Confronting Myths about vRE Integration

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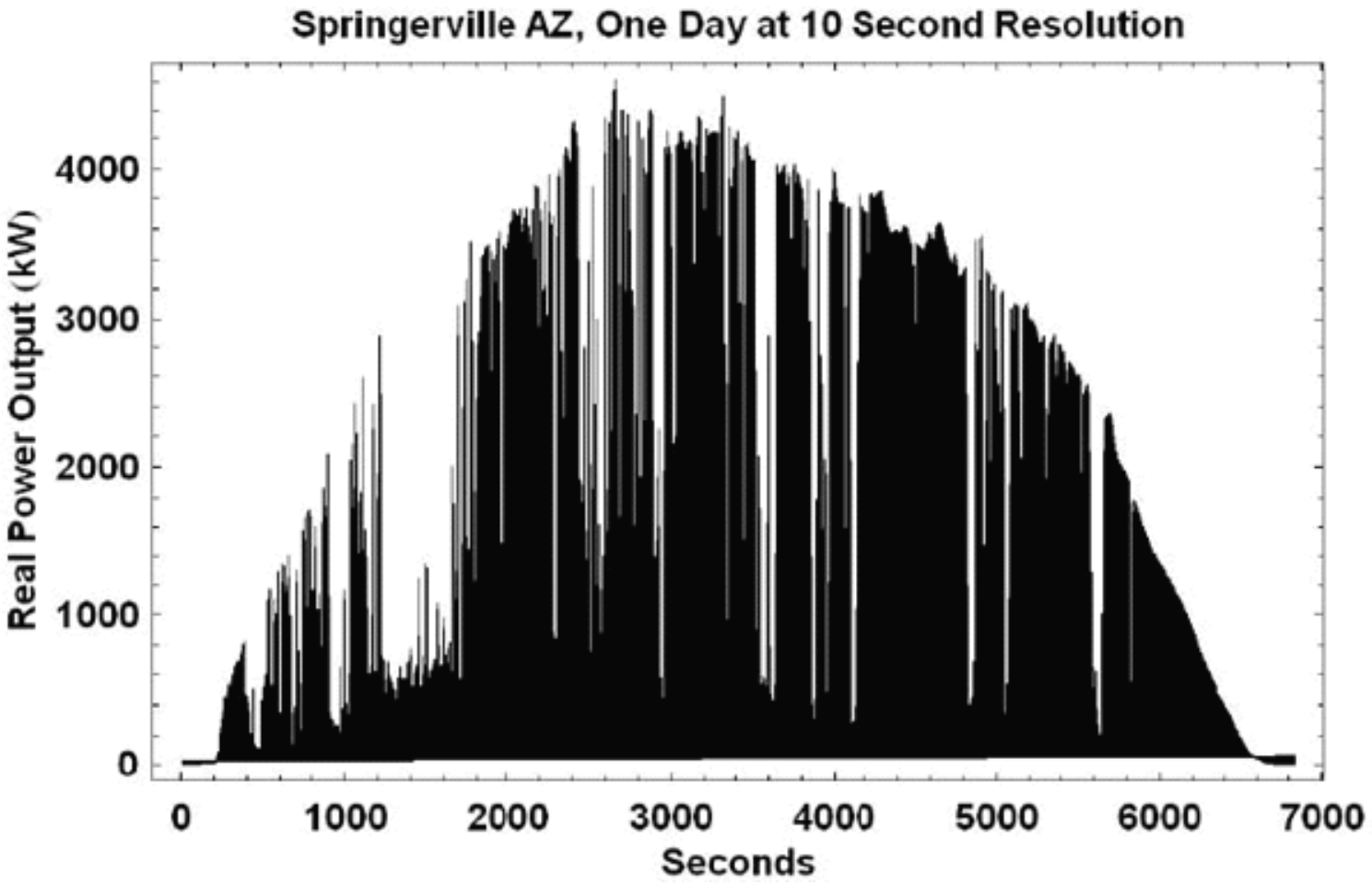
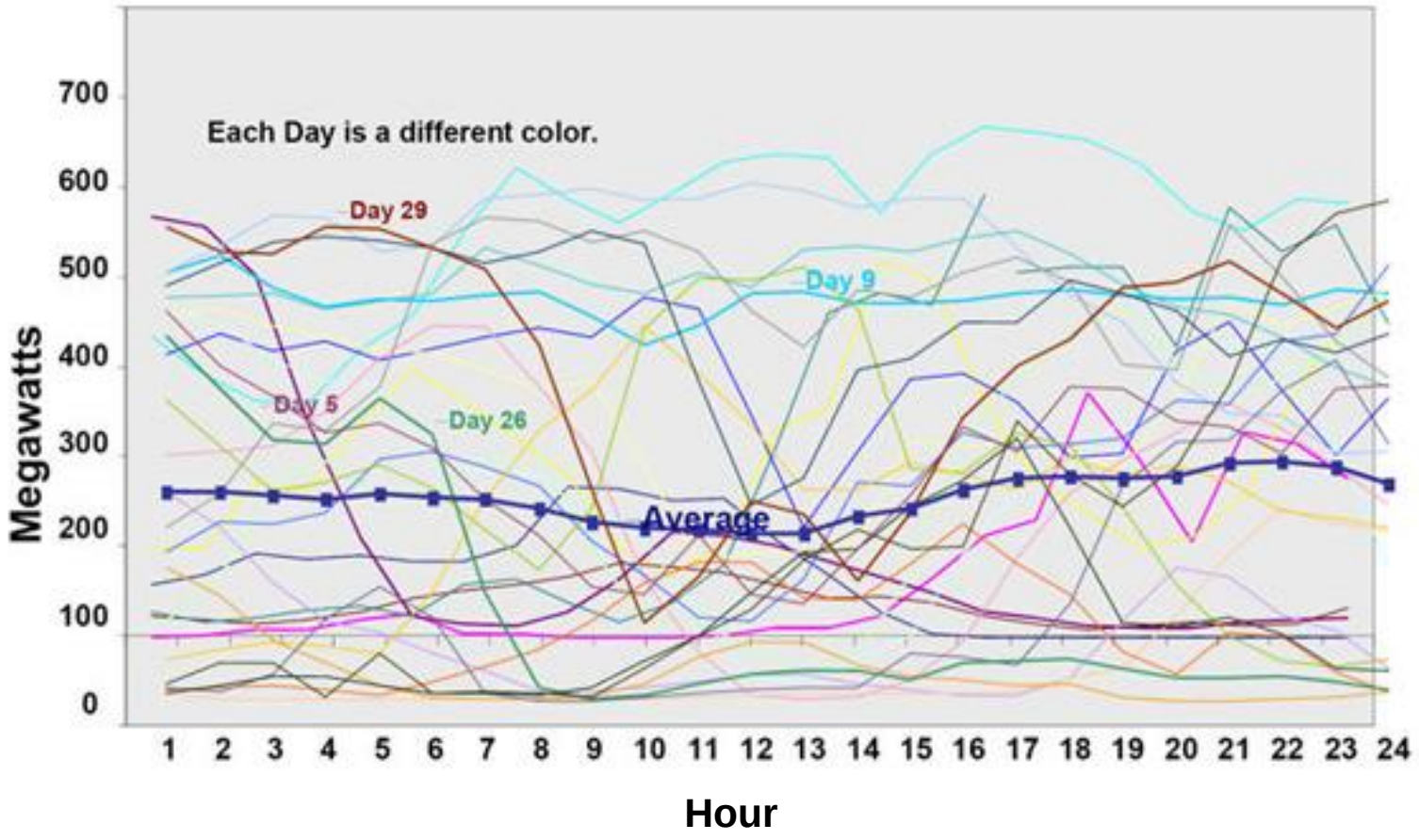
Asia Clean Energy Forum

