How Good are The Traditional Optimal Energy Scheduling Approaches?

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PowerWeb

February 2016

Outline

Short-term Energy Scheduling

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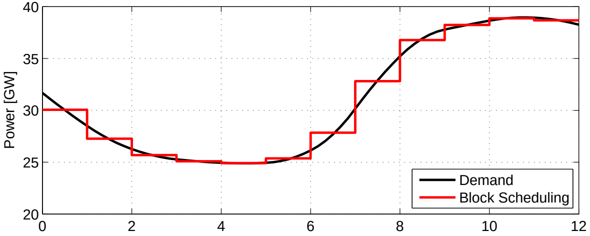
Underlying assumption:

UC generation schedule can always deliver what it promises

Outline

Energy-Based Scheduling: what is scheduled

Energy blocks satisfying hourly demand:



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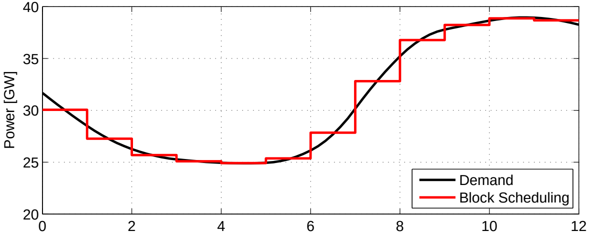

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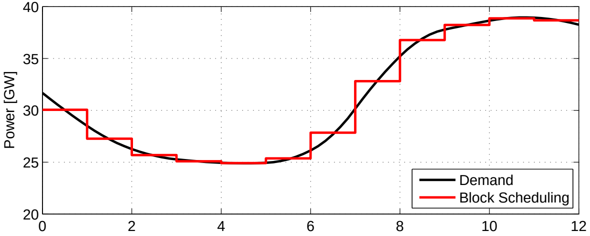

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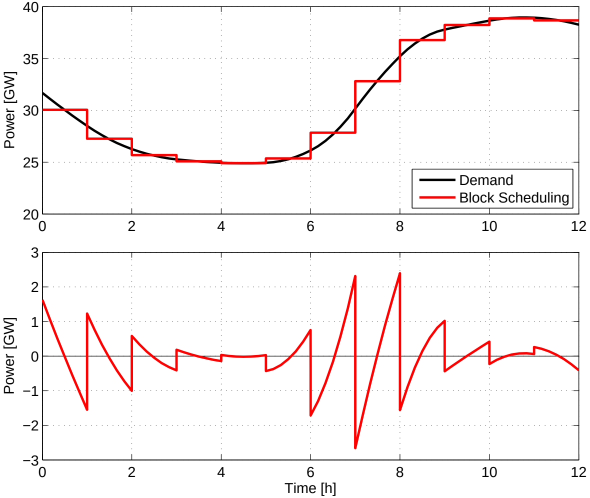
$\Downarrow$

reserves provide the difference

Energy-Based Scheduling: Deployment

Reserve deployment and impact on frequency



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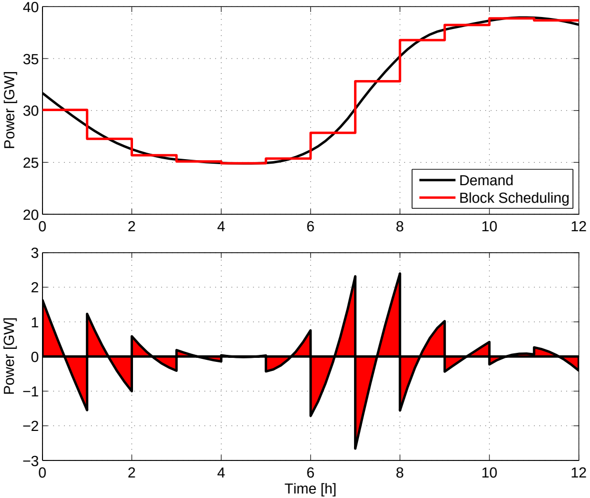
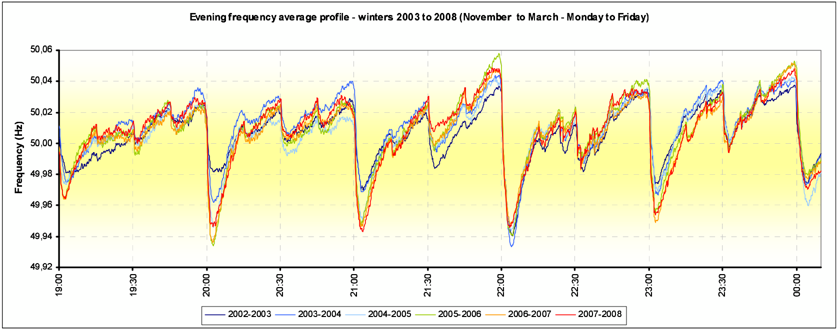


