

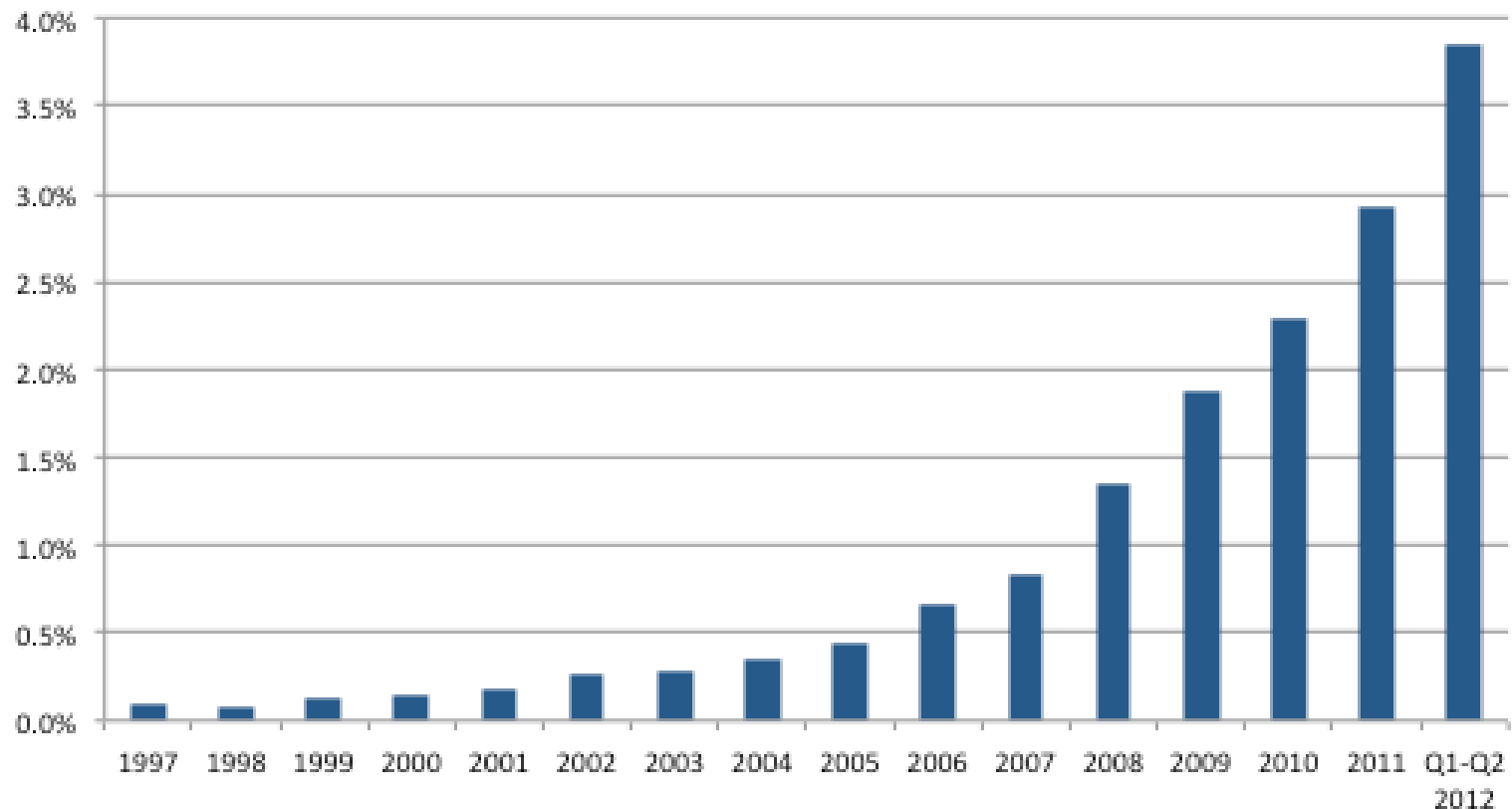
If Wind Energy is the Future How Will We Keep the Lights On?



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September 28, 2012

Wind Energy is Not a Rounding Error Anymore

Annual Wind Energy Generation as a Percent of US Total Electric Generation



Grid Basics

What is “The Grid”

- The whole system that provides electricity to consumers
 - Power plants
 - Wires
 - Substations
 - Etc.

