Objective

- Explain why ramping can be costly when marginal generators cannot ramp fast enough
- Examine the impact of within-hour (5-minute) ramping impacts of a high wind penetration
- Quantify the benefits of Balancing Area combined operations on mitigating these ramp impacts.

Approach

- Obtain 5-minute load and wind power data from the Minnesota 20% Wind Integration Study
- Utilize the 25% (by energy) wind penetration
- Calculate ramp requirements:

Why can ramping be costly?

Ramping capability may be limited in some circumstances, even though there is sufficient overall capacity. This can cause higher dispatch costs, as illustrated in this figure. The base load generation cannot ramp fast enough, so a peaking unit is necessary to provide the ramp. This increases costs. Ramping can be part of energy if it is abundant or it may need to be a separate service if it is scarce.

Ramp requirements increase with 25% wind energy penetration. The upper panel also shows the importance of being able to achieve lower minimum loads by the conventional generation fleet.

The need for additional turn-down capability is also shown by this load duration curve, based on 5-minute data. Lower minimum loads require greater flexibility but additional capacity is not needed.

Even without wind there is excess ramping when Balancing Areas operate separately. This graph shows the ramps that could be eliminated with combined operations.

With a large wind penetration, there is an increase in excess ramping when Balancing Areas operate separately.

This graph combines the previous two graphs. The red trace shows the excess ramping from load alone, and the blue shows excess ramping from load and wind together. It is clear that the excess ramping is larger with wind and load together, compared to load alone.

Conclusions

- Combined operations of separate Balancing Areas can reduce 5-minute ramping needs, both without wind, and with wind
- Additional turn-down is needed at high penetrations, but not extra capacity
- Combined operations can significantly reduce large but infrequent ramps.