LCOE Perspective

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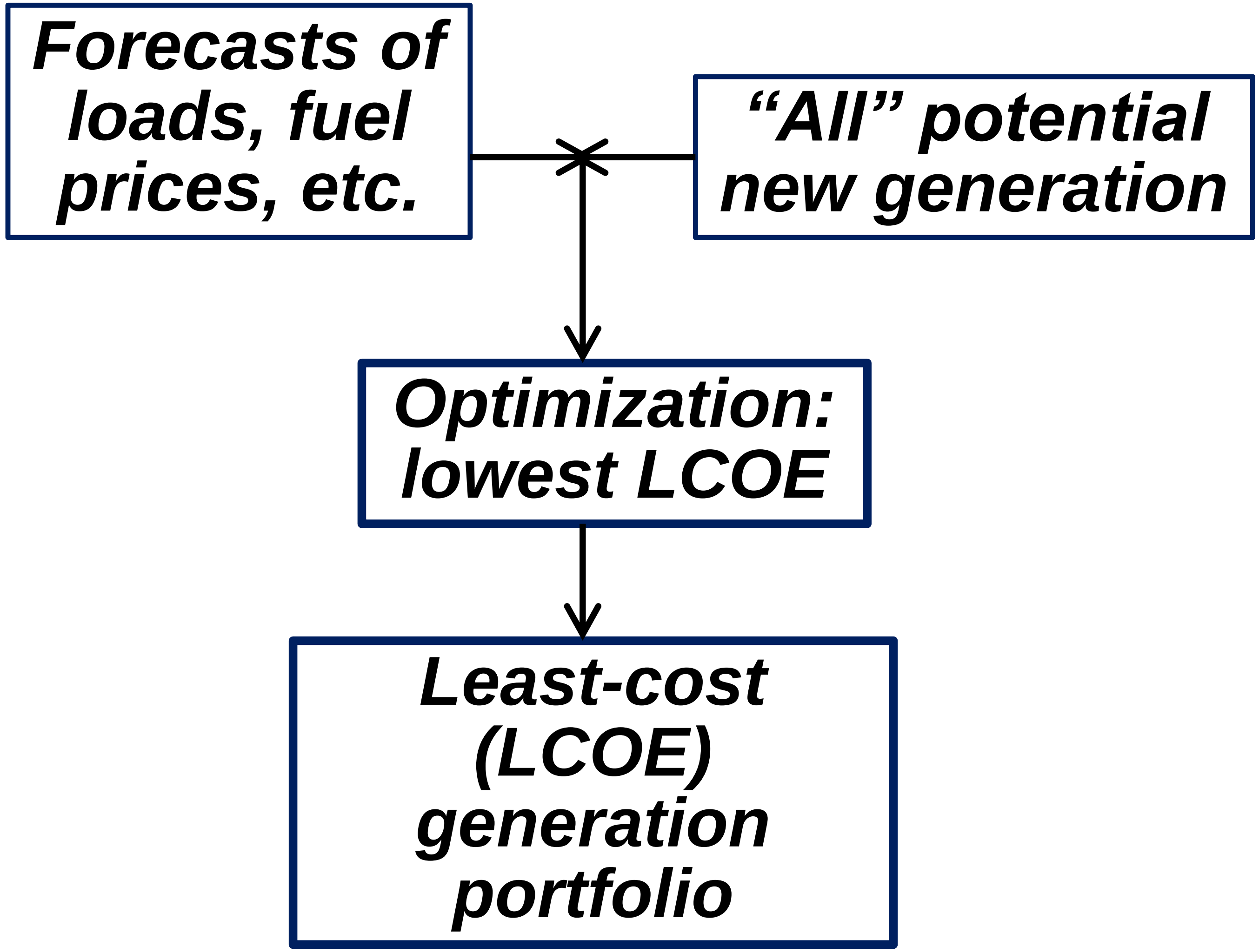
Context

- Traditional generation planning models; search for min LCOE of portfolio
- EGEAS, PowerSym, others…
- Only needed because selecting only the single source with min LCOE won’t work
- What is included: carbon? What discount rate? What are key sensitivities
- Good for basic comparison but is only a single indicator