This Looks Scary

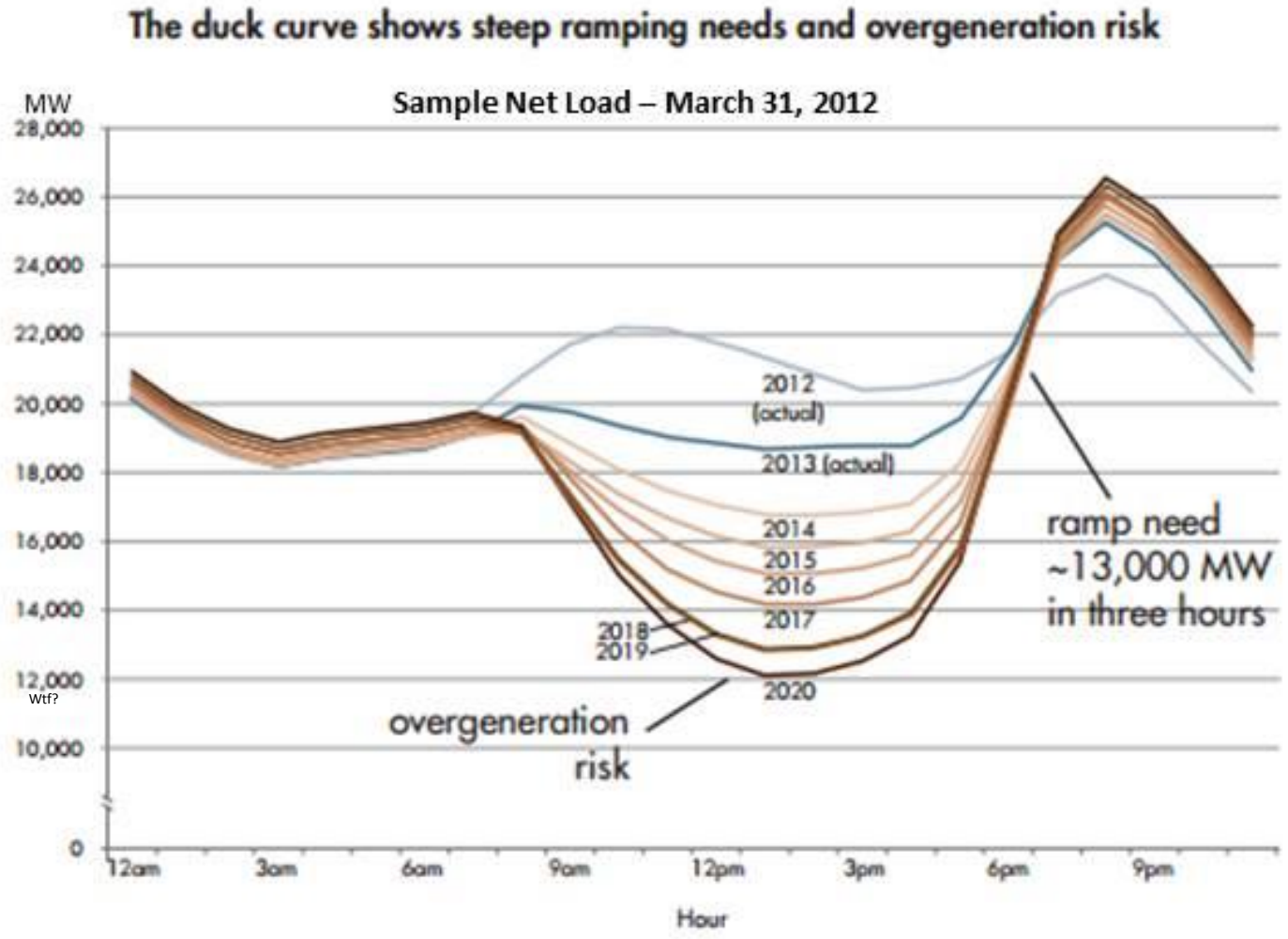


Output from a PV plant

This Looks Scary, Too

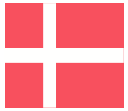


And this….



(from the California Independent System Operator)

Can grids support high levels (>10-20% annually) of variable RE?

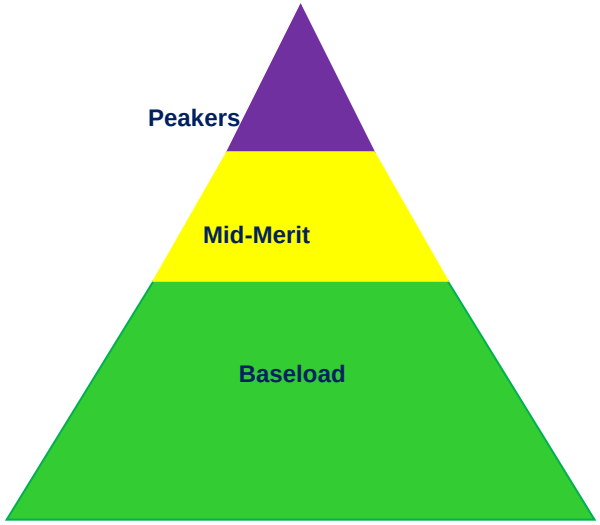
Country	% Electricity from Wind	Balancing
Denmark 	**43% in 2015**	Interconnection, flexible generation (including CHP), and good markets
Portugal 	**25% in 2013**	Interconnection to Spain, gas, hydro, and good market
Spain 	**21% in 2013**	Gas, hydro, and good market
Ireland 	**18% in 2013**	Gas and good market

Many grids are operating with 20%–30% variable renewables.

