Ramping effect on forecast use: *Improving the way we use forecasts (for load and net load)*

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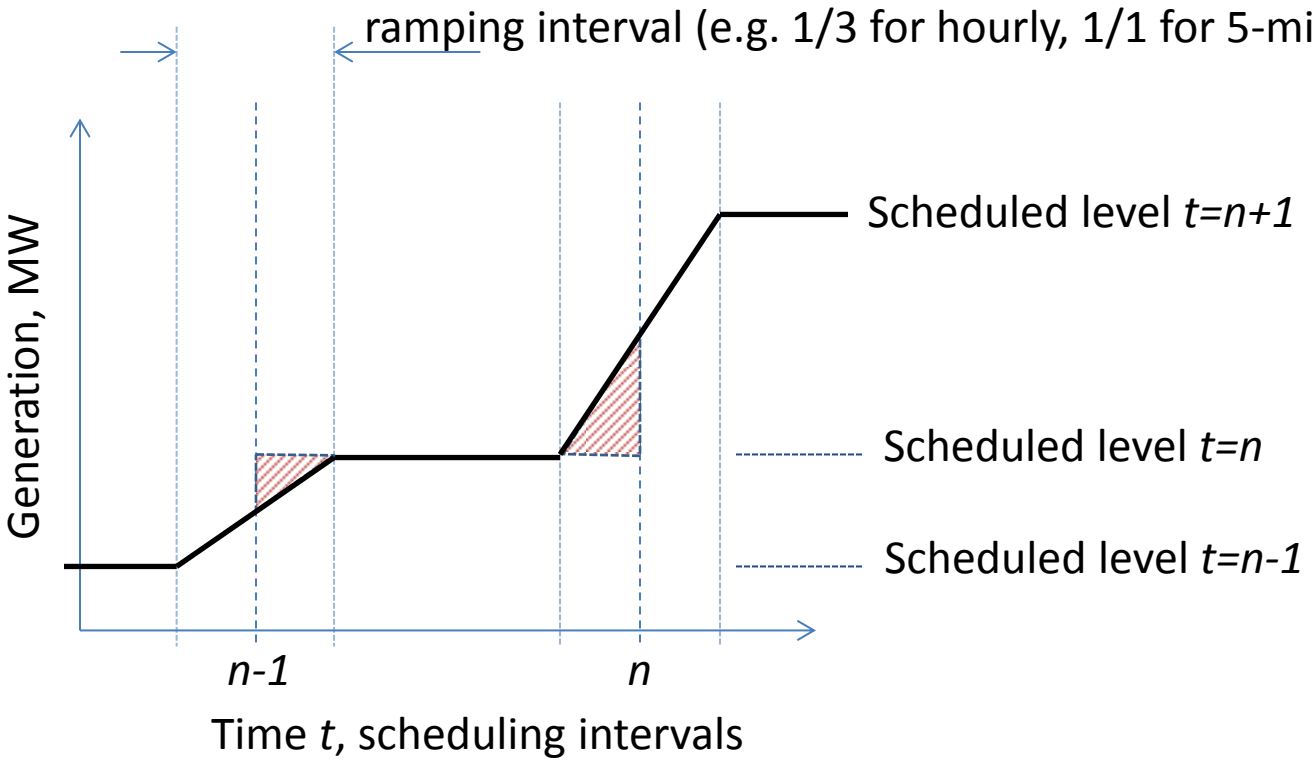
outline

