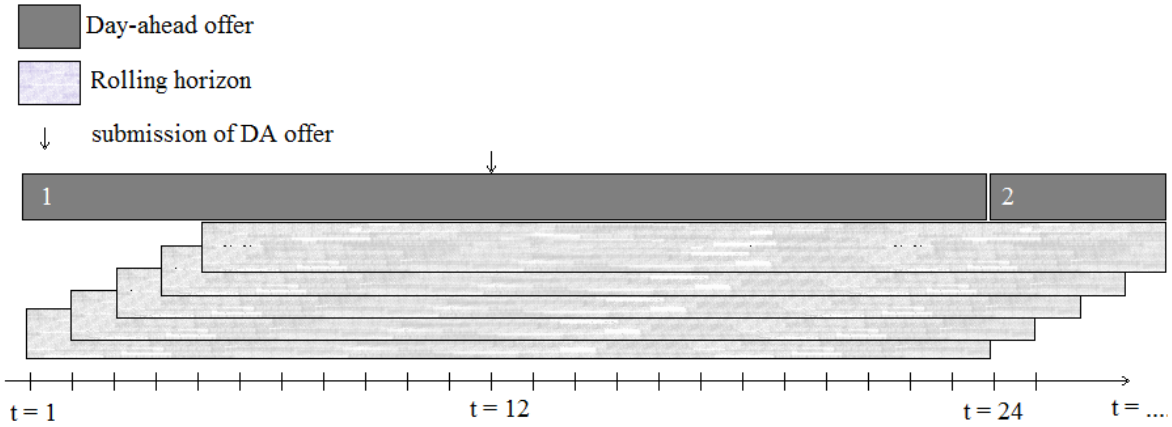
(Real CHP system owned by DONG Energy)

Market & Decision-Making Frameworks



Simulation Framework

- **Day-ahead planning**. The 24 hourly day-ahead market offers are decided at once:
  - Wind farms: Expected wind power production at the minimum allowed offer-price.
  - CHP system: Single-quantity bid at the minimum allowed offer-price. The quantity is computed as the solution to one deterministic optimization problem that maximizes profit and spans 36 hours into the future.
- **Operation.** Hourly deterministic optimization problems spanning 24 hours into the future (**rolling horizon**, only first-hour decision is implemented)

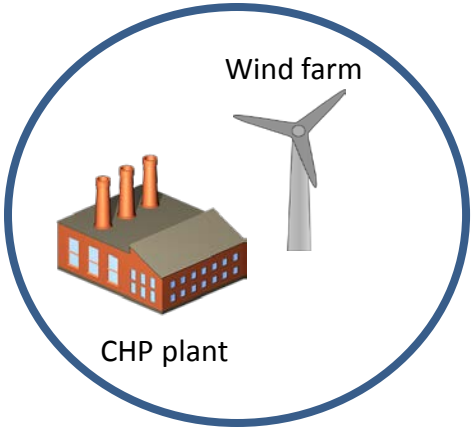


Real-life case study:

1. 20-MW wind farm
2. Start-of-the-art forecasting tools for heat demand, wind production and power prices (day-ahead and balancing)
3. Forecasts are updated hourly
4. Out-of-sample evaluation using historical data ranging from February 1st, 2012 to December 1st, 2012 (10 months)

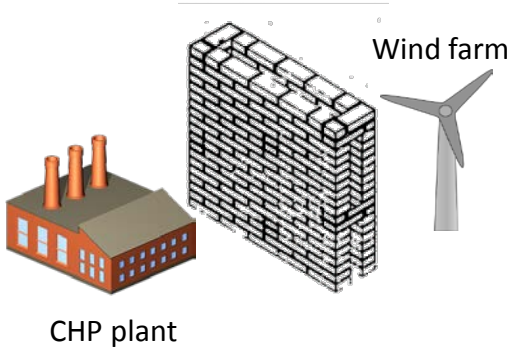
Setup that mimics the actual operation of the system!