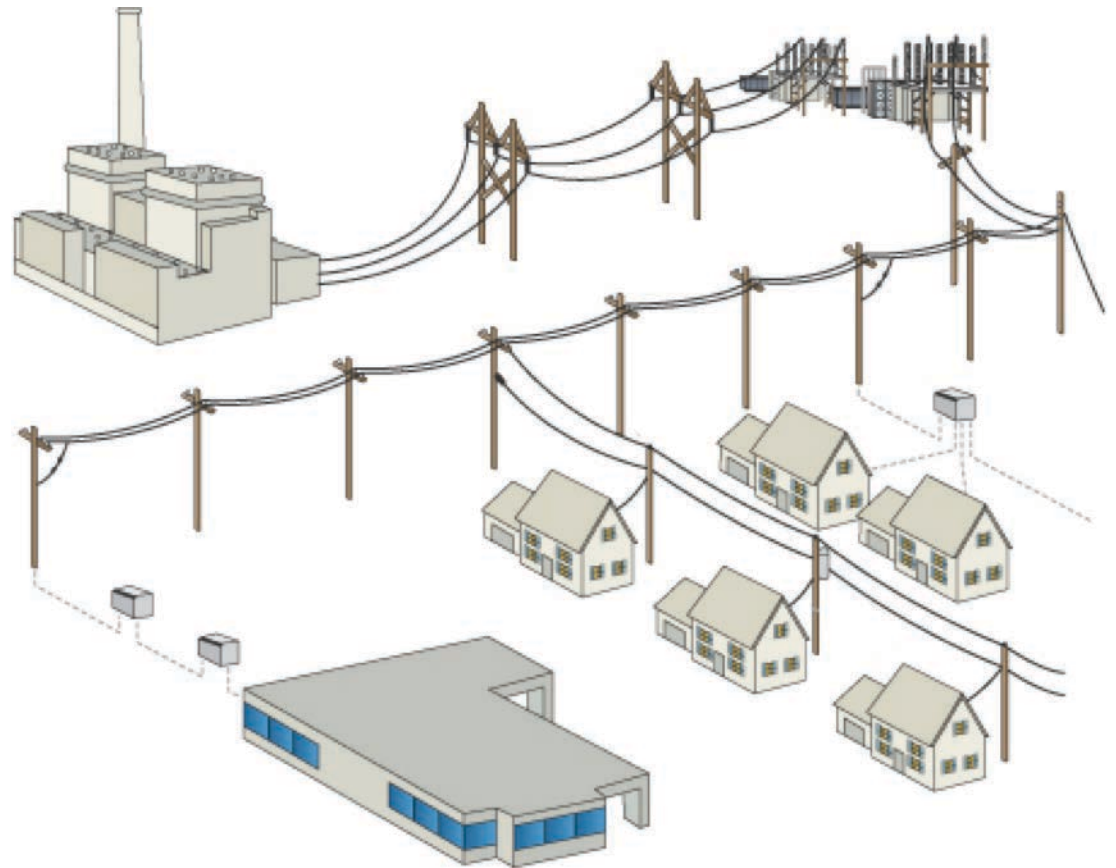


Image Source: <http://www.powersystemsloss.com/2011/07/distribution-lines-electrical.html>