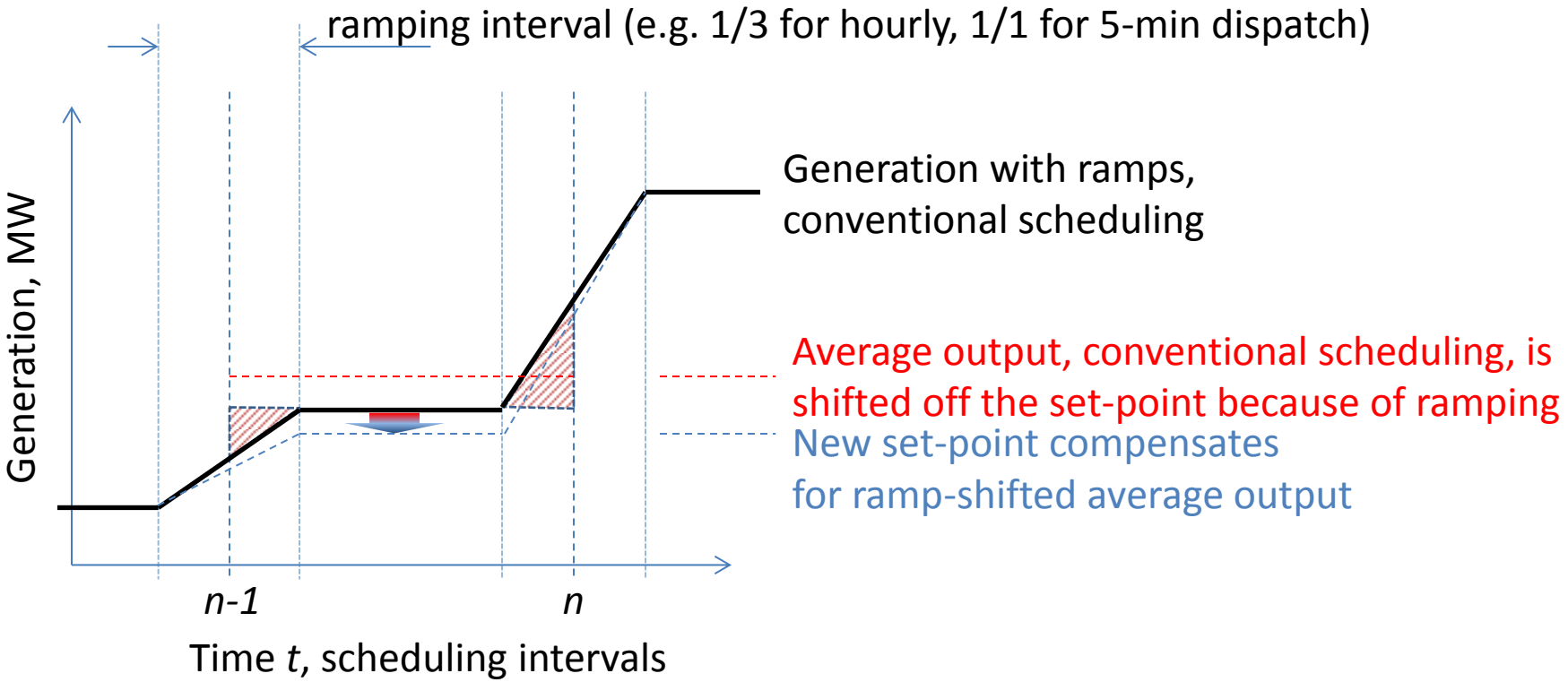
- the problem
  - Ramping affects generation output, especially peak (and valley) values by shifting average output from its target value.
- the solution
  - Integrated Ramping re-sets the target (schedule or dispatch) values to compensate the shift from ramping.
- the benefits
  - better use of forecast values (load or net load)
  - reduce the amount of variability that the regulation reserve must accommodate