Example of Uses of LCOE

- Generation (resource) planning



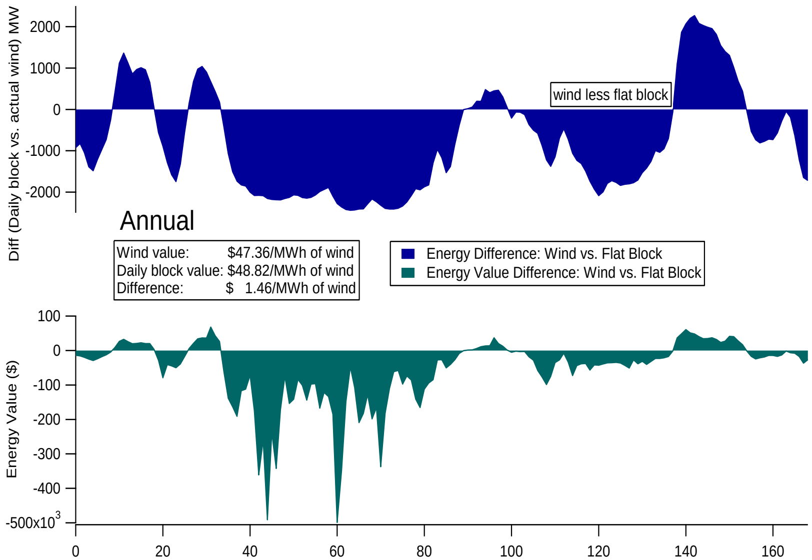
From LCOE to "Integration Cost"

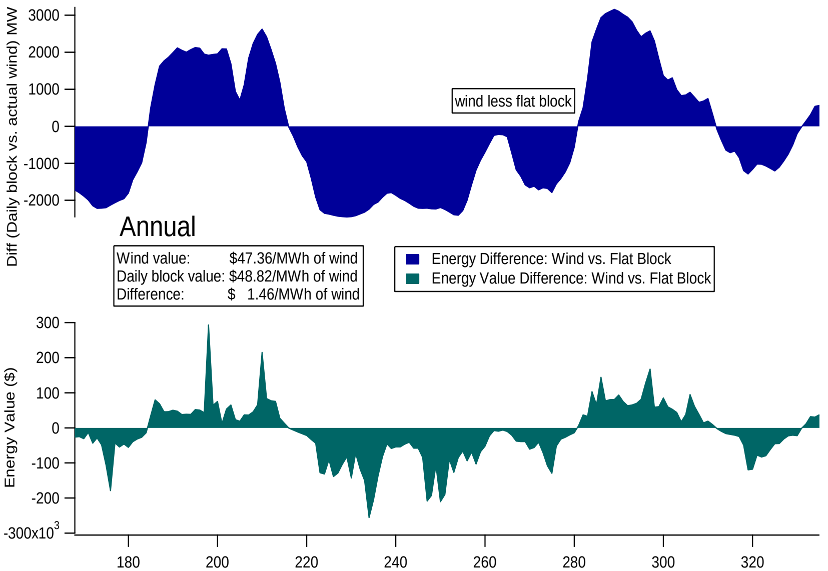
- **In the early 2000's, interest in "adjusting" the LCOE of wind to account for cost of variability+uncertainty**
  - **In spite of methodological problems (more later) these were useful explorations**
  - **The short history: a simple question, but in the ~15 years since this began, there has been *no general agreement* on an acceptable method**

Integration Cost

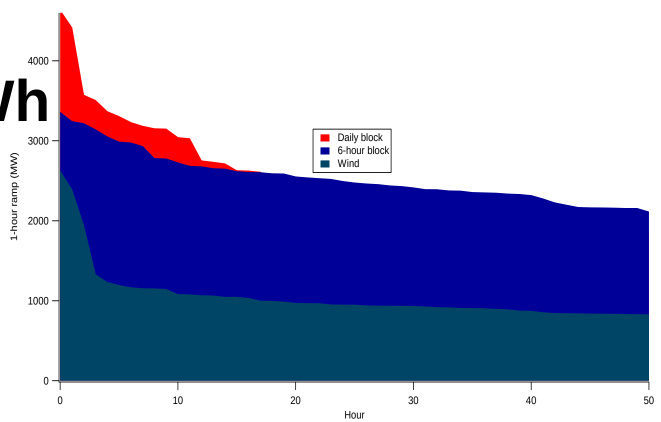
- Calculate incremental cost of wind by simulating system with/without wind
- What to compare wind to? A daily flat block of equivalent energy
- The approach was useful in the early days, showing how system can operate successfully with wind
- However:
  - Multiple, non-linear interactions: ”integration cost” of wind is heavily influenced by system flexibility and other factors
  - “Everything” has an integration cost; should we calculate them all?