Grid Basics

The Eastern Interconnection

Everything east of the Rockies is

- connected
- synchronized
 - except Texas and Quebec

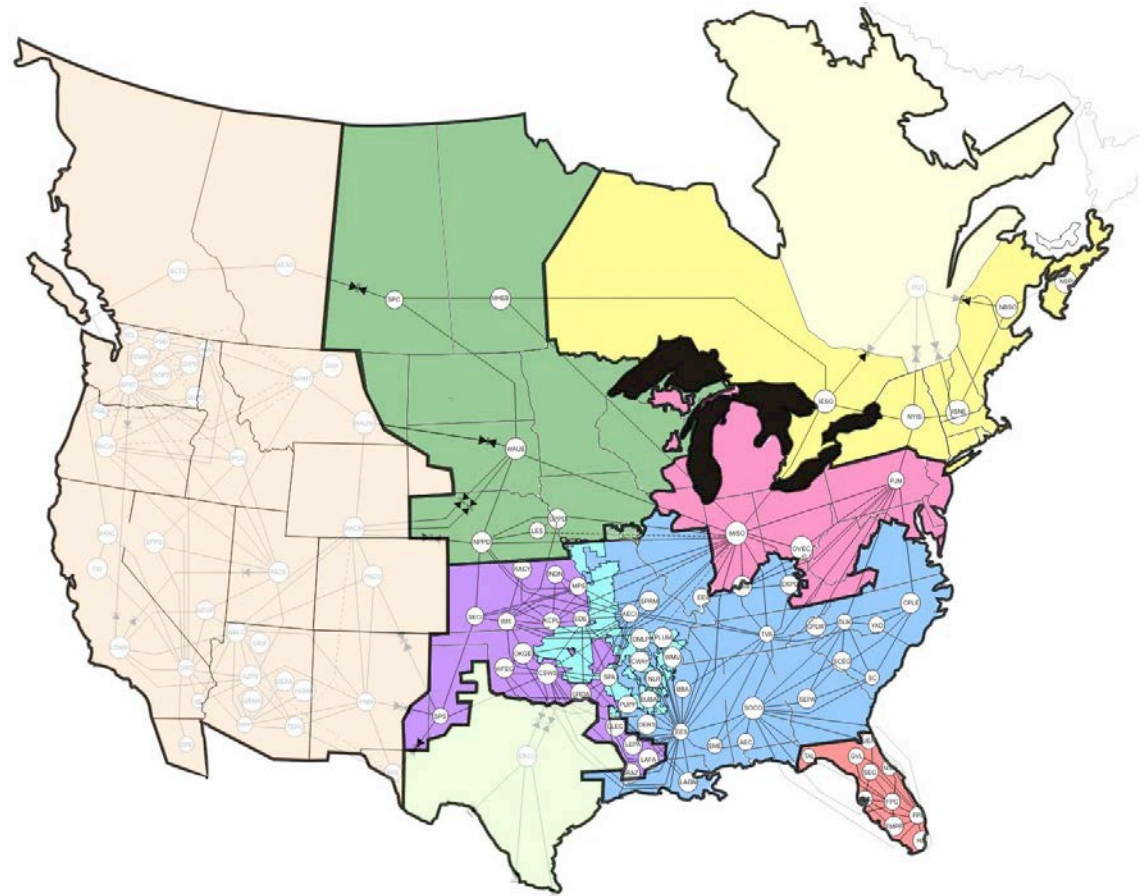


Image Source: www.nerc.com

Grid Basics

Supply = Demand (or else)