Energy-Based Scheduling: Impact on Frequency

Frequency deviations in the European grid: years 2003-2008[1]



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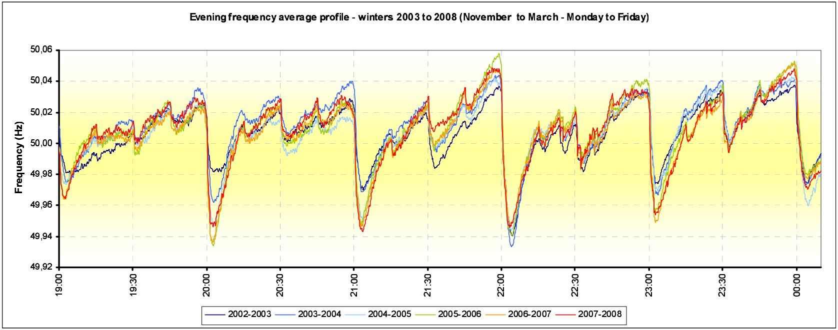

- Frequency deviations equivalent to 2GW generation outages.
- Many times everyday and increasing[2]
  - excessive use of **primary** & **secondary** reserves ⇒ ↑$ & ↓flex.

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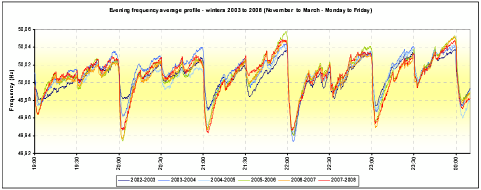

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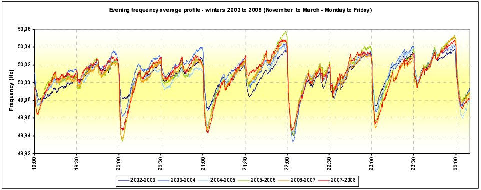

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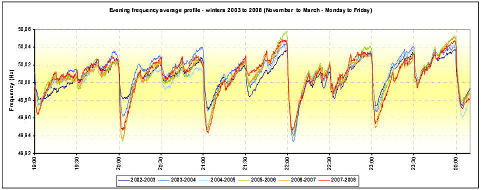


  - Microgrids & smart grids could face worse consequences (↓ inertia)
  - Even DC systems might face similar problems (in voltage)

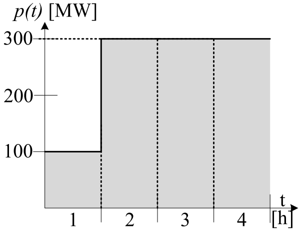
Outline

Energy Scheduling

Generation levels are usually considered as energy blocks.

Example: $\overline{P} = 300$MW; $\underline{P} = 100$MW; Up/Down ramp rate: 200 MW/h

Traditional UC



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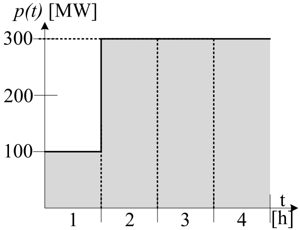
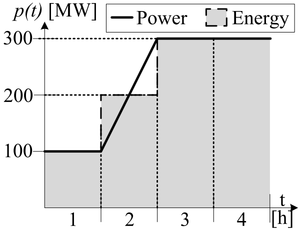


Feasible energy profile



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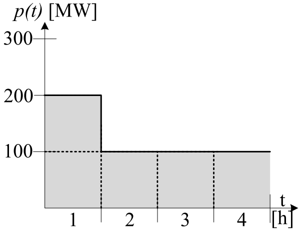

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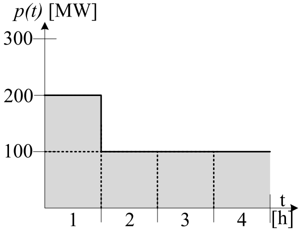

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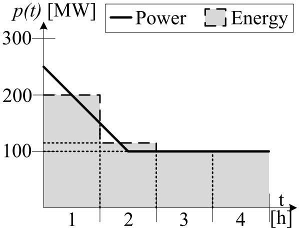

