Time-Adaptive Unit Commitment

POWER TECH 2021

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June 28, 2021

Unit commitment problem

- For given:
  - Set of generating units $g = 1, \ldots, N_G$
  - Set of time periods $t = 1, \ldots, N_T$
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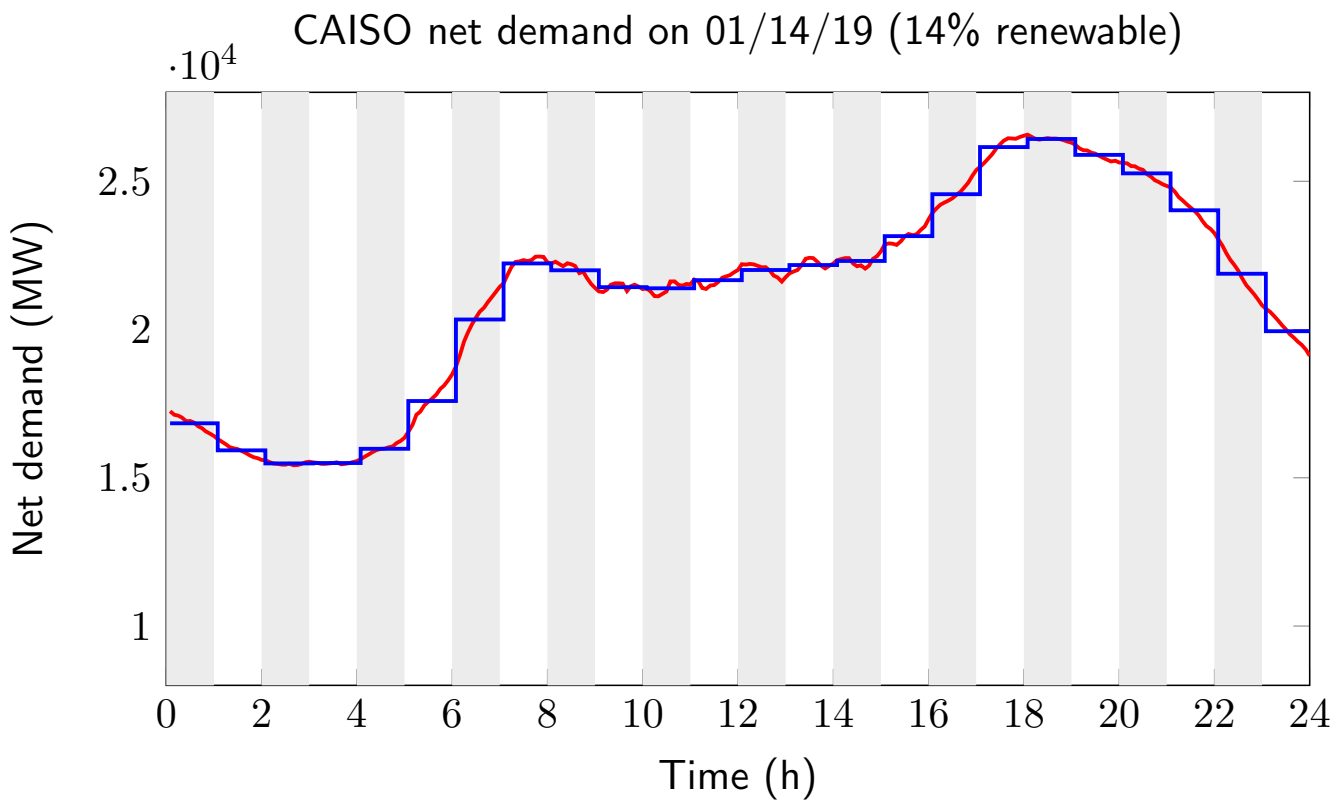
- UC problem is computationally expensive
- Increasing N_G or N_T may turn UC intractable