Their experiences demonstrate that actions taken to integrate wind and solar are unique to each system, but do follow broad principles.

Can variable RE provide baseload power?

- Yes, variable RE can contribute to resource adequacy, but changes how we think of “baseload”
- In high RE systems, we want the balance of generation to be flexible, and not necessarily be designed to run like a traditional baseload unit



Traditional Utility Paradigm

Figure credit: Keith Parks, Xcel Energy

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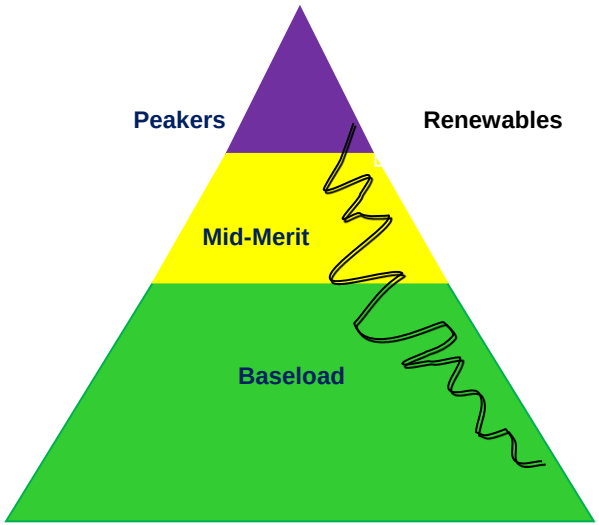
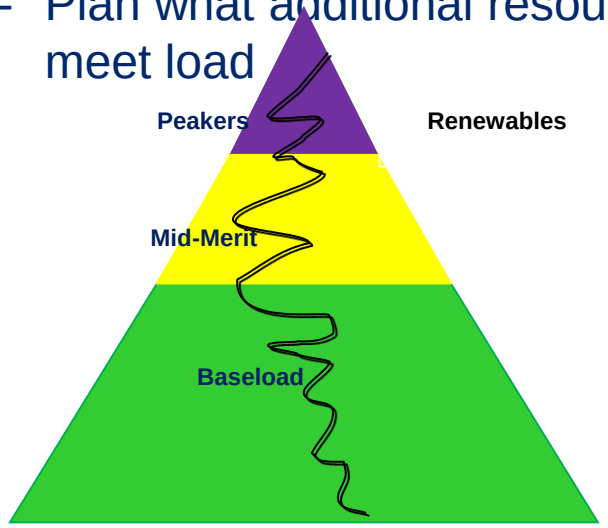


Traditional Utility Paradigm (w/ some RE)

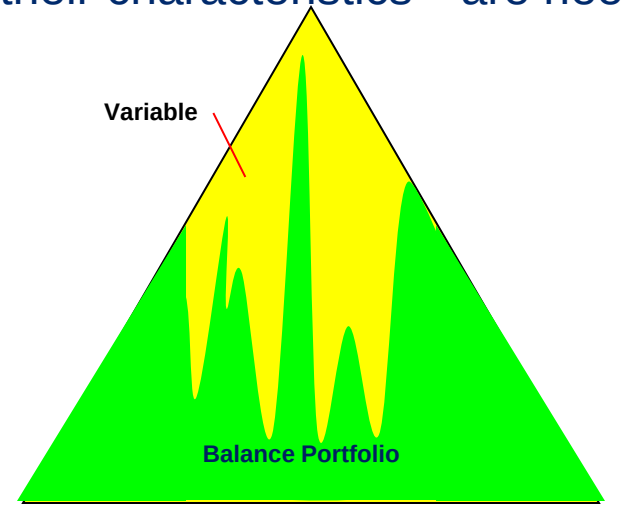
Figure credit: Keith Parks, Xcel Energy

Can variable RE provide baseload power?