Ramping affects the output



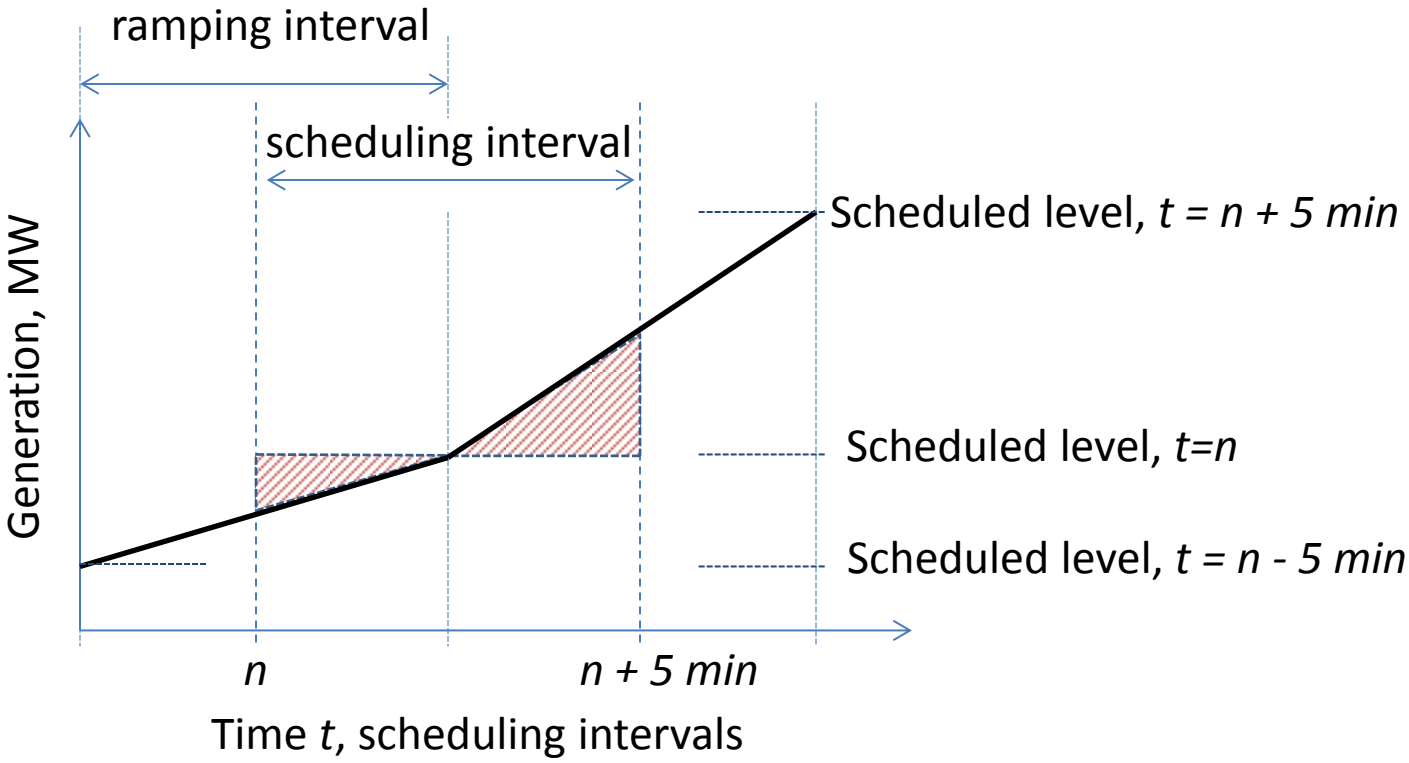
- Triangle areas differ, the average output (MWh) is not the same as the scheduled level
- The effect is bigger for larger ramping intervals
  - smaller ramping intervals require higher ramping rates