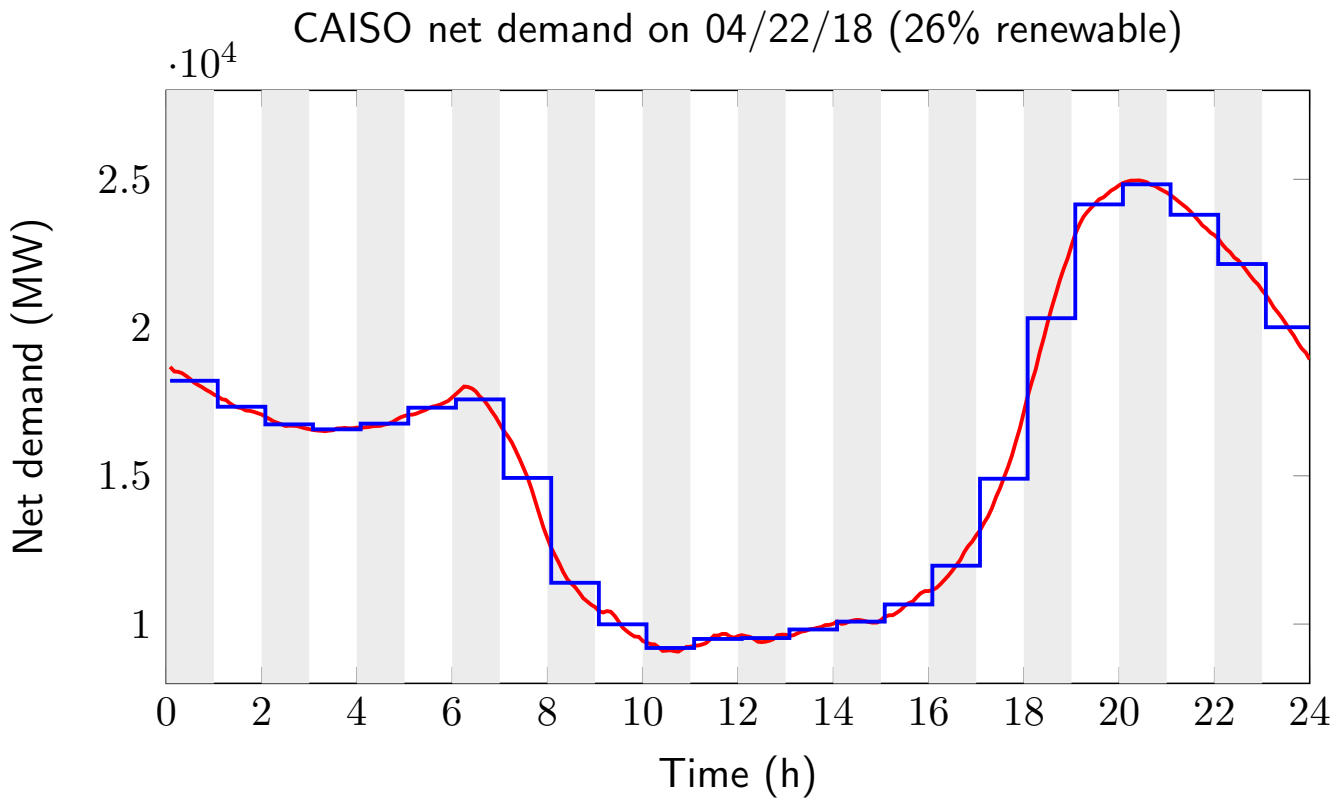
Motivation

- Traditionally: 24 hourly time periods
- Conventional hourly unit-commitment (CH-UC)