- System supply must nearly precisely equal demand in every instant

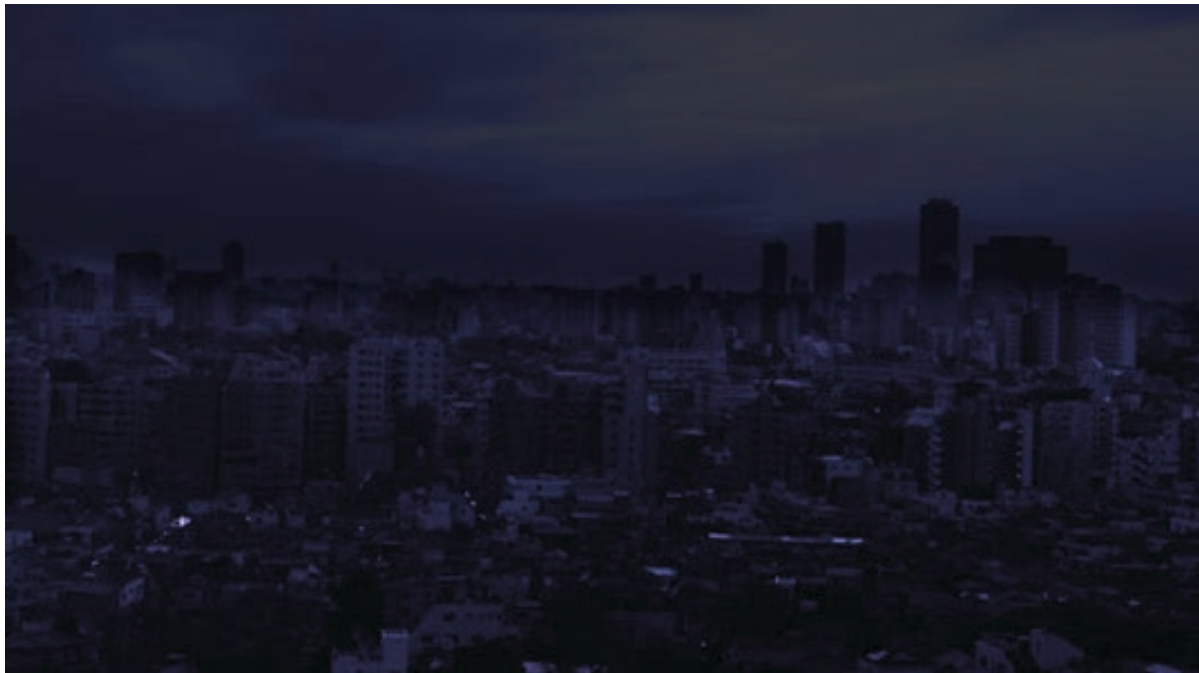


Image Source: <http://mnm1ssg.blogspot.com/2011/04/rolling-blackouts-mix.html>

Grid Basics

Generation Fleet Must Balance Load

- Load is constantly varying. Generation fleet as a whole must match it

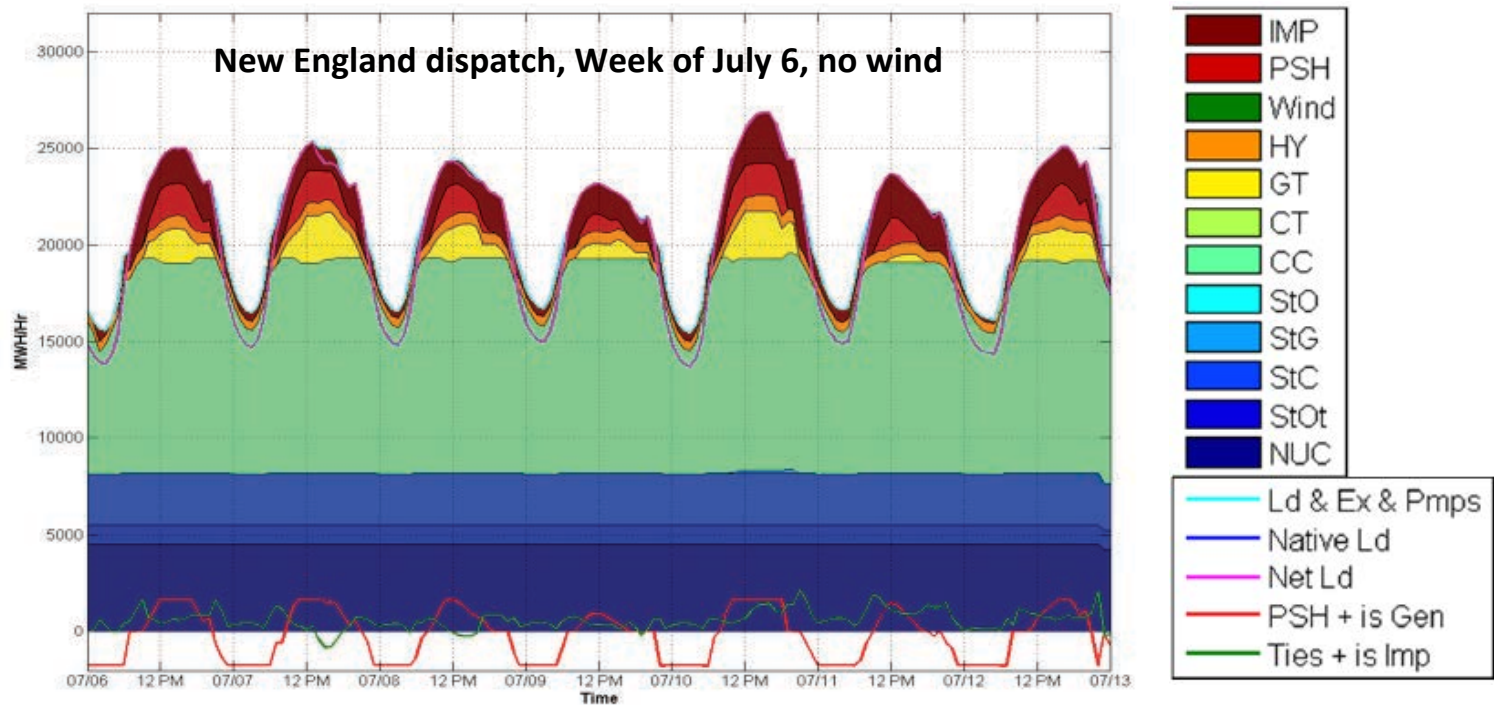


Image Source: ISO New England, New England Wind Integration Study, 2010

Wind is A Lot Like Load Can Be Managed Similarly

- Both vary and (for the most part) cannot be scheduled
- Both can be forecasted
- Both can vary from the forecast
- Both exhibit high variation from individual sources and much less variation in aggregate
- They vary independent of each other