Operational Strategies



Portfolio operation

(At operation time, the portfolio must comply with the day-ahead offer from CHP + wind, or participate in the balancing market to cover their imbalance)



Independent operation

(The CHP system and the wind farm act as independent participants in the balancing market)

Three different criteria:

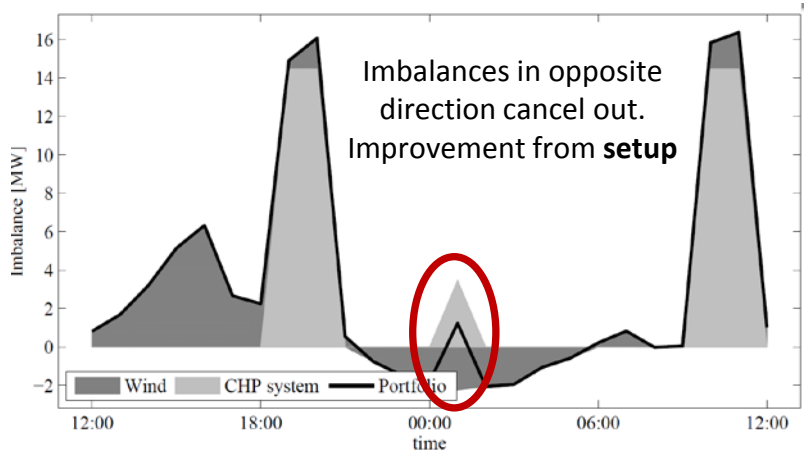
I. **Profit maximization**: the balancing market is regarded as a potential source of additional revenue. Risky?

II. **Imbalance limitation**: The net imbalance of the portfolio must be lower than the wind power deviation. Lower profit volatility?

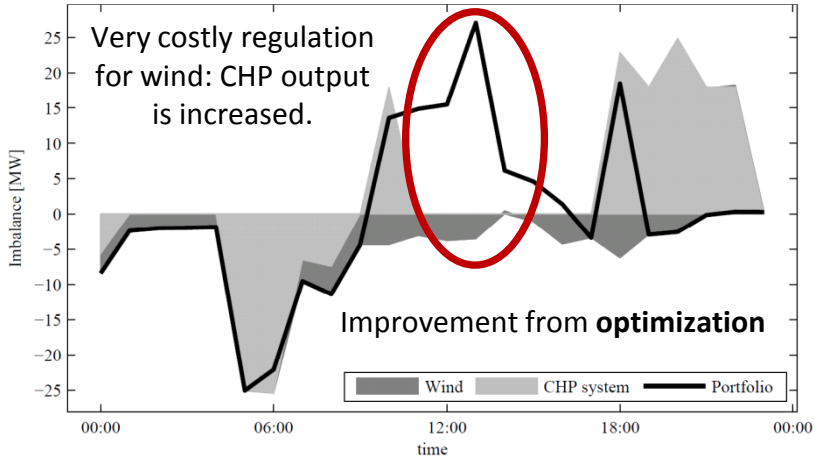
III. **Imbalance minimization**: The net imbalance of the CHP-Wind system is minimized. Used as a benchmark of potential system flexibility.

Results

February 6-7, 2012



October 6, 2012



Operation mode	Criterion	Profit (M€)	Imbalance (GWh)
Independent	Profit maximization	12.67	62.04
	Imbalance minimization	-37.97	18.61
	Imbalance limitation	10.48	25.98
Portfolio	Profit maximization	12.74	51.91
	Imbalance minimization	-33.36	8.56
	Imbalance limitation	10.50	15.25

Portfolio effect: Profit increases, while net imbalances diminish!

Conclusions

- General models for determining day-ahead offers and **operating a CHP-Wind system**
- Models have been tested on a **case study using real-world data**
- Two operational strategies have been compared: **portfolio vs. independent operation**
- Operating the CHP-Wind system as a **portfolio increases the profit and decreases the total net imbalance**
- The portfolio effect is mostly due to situations where the imbalance of the CHP system and the imbalance of the wind farm are opposite in sign
- Operating as a portfolio is relevant in **two-price balancing markets**
- **Future work**: consideration of intraday trading, techniques of optimization under uncertainty to make day-ahead decisions, etc.