Motivation

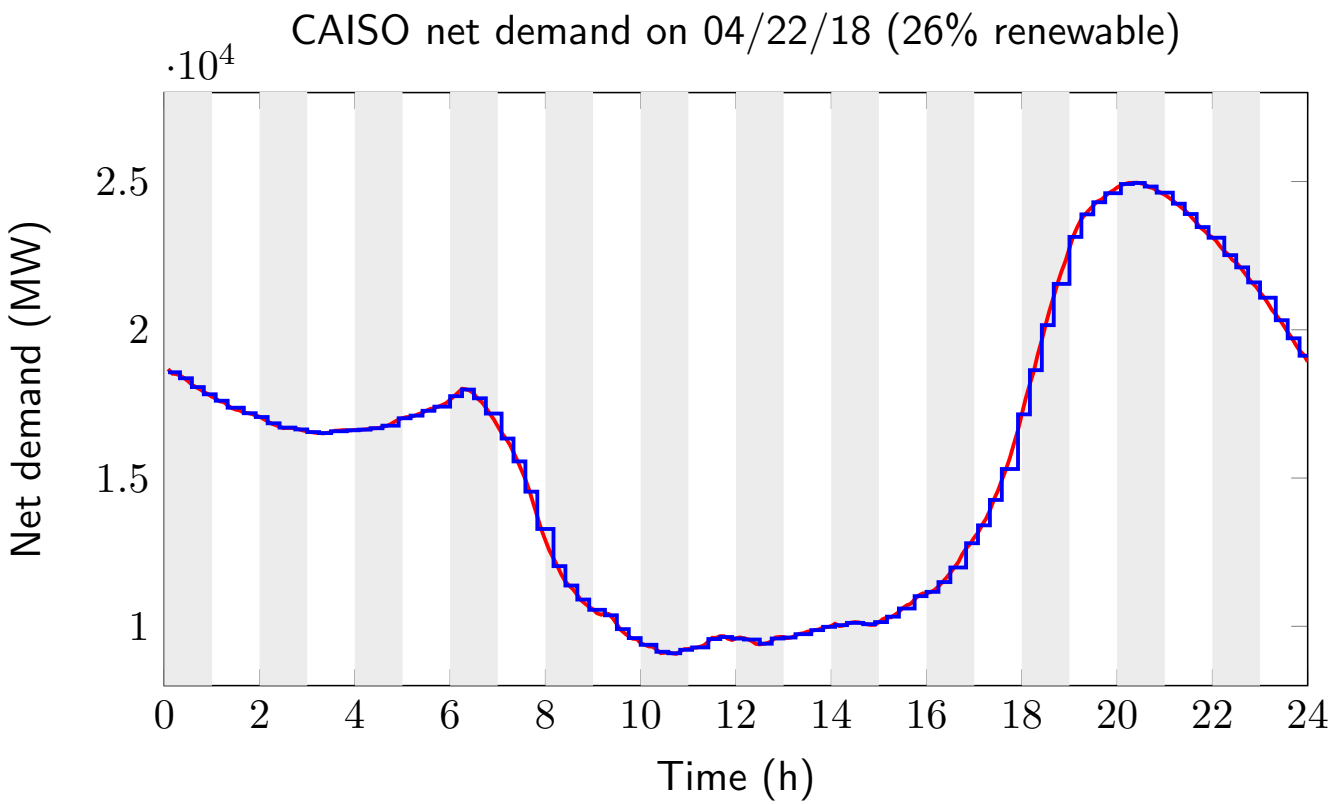
- What happens if renewable penetration increases?



- **FERC Order 764**: "hourly transmission scheduling protocols (...) are insufficient to provide system operators with the flexibility to manage their system effectively and efficiently"

Motivation

- What about increasing time resolution to 15 minutes?