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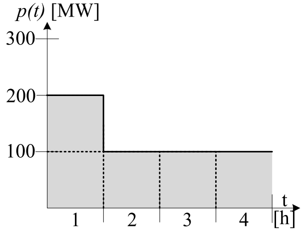

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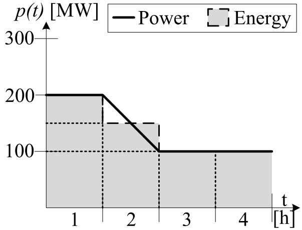

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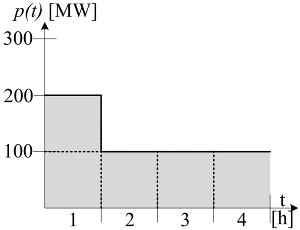

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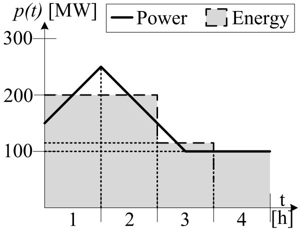

Infeasible energy delivery[3]

Overestimated ramp availability

$\Downarrow$

A clear difference between power and energy is required

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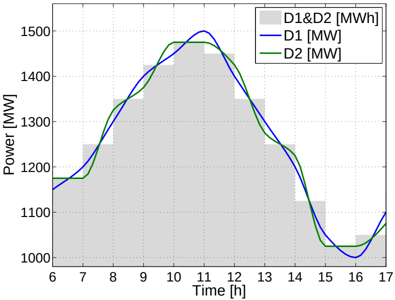
Energy vs. Power Profiles

Demand Example



Demand requirements

	Hour	D1	D2
Ramp [MW/h]	9-10	50	100
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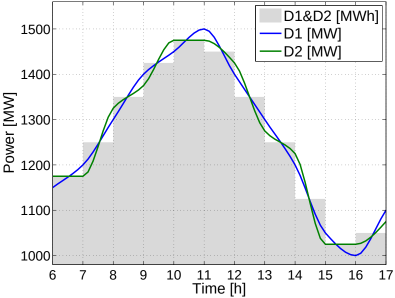

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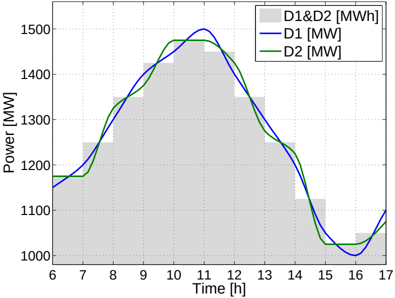

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UC was reformulated for better scheduling (↓ costs)[5,6]

- Key features:
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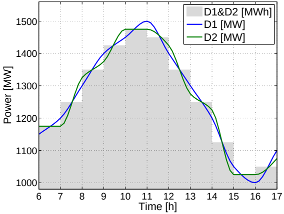

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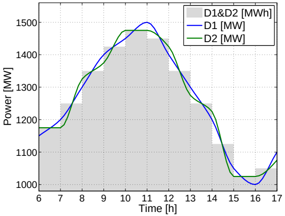

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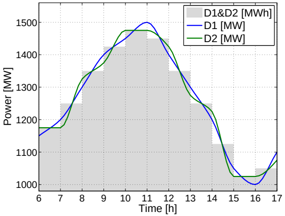

- Challenge:
  - **Trade-off**: Model detail vs. Computational burden[6,7]

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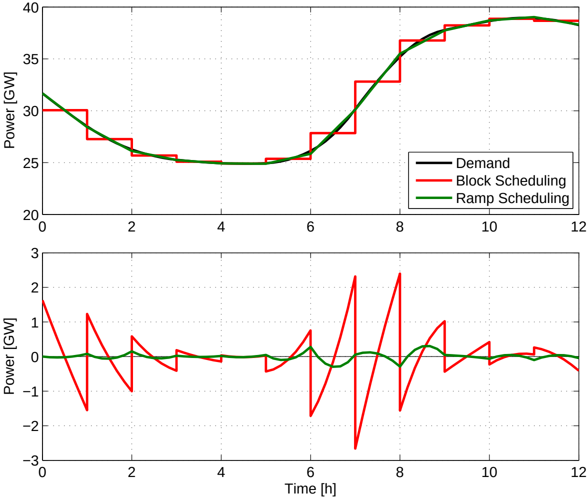
[7] G. Morales-Espana, J. M. Latorre, and A. Ramos, "Tight and compact MILP formulation of start-up and shut-down ramping in unit commitment," *IEEE Transactions on Power Systems*, vol. 28, no. 2, pp. 1288–1296, 2013