Relative market values of the daily block and wind change from week to week





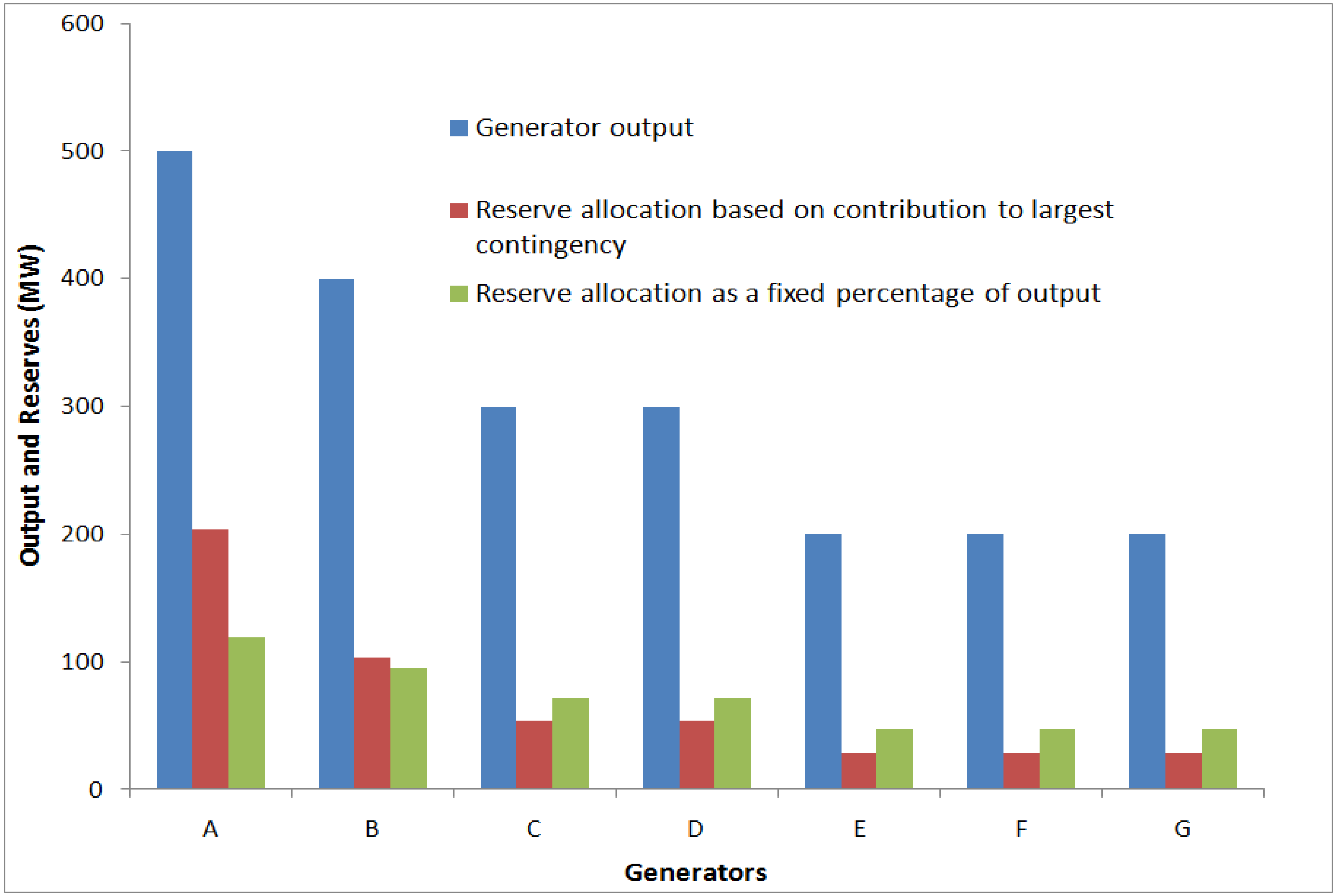
- Annual wind value $47.36/MWh
- Annual daily block value $48.82/MWh
- Difference $1.46/MWh
- Ramping artifact



Graph from NREL – citation at end.