Motivation

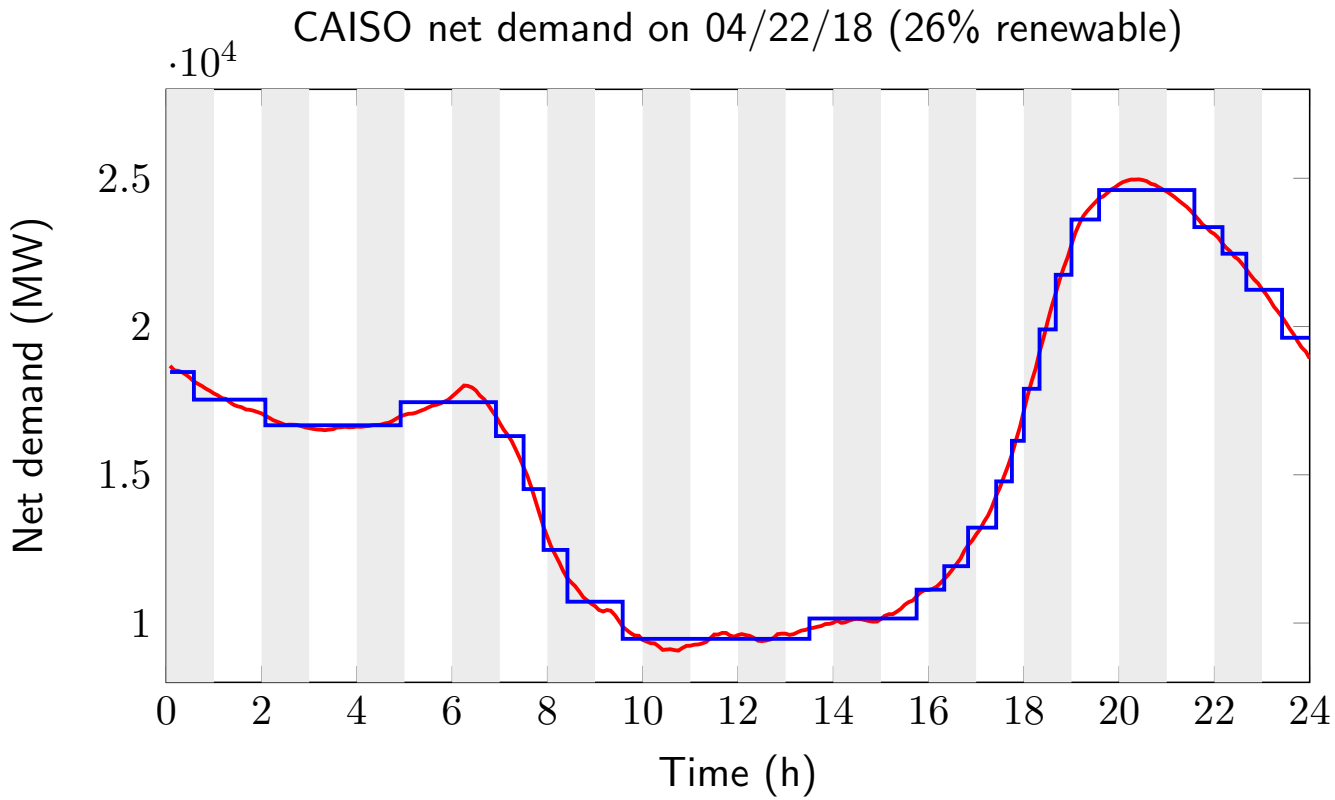
- Existing approaches with finer time resolutions
  - Pandžić et al. 2014 (15 min)
  - Deane, Drayton, and Ó Gallachóir 2014 (5, 15, 30, 60 min)
  - Kazemi et al. 2016 (5, 10, 15, 30, 60 min)
  - Bakirtzis et al. 2014; Bakirtzis and Biskas 2017 (5-60 min)

👍 Operating cost savings

👎 Increase of computational time

Motivation

- What about using 24 time periods of different duration?
- Time-adaptive unit-commitment (TA-UC)



Research question

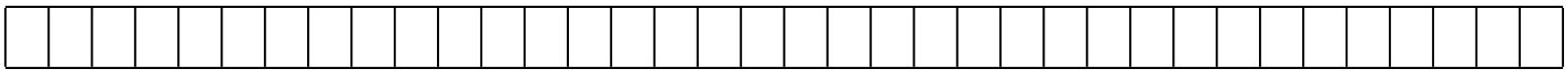
Can we determine the duration of 24 time periods to make

a more efficient use of the system flexibility

without increasing the computational burden of the UC?

Proposed time-period aggregation

1. Original data (5-min resolution)



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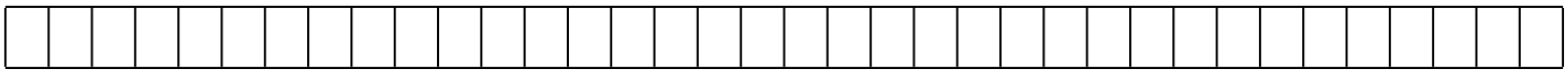

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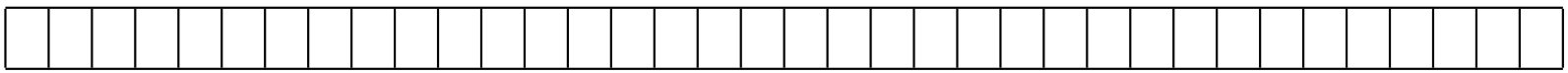

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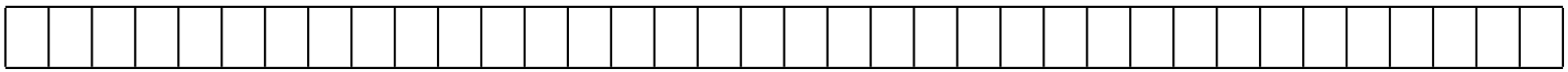