- Yes, variable RE can contribute to resource adequacy, but changes how we think of “baseload”
- In high RE systems, we want the balance of generation to be flexible, and not necessarily be designed to run like a traditional baseload unit
  - First plan to use all the available RE; determine when and where the RE is available
  - Plan what additional resources—and their characteristics—are needed to meet load



Traditional Utility Paradigm (w/ high RE)



High Penetration Portfolio

Figure credit: Keith Parks, Xcel Energy

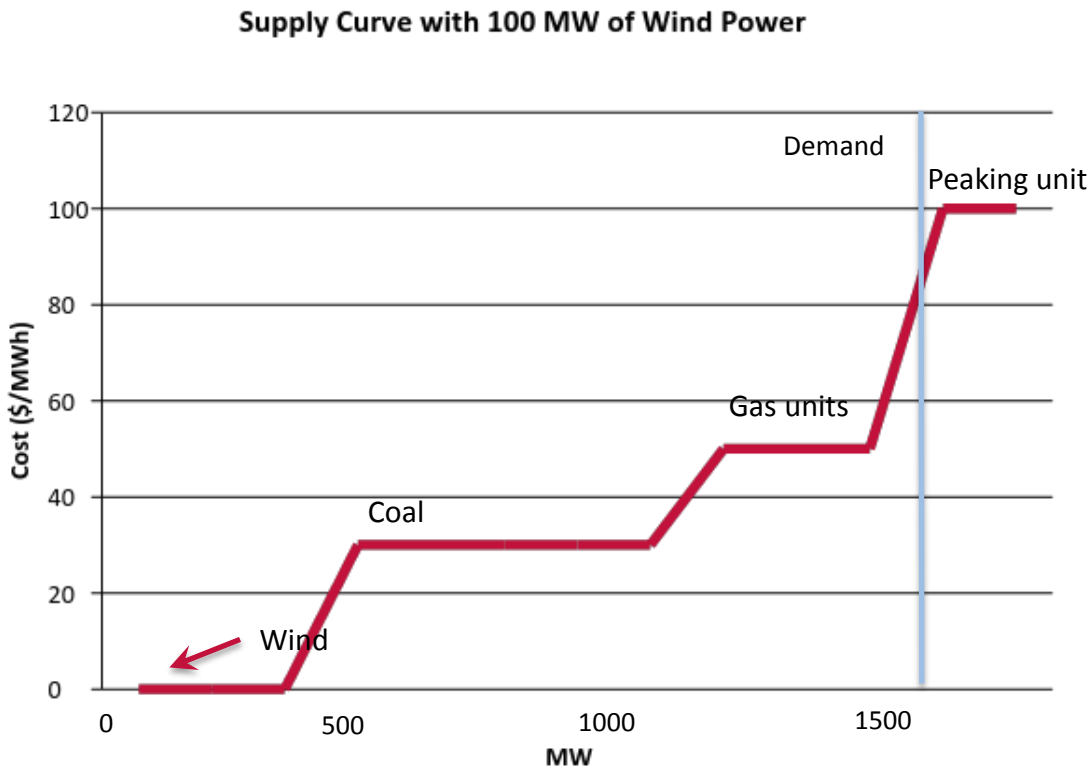
Do individual renewable energy plants require backup by conventional plants?

- Individual plants do not require backup
  - Reserves are optimized at system level.
- Wind and solar could increase need for operating reserves.
  - But this reserve can usually be provided from other generation that has turned down
  - This reserve is not a constant amount (depends on what wind/solar are doing)
  - Many techniques are available to reduce needed reserves.
- Wind and solar can also provide reserves; in both directions when curtailed

Photo from iStock 72283000

Does RE require priority dispatch (must-run)?

- No, trend is toward treating RE like real power plants:
  - Visible
  - Schedulable
  - Dispatchable
  - Curtailable
  - Able to provide ancillary services
- Requires least-cost dispatch
- Address RE bankability separate from system operations



RE production costs at $0/MWh, so typically dispatched first to minimize operational costs

What impact does variable renewable energy have on grid stability?