Large units can have an integration cost

- **Many costs are shifted from one resource to another: Example of contingency reserves**



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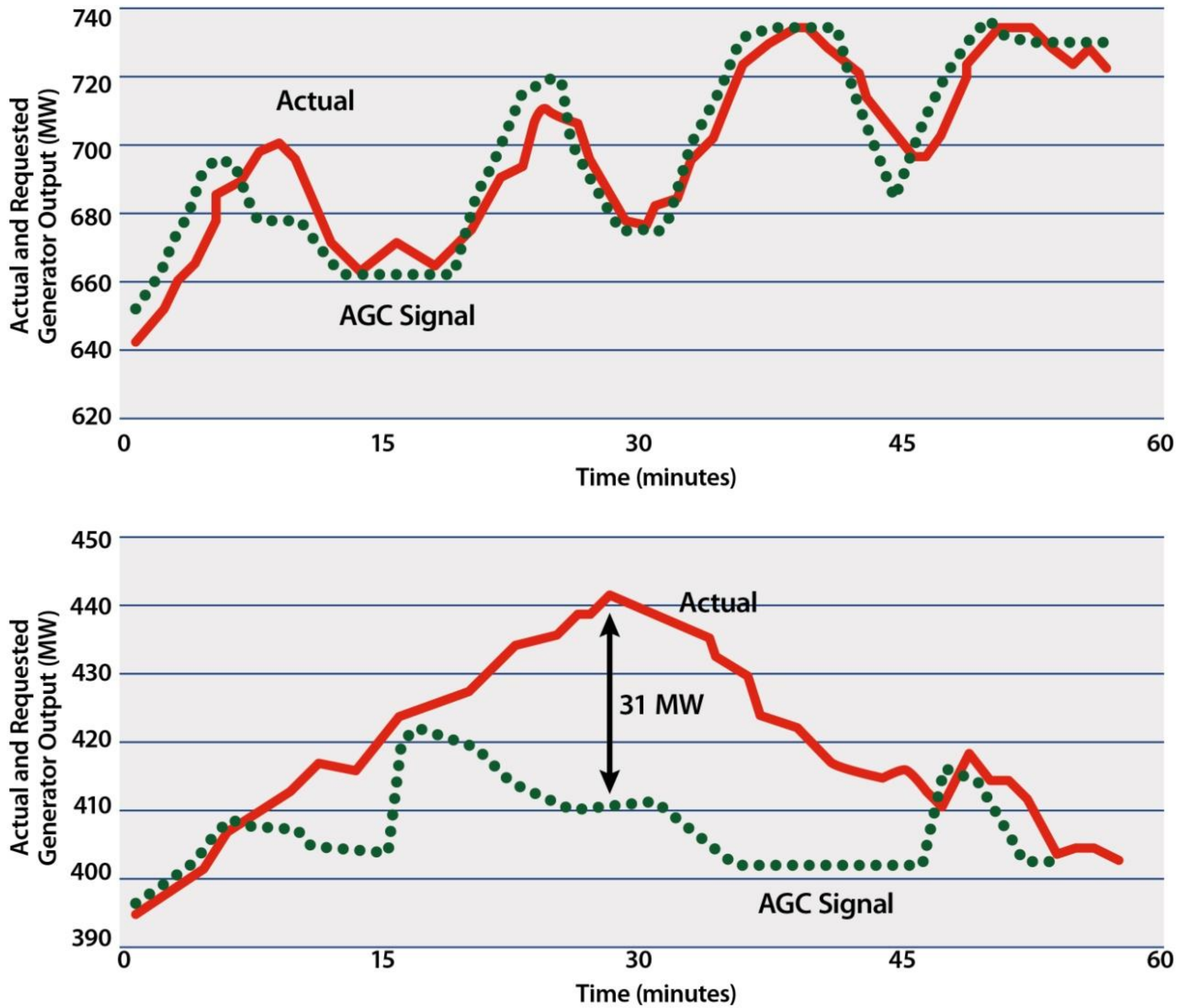