Integrated Ramping: how does it work



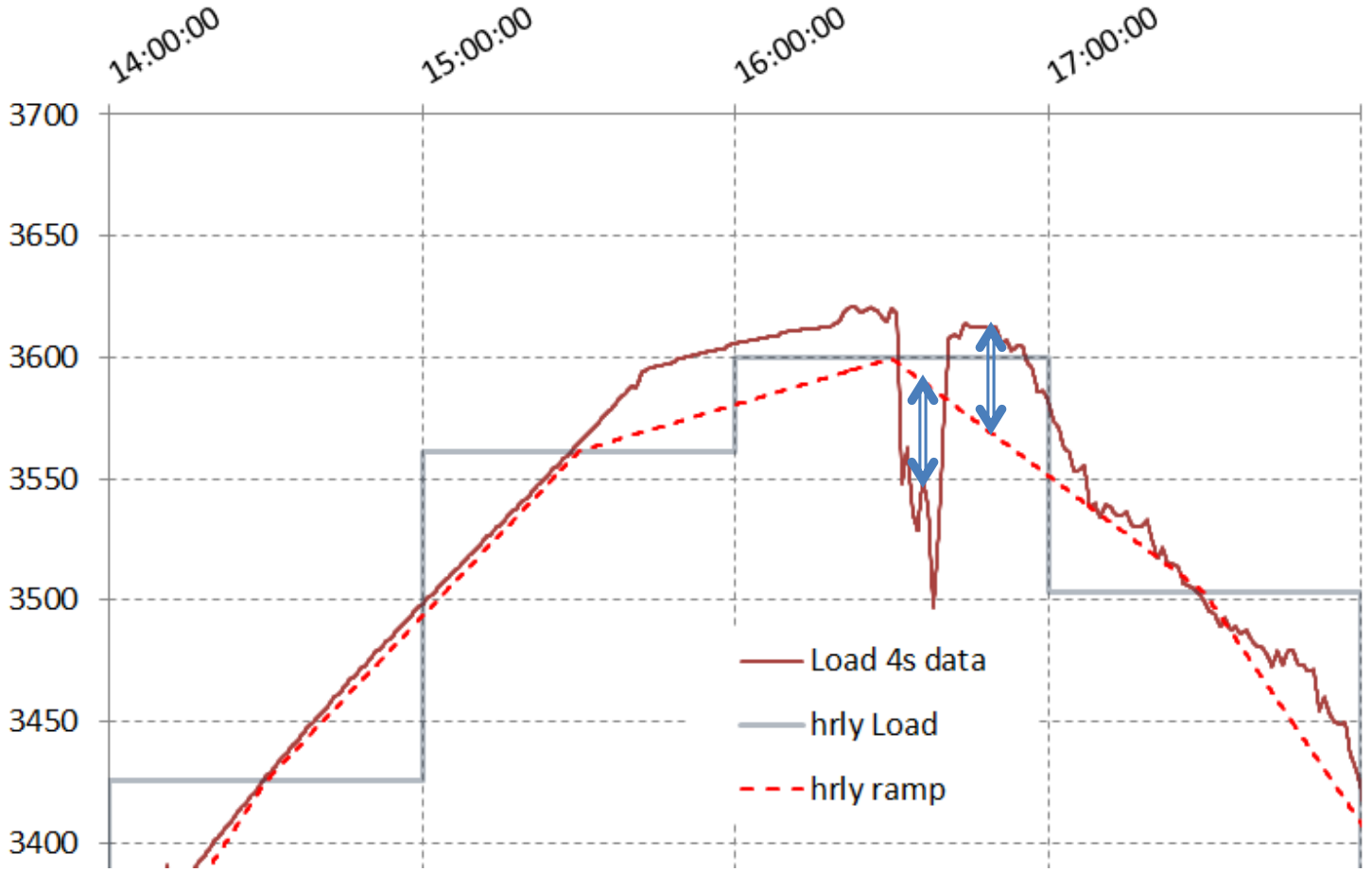
- The Integrated Ramping changes the set-point(s) to compensate for ramp shifting the average output
- It is slightly more complicated than shown because the *n-1* and *n+1* set-points also need shifting
- Doesn't change the way ramping is done (same ramping interval)

Ramping (5-min scheduling)



- Similar to the hourly scheduling, triangle areas differ
- Unlike hourly scheduling, ramping occurs thru the entire scheduling interval