Frequency stability

- Solution: RE will need to provide active power controls (synthetic inertia, governor response, automatic generator control)

- Example: Xcel (Colorado) requires new wind turbines to have AGC

Voltage stability: potential issue in small and/or weak systems, such as those with long, radial lines

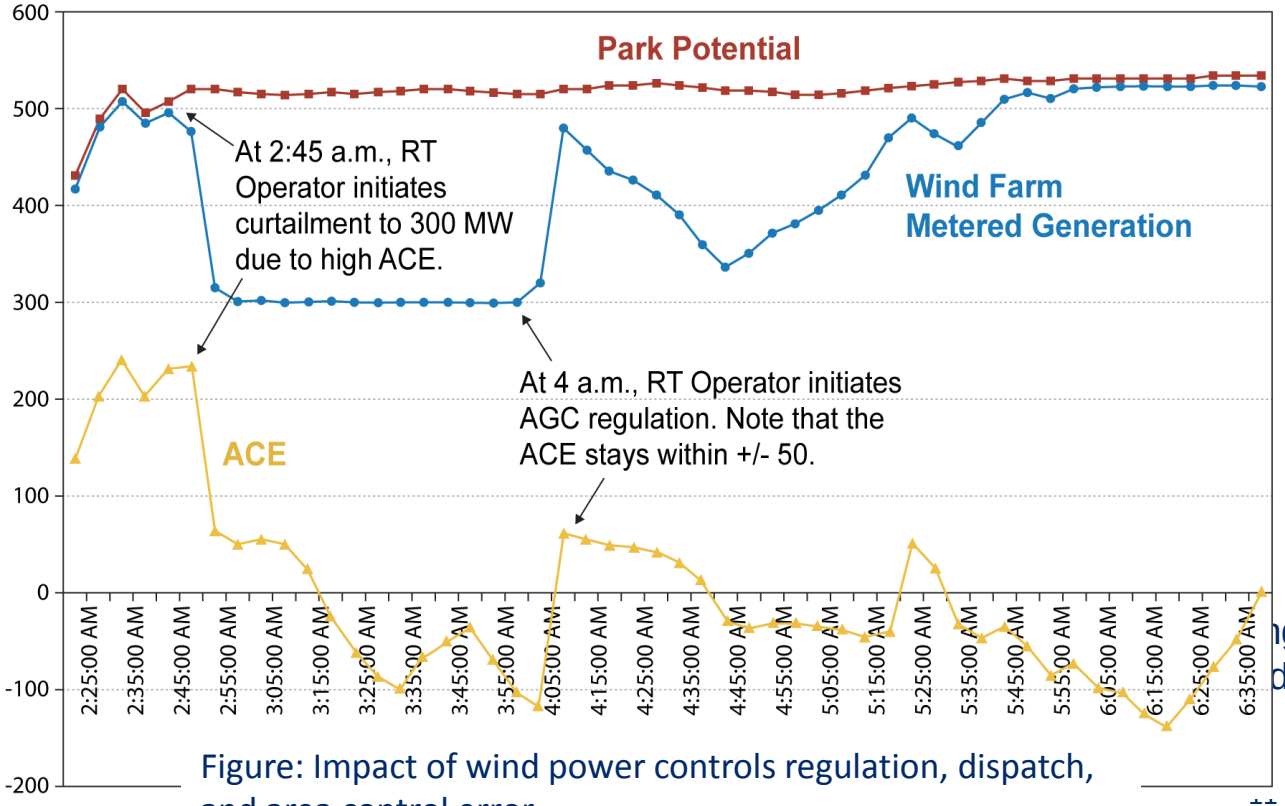
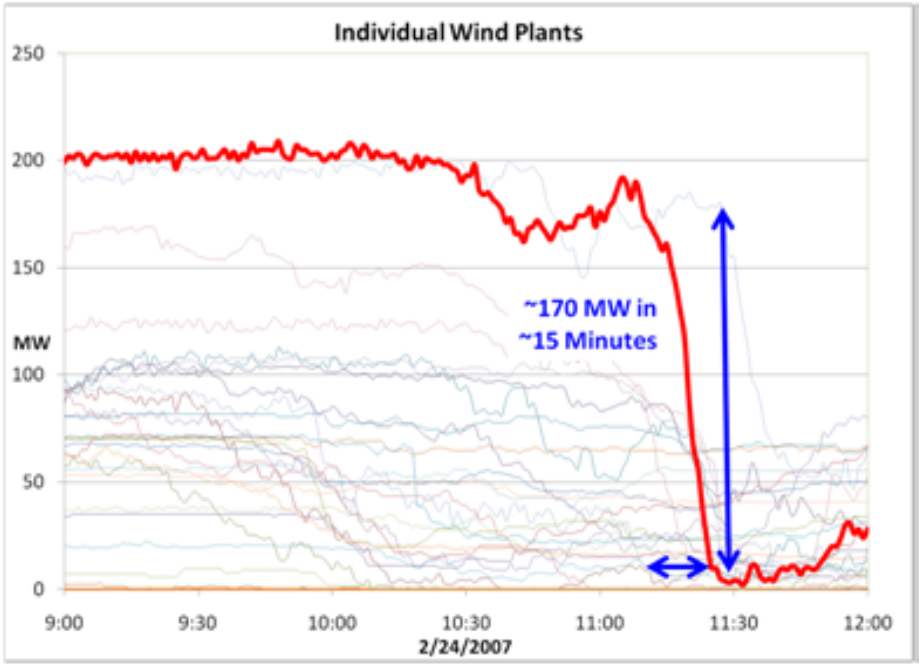
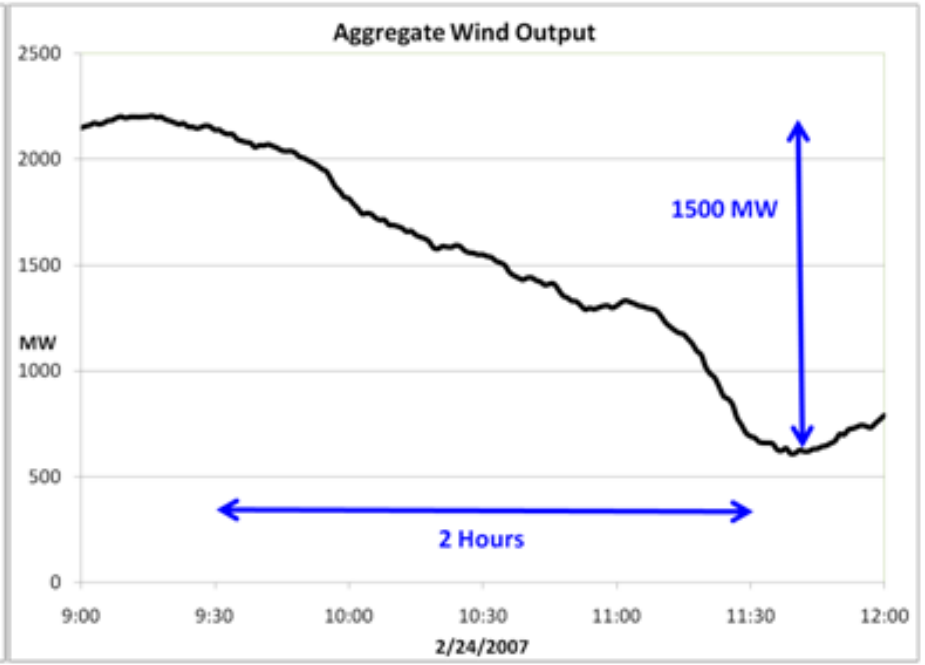