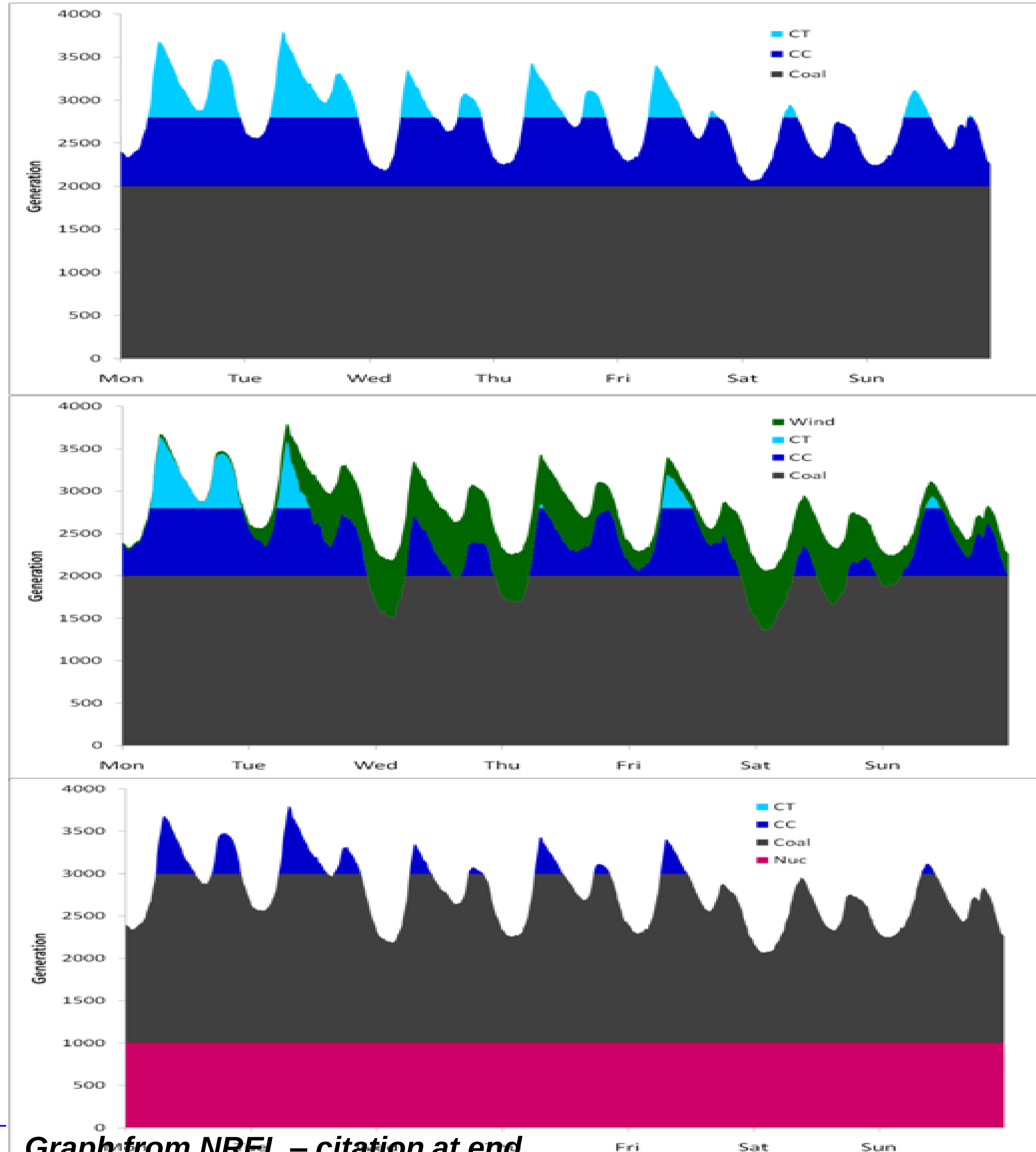
Other units impose a cost of variability

- **Actual data from 2 thermal units which were selling regulation into MISO**



Graph from NREL – citation at end.