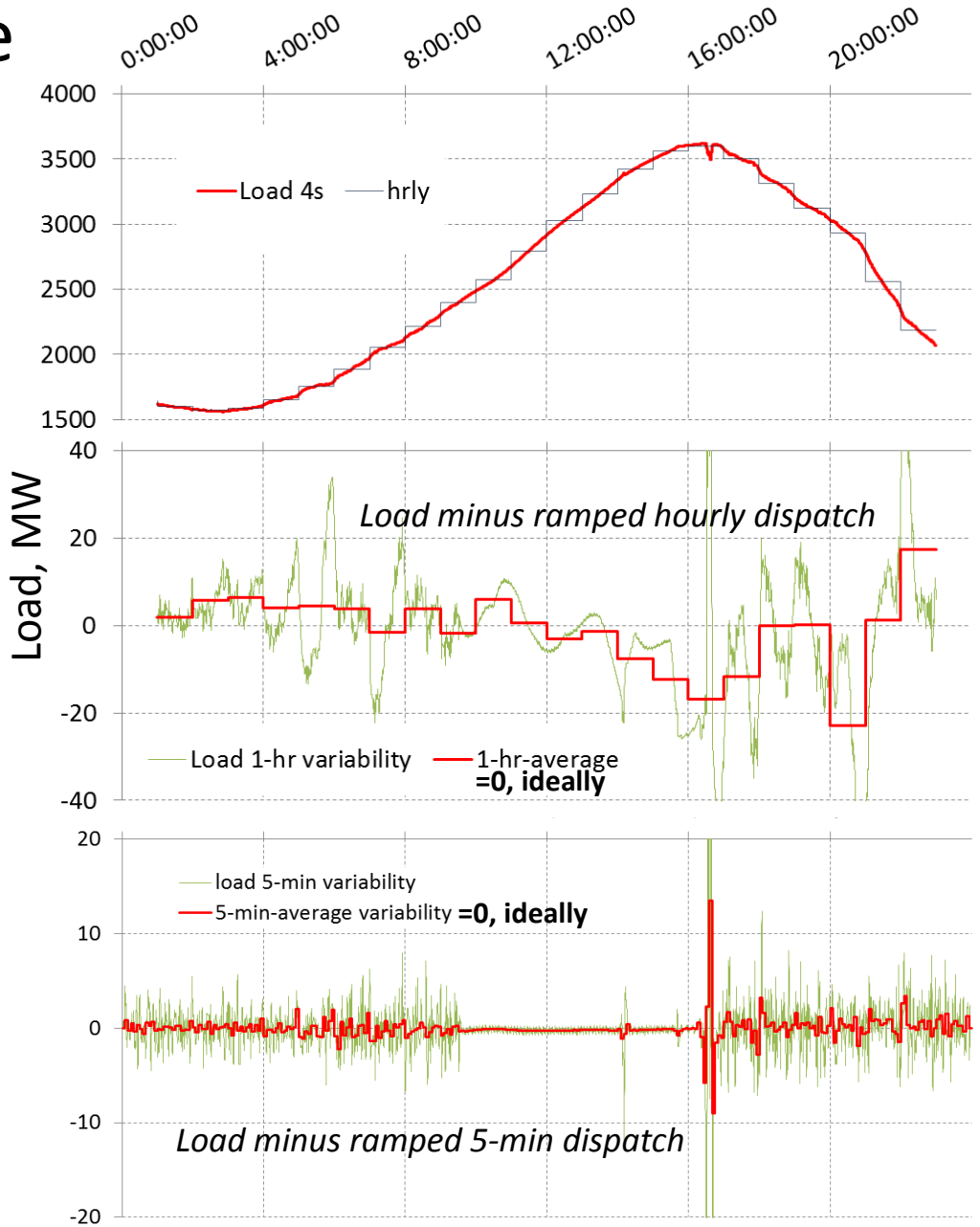
Variability (quantified)



- Variability (blue arrows) as the difference between actual (4-sec data, dark red line) and the ramped schedule (red dotted line)

How large is the ramping effect?

- One day load example
  The ramping effect is not dominating but still significant:
  - ~8% of sub-hourly variability (for the hourly dispatch case)
  - ~12% of sub-5min variability (5min dispatch)