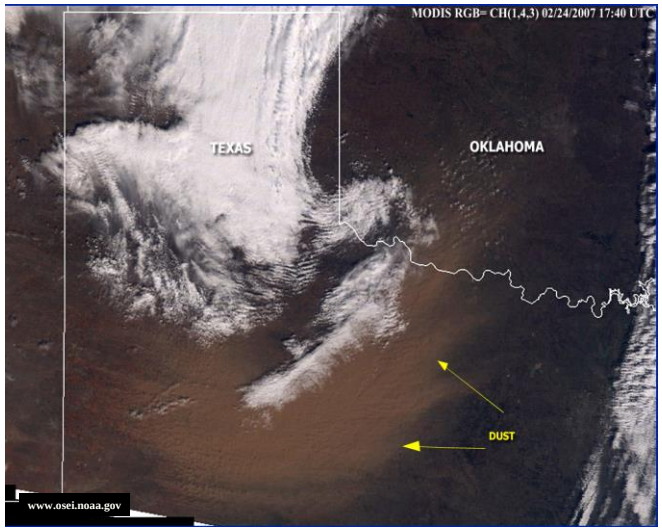
Figure: Impact of wind power controls regulation, dispatch, and area control error

Source: Public Service Company of Colorado

How often does the wind stop blowing everywhere at the same time?



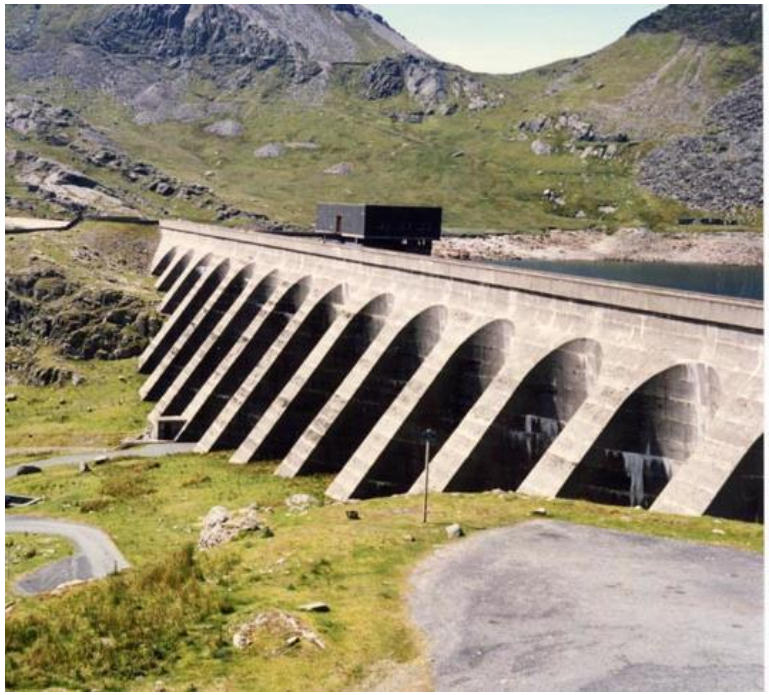




Source: ERCOT, WindLogics

Does variable renewable energy generation require storage?

- Storage is always useful, but may not be economic.
- Detailed simulations of power system operation find no need for electric storage up to 30% wind penetration (WWSIS, CAISO, PJM, EWITS).
- 50% wind/solar penetration study in Minnesota found no need for storage (MRITS, 2014)