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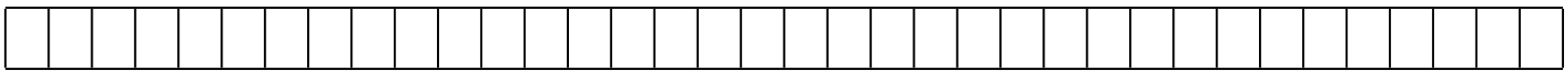
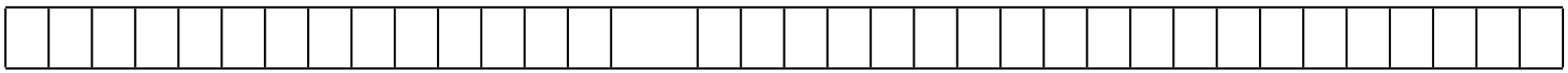


3. Merge the two closest adjacent clusters and update distances



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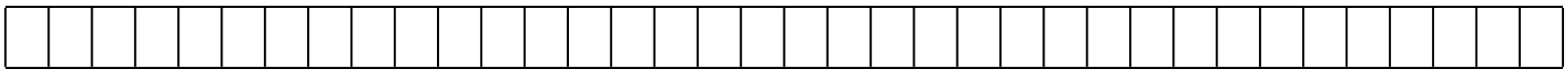

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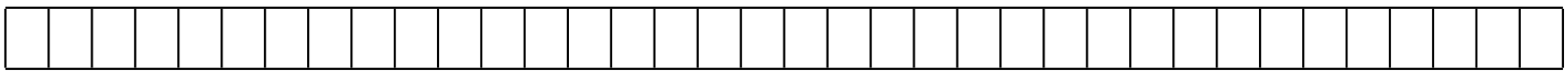

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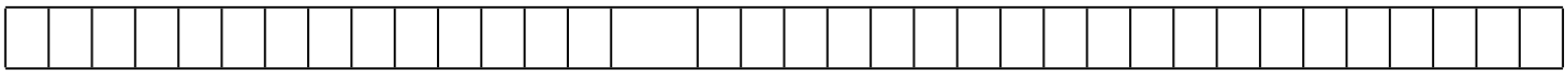

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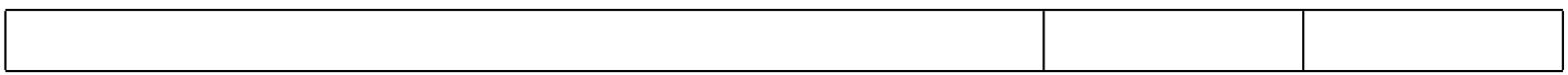
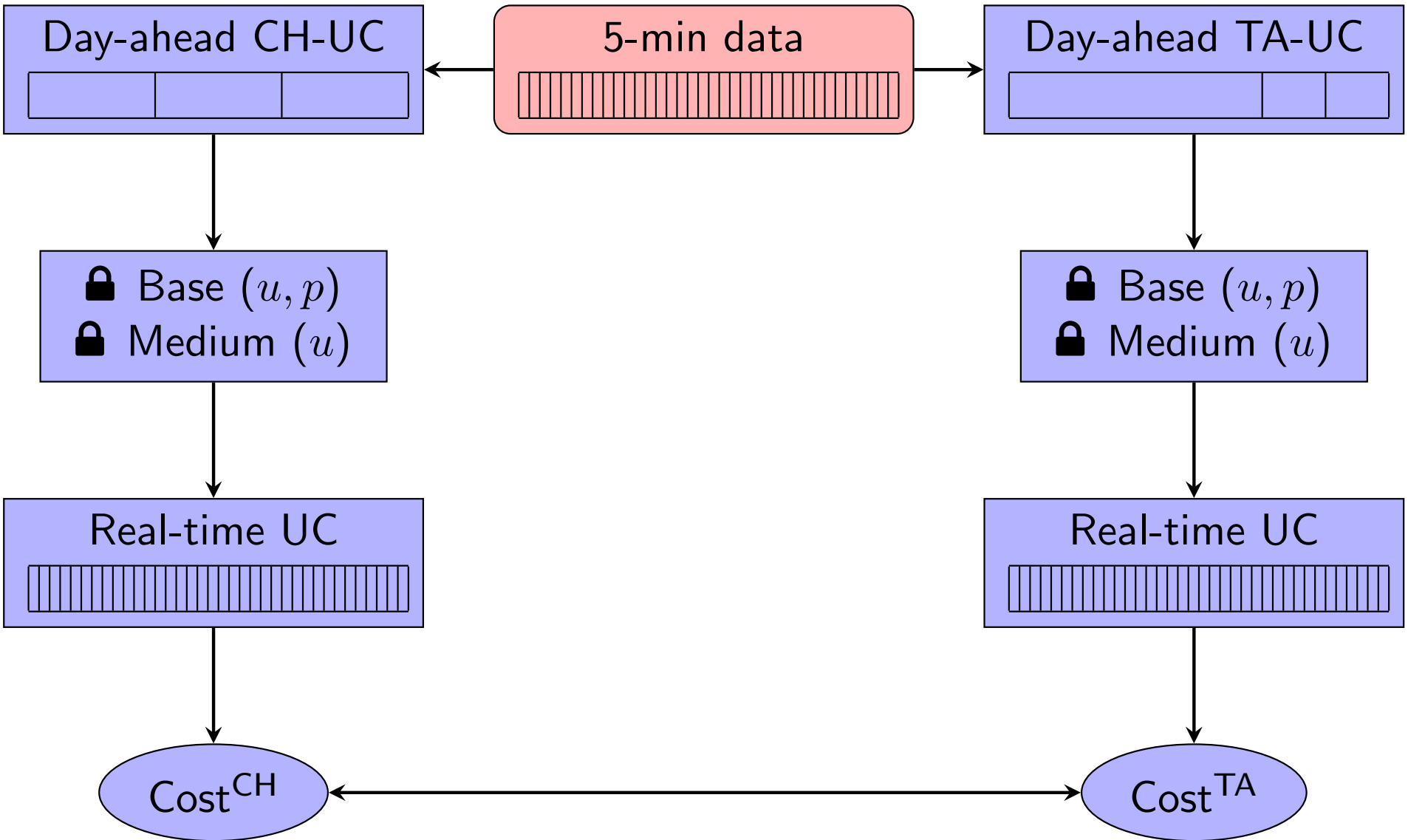
4. Repeat 2 and 3 until the final number of clusters is obtained