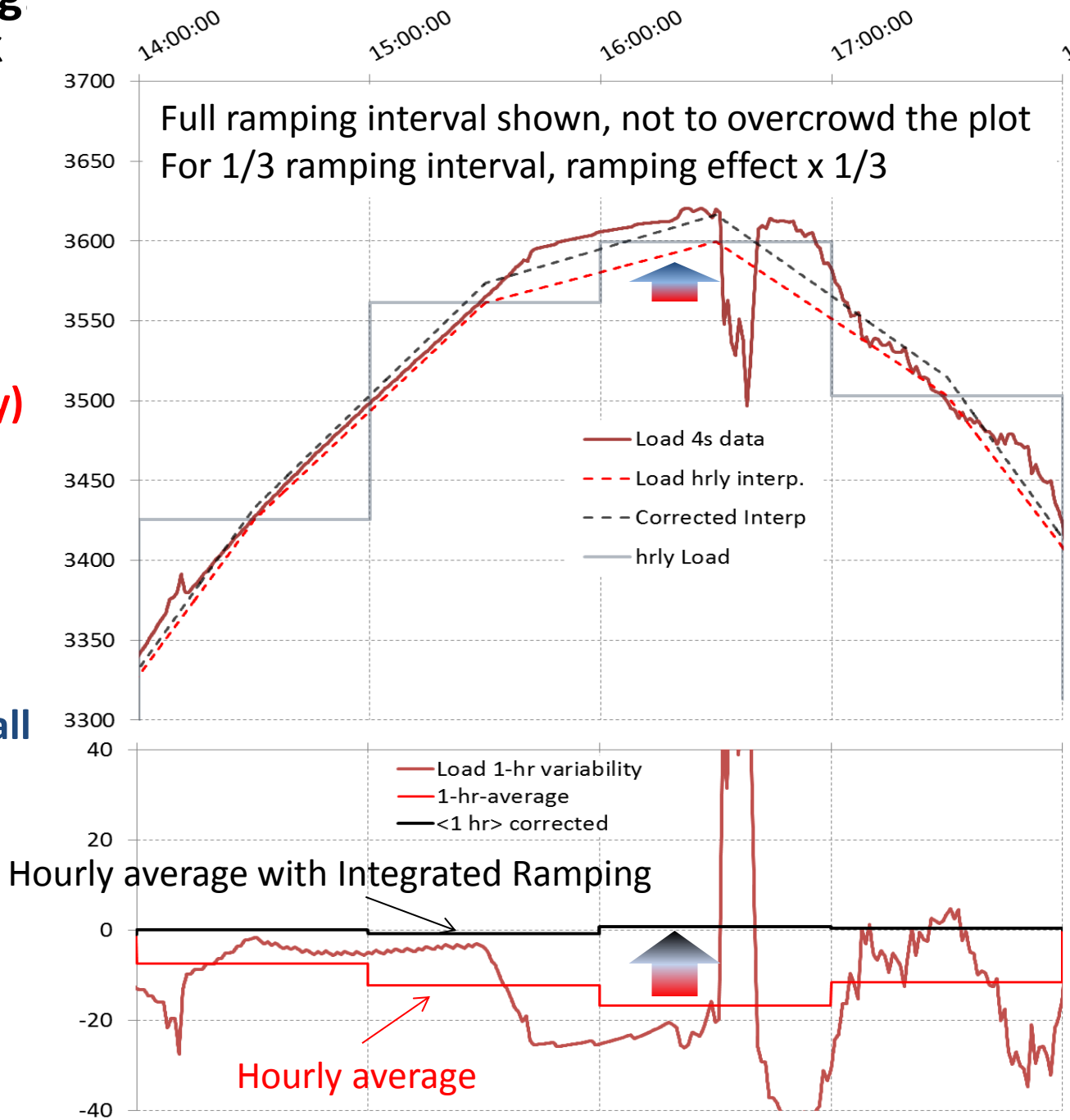
Possible countermeasures

- Include ramp rates as variables in the scheduling/dispatch model (G. Morales-Espana, IEEE Trans. Power Systems 2014, 476-488; H. Wu, IEEE Trans. Power Systems in print)
  - Drawback: At least twice the complexity compared to conventional dispatch
- Integrated Ramping (our approach)
  - Compensate for the ramping error prior to solving the scheduling/dispatch problem
  - Virtually no computational cost, a straightforward procedure applied to the (net-) load forecast
  - doesn't improve forecast, only removes errors induced by ramping

Integrated Ramping: how does it work

By re-scheduling (hourly) set-points, bring the hourly average to the scheduled level

All needed for the re-setting is to invert a small (24 x 24 for DA hourly) matrix



Summary

- Integrated Ramping: a straightforward method to improve the use of load and net-load forecasts
- For sample real-life data and hourly scheduling, improves scheduling (by about ~0.2% of the load, comparable to ~2% load forecast error; or by 8% of the sub-hourly variability)
- For 5-min scheduling, reduces the sub-5-min variability by >10%
- For hourly scheduling, allows to increase the ramping interval and decrease ‘end-of-hour’ ramping requirements thus releasing ramping capability for AGC
- The improvements are free, as they only involve operation with data that are already in use by system operator