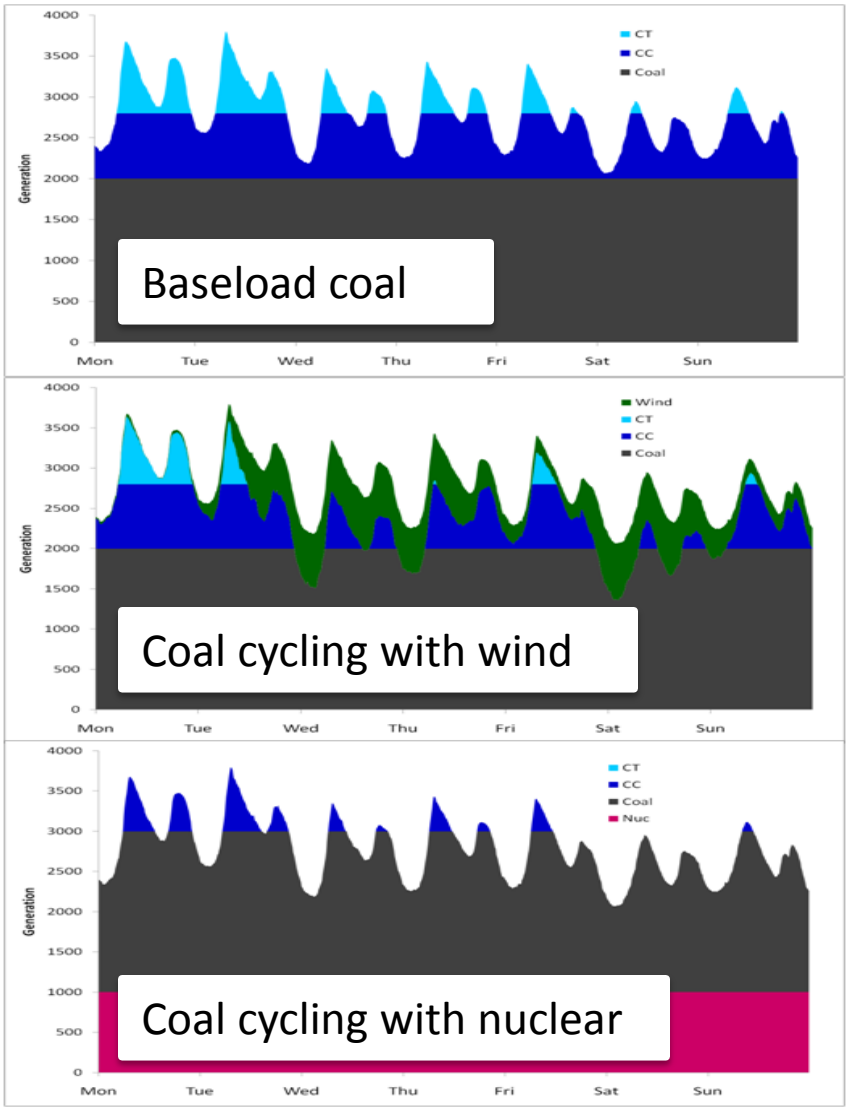
Source: Adrian Pingstone (Wikimedia Commons)

- At higher penetration levels, storage could be of value.
  - Recent E3 integration study for 40% penetration in California: storage is one of many options.

How expensive is integrating variable renewable energy generation to the grid?

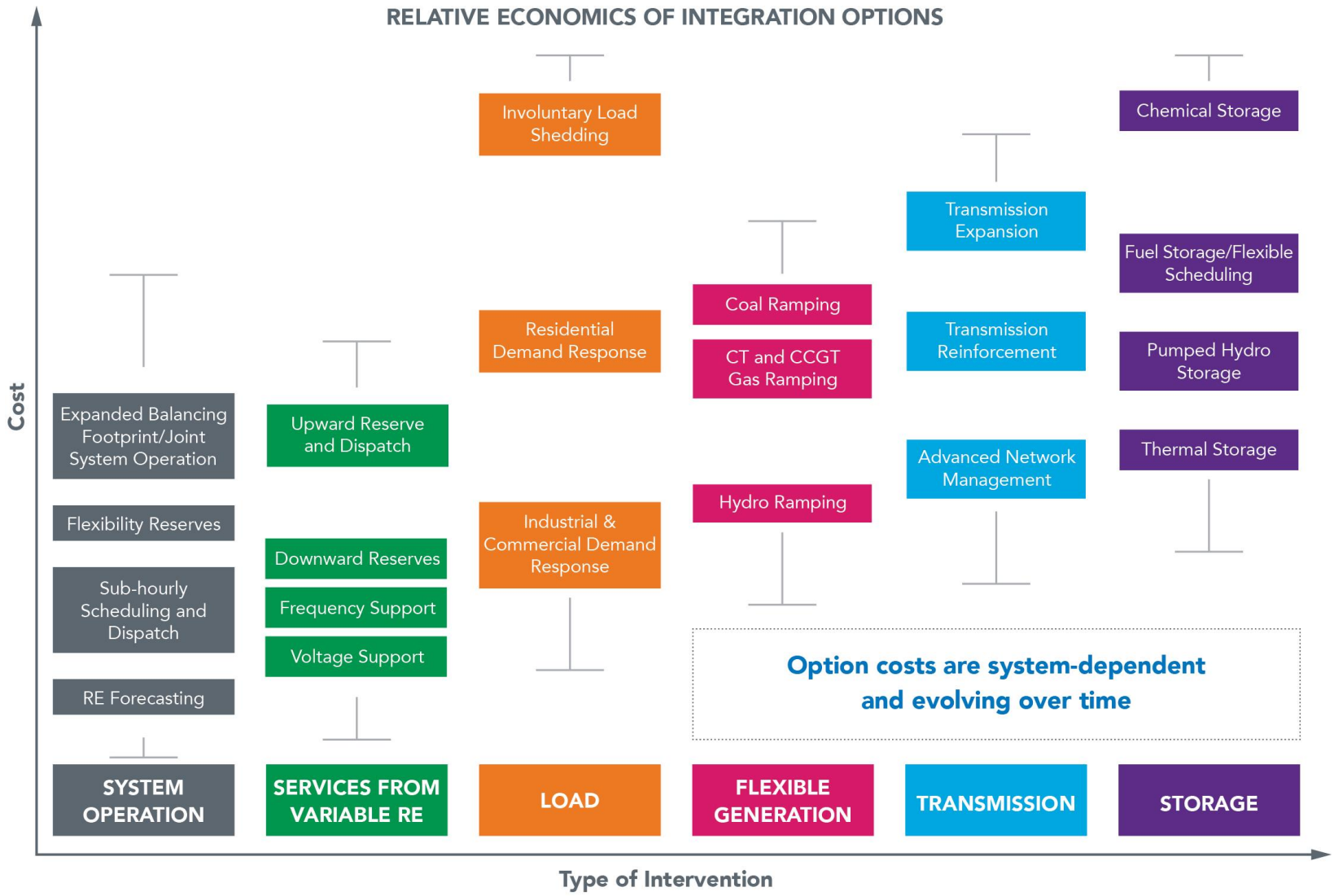
All generation (and load) has an integration cost:

- Any generator can increase cycling for remaining generation
- Conventional plants can impose variability and uncertainty costs
- Conventional plants can create conditions that increase need for system flexibility
  - Must-run hydropower and IPP contracts; thermal plants that cannot be turned down
  - Start-up times for coal require day-ahead scheduling, which is harder for wind



http://www.nrel.gov/docs/fy11osti/51860.pdf

Frequently used options to increase flexibility



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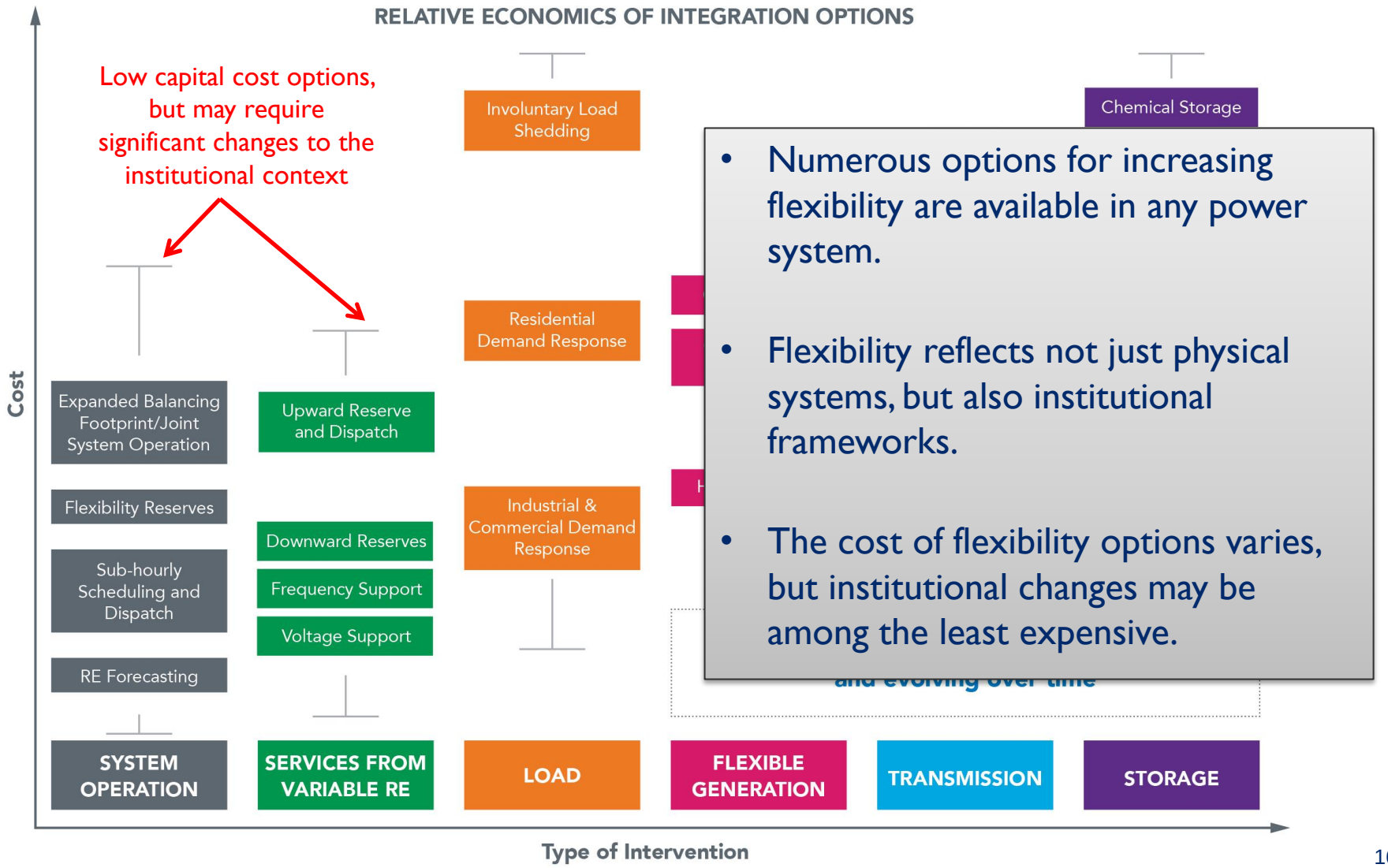

- Numerous options for increasing flexibility are available in any power system.
- Flexibility reflects not just physical systems, but also institutional frameworks.
- The cost of flexibility options varies, but institutional changes may be among the least expensive.