Load – Wind = Net Load

- Net load is what must be matched by the remaining generation fleet.

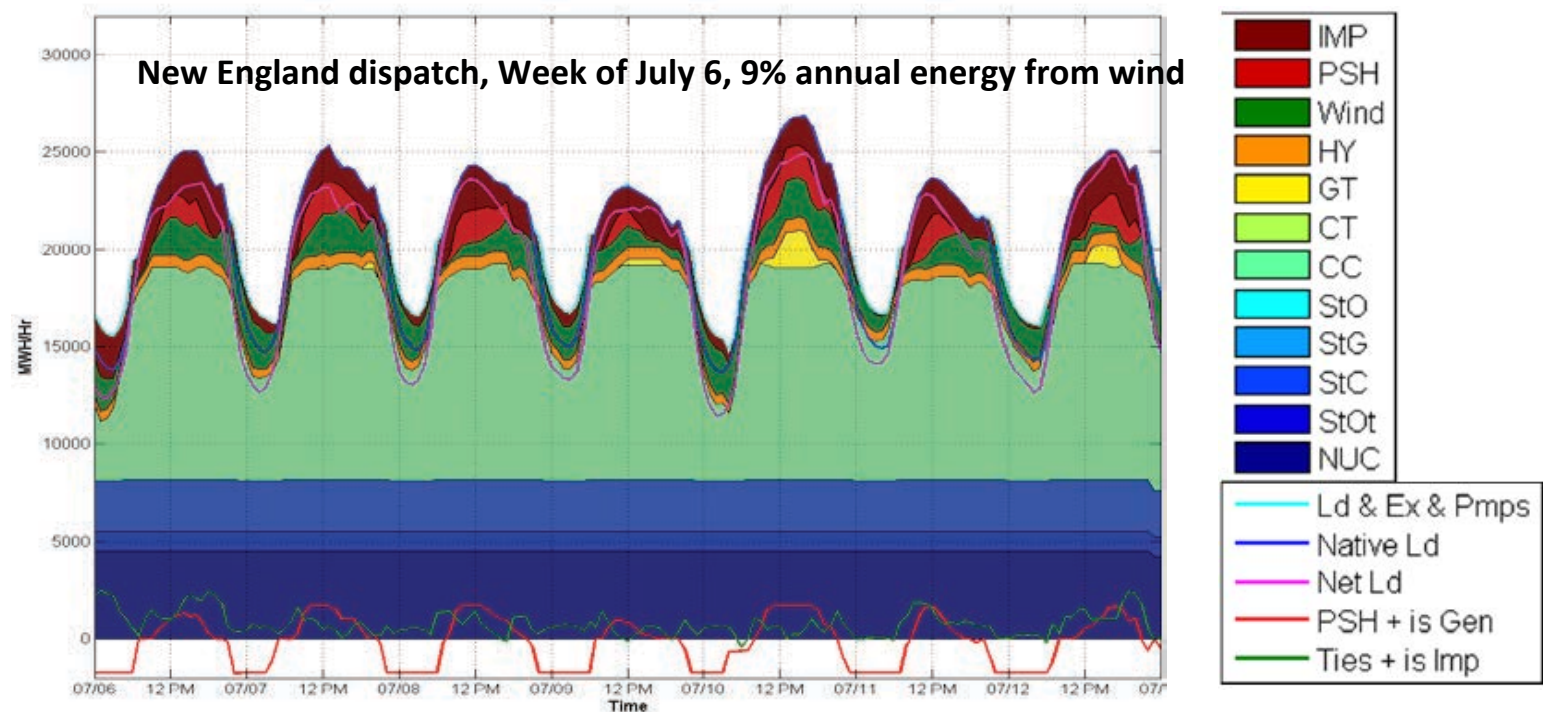


Image Source: ISO New England, New England Wind Integration Study, 2010

System Flexibility is Critical

- Flexible generation, load, and markets to incentivize them are needed

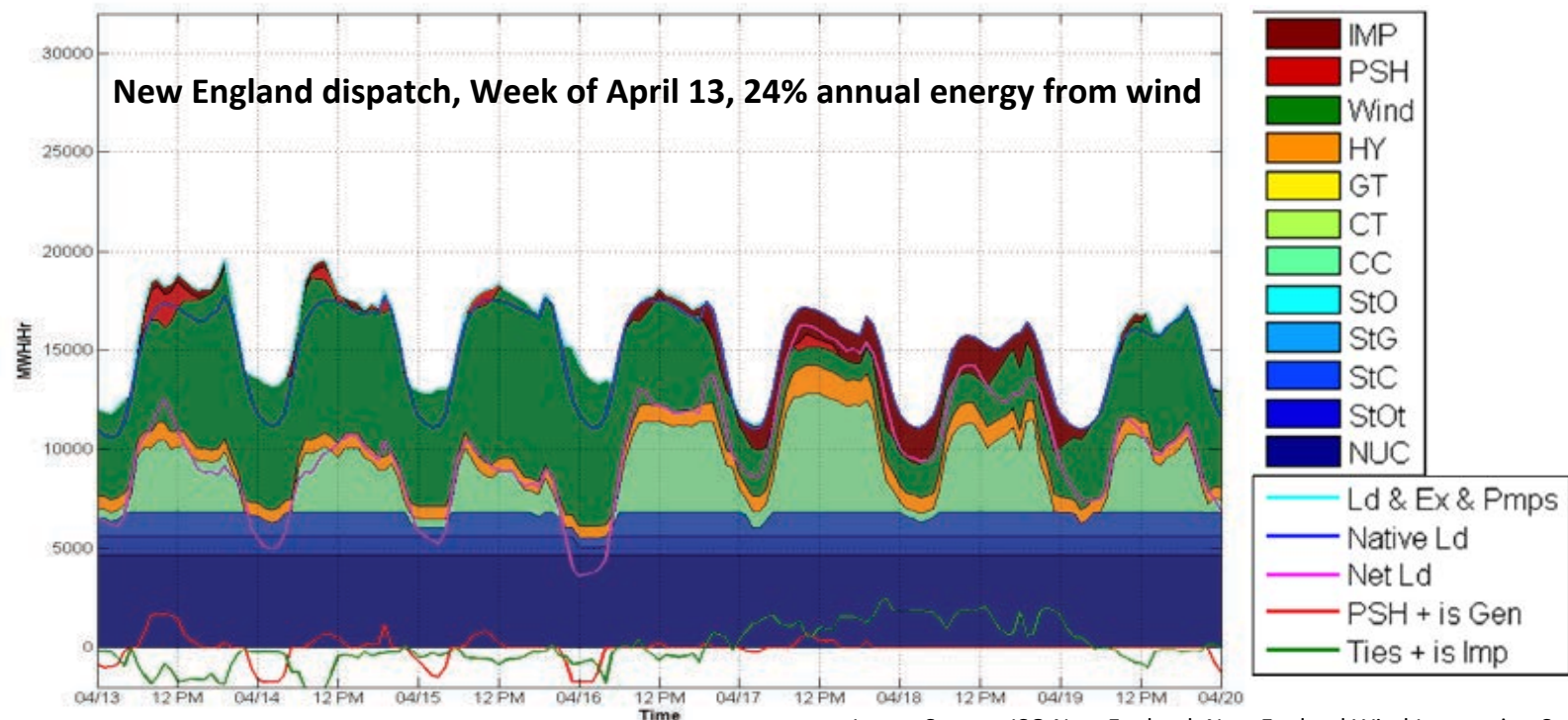


Image Source: ISO New England, New England Wind Integration Study, 2010

Wind Rarely Disappears Suddenly

- Average ramping rates are less than 0.5% of plant capacity per minute
- Observed statistics show wind plants do not drop from full capacity to zero in less than an hour due to wind
- Malfunction of a single turbine will not cause loss of the entire plant. Wind plant reliability is consequently higher than that of large conventional power plants.

Source: <http://www.nrel.gov/docs/fy06osti/36230.pdf>

Questions?



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