- **Even base-load generation has an integration cost**



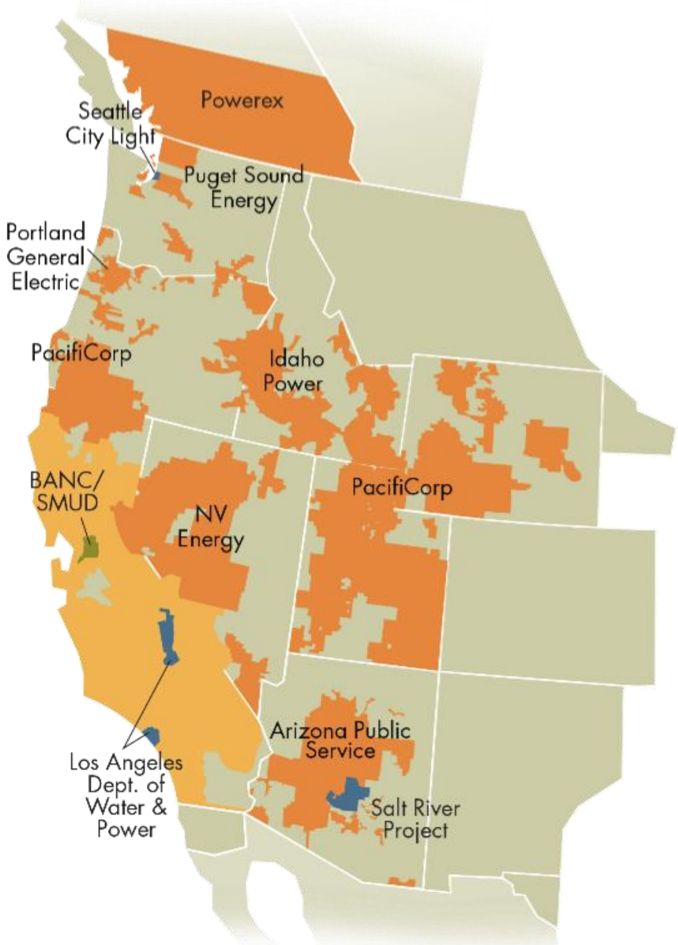
Graph from NREL – citation at end.

Anomalies were not uncommon

- **Example: PSCo Integration Study, circa 2005-6**
- **Interest in calculating impact of gas prices on wind integration cost**
- **As gas prices increased from ~$3.00/MBTU to ~$7.00, the integration cost increased**
- ***However*, no recognition of the increased benefit of wind in reducing expensive gas burn**

Inefficient Market Design/Flexibility has an Integration Cost

- **Example Energy Imbalance Market (EIM) work found savings of ~$300B/year of a full-fledged EIM in the West**
- **According to CAISO 10/1/2018 last quarter savings of the EIM were $71M.**
- **The "integration cost" of small, slow dispatch in the West could be interpreted as the benefit of the EIM**



CAISO https://www.westerneim.com/Documents/ISO-EIMBenefitsReportQ2_2018.pdf

Inflexible Generation has an Integration Cost

- **Min-gen constraints have an impact on system operation**
  - **Increase VG curtailment**
  - **Increase costs by imposing a constraint on the economic dispatch**

Why so many difficulties?

- Sum of all parts may not equal the whole
- Focus on one component without taking big-picture into account
- “Benchmark” unit doesn’t exist, and other resources were not subject to these analyses
- No well-accepted method has emerged in the last ~15 years, which indicates significant methodological problems

Moving beyond integration cost

- **UK ERC http://www.ukerc.ac.uk/publications/the-costs-and-impacts-of-intermittency-2016-update.html**
- **"Different categories of impact …create(s) the risk of double-counting some elements of costs, and the possibility that the benefits offered by particular types of generator are not accurately represented in some cost estimates."**
- **Most folks have moved on, in favor of more all-inclusive estimates of costs/benefits (IEA Task 25 paper Milligan, Kirby, Holttinen, et al (in references)**

Lessons Learned

- Isolating "integration cost" is difficult, or (more likely) impossible.
- The sum or the parts vs. the whole→LCOE of a part may be hard to interpret
- Emerging best-practice: Comparison of all-in costs

References

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- Also see Stark, (2015) A Systematic Approach to Better Understanding Integration cost. NREL Technical report https://www.nrel.gov/docs/fy15osti/64502.pdf

Thank you!

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