Comparison: CH-UC vs. TA-UC



Case study

- Demand is 10% of that in Spain in 2017 (3.8GW peak demand)
- Wind and solar capacity factors in Spain in 2017
- Renewable penetrations from 20% to 60%
- Start-up costs, ramp limits and minimum times of thermal units
- 13 units and three generation portfolios:

	Base ($\blacksquare u, p$)	Medium ($\blacksquare u$)	Peak
Normal-flex	$g_1 - g_3$(1.2GW)	$g_4 - g_7$(1.2GW)	$g_8 - g_{13}$(1.5GW)
High-flex	-	$g_1 - g_7$(2.4GW)	$g_8 - g_{13}$(1.5GW)
Low-flex	$g_1 - g_7$(2.4GW)	-	$g_8 - g_{13}$(1.5GW)

Case study

Table: Relative Cost Savings (%)

Wind (%)	Solar (%)	Normal-flex	High-flex	Low-flex case
10	10	0.01	0.00	0.27
20	0	0.01	0.01	0.30
0	20	0.12	0.07	0.53
30	30	2.35	1.04	3.49
60	0	0.56	0.08	1.02
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- More renewables ➔ Higher savings
- More solar ➔ Higher savings
- Low flexibility ➔ Higher savings

Summary

- The conventional-hourly UC is proven inadequate for high penetration of renewables (Duck curve)
- Finer time discretizations reduce operating costs while increasing computational time
- The proposed time-adaptive UC reduces operating costs without increasing computational time
- The cost savings increase with renewable (solar) penetration and decrease with generation flexibility

Thanks!! Questions??

website: oasys.uma.es

S. Pineda, R. Fernández-Blanco and J.M. Morales, "*Time-Adaptive Unit Commitment*", in **IEEE Transactions on Power Systems**, 34(5), 3869-3878, 2019.

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Deane, J. P., G. Drayton, and B. P. Ó Gallachóir (2014). "The impact of sub-hourly modelling in power systems with significant levels of renewable generation". In: *Applied Energy* 113, pp. 152–158.

Kazemi, Mehdi et al. (2016). "Evaluating the impact of sub-hourly unit commitment method on spinning reserve in presence of intermittent generators". In: *Energy* 113, pp. 338–354.

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