Energy- vs. Power-Based Scheduling

Energy-Based (block, stepwise) vs. Power-Based (ramp, piecewise)



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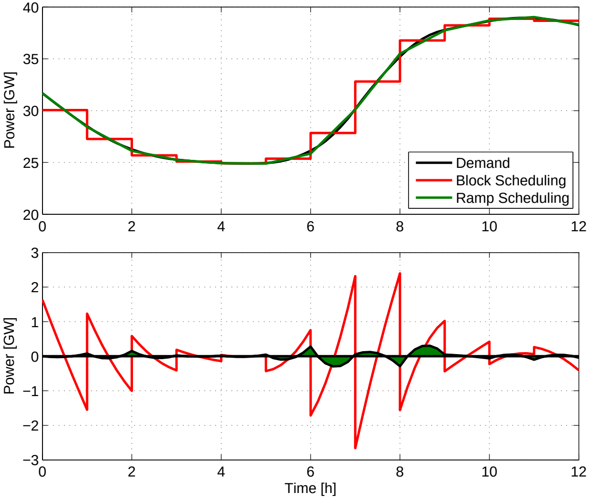

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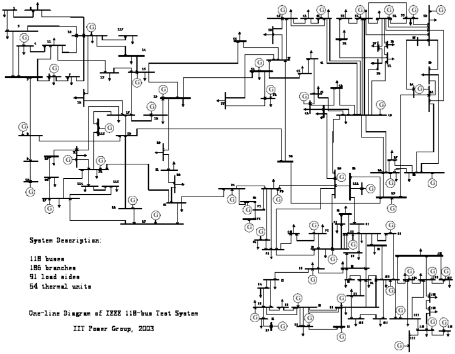
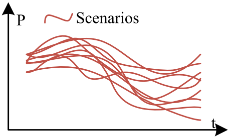
IEEE-118 Bus System



- 54 thermal units; 118 buses; 186 transmission lines; 91 loads
  - + 10 Quick-start units (∼10x more expensive)
  - 24 hours time span
  - 3 wind farms, 20 wind power scenarios

Case Study

- 2 Stochastic UC formulations:
  - **E-UC**: Traditional Energy-based UC
  - **P-UC**: Power-based UC



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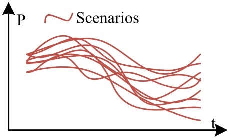

- All problems solved with Cplex 12.6.0, stop criteria:
  - 0.05% opt. tolerance or 24h time limit

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    - Network violation costs: 5000 $/MWh
    - Negative wind bids: -50 $/MWh

Energy-Based vs. Power-based UC: Evaluation

	Scheduling (hourly)		Real-time dispatch (5-min)	
	Costs† [k$]	Curt [%]	Costs† [k$]	Curt [%]
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- P-UCs turned out to be more flexible (↓ Curt) than E-UC

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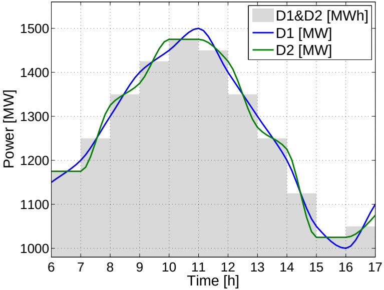
  - More accurate system representation
  - ⇒ better exploitation of unit's flexibility in real-time
- Efficiency of scheduling approaches must be measured based on ex-post performance, and not ex-ante as usually done
  - by using electrical system models measuring the use of primary, secondary & tertiary reserves

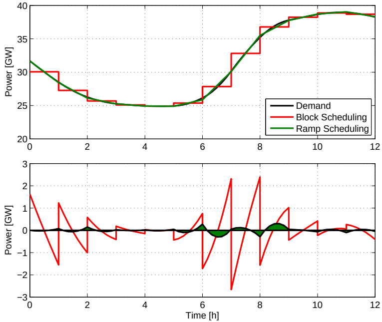
Research Challenge: URSES project

- Create markets based on power trajectories:
  - Providing the right price signals for the system's energy & ramp requirements



Research Challenge: URSES project

- Create markets based on power trajectories:
  - Providing the right price signals for the system's energy & ramp requirements
  - Better following the actual demand
    - Avoiding unnecessary and costly use of reserves
    - Avoiding possibility of gaming: energy vs. reserve markets



Questions

Thank you for your attention

For questions and **possible future collaboration**:
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For Further Reading

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