Briefing on regional resource adequacy initiative

Some Comments on Capacity Credit Calculations

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Reference: C. Bothwell and B.F. Hobbs, "Crediting Renewables in Electricity Capacity Markets: The Effects of Alternative Definitions upon Market Efficiency," Working Paper, Johns Hopkins University (Posted on MSC Website)

Thanks to JHU Ph.D. Student Cindy Bothwell and NSF grant OISE 1243482 (WINDINSPIRE)

Problem Definition

- Adequacy ≡ When system resources suffice to meet demand
  - With a predetermined reliability standard (e.g., LOLP = 1 day in 10 years)
- Capacity counting for RA constraint:

  $$\text{SUM}_i \ \text{Credit/MW}_i \ * \text{Installed Capacity}_i \geq (1+\text{RM})*\text{Peak Load}$$

- *Question:* Can market rules about counting RA capacity influence/distort (1) investment amount, type, and location, and (2) overall cost of meeting load?
  - Interaction with other market rules:
    - Energy price caps
    - Renewable portfolio standards, subsidies

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Hypothesized Consequences of Inaccurate Counting of Wind Capacity

- If we *under credit* capacity in adequacy studies, then might:
  - Might build too much *or* too little of capacity type in question
  - Build capacity of other types that doesn't get used, and increase reliability beyond standard
- If *over credit* capacity, then might:
  - Might build too much *or* too little of capacity type in question
  - Build too little of everything, and lower system reliability below standard
- If *don't differentiate* crediting of renewable capacity by location, might:
  - Insufficiently diversify renewable portfolio
  - Bias renewable portfolio towards high capacity factor resources rather than resources that truly contribute to system adequacy

Principles

Given an energy & A/S market design (e.g., flexiramp, energy/bid caps RPS), to minimize the social cost of investment, fuel, and outages:

1. Set Credit/MW_i to "equalize the reliability value of 1 MW of capacity" (Ontario System Operator, 2014)
   – Recognize the *marginal contribution* to decreasing LOLP or Expected Unserved Energy (EUE) (or other reliability metric)
   – Recognize *diminishing returns*: resource type's marginal contribution decreases as penetration increases (and so is less than average contribution)
   – Recognize *location*: due to resource diversity, a variable renewable at one location will have a different marginal contribution than elsewhere
2. Recognize that periods when system reliability is at most risk may *not* be at system (load) peak, & will change with renewable penetration
3. Set RM at level such that the reliability standard (e.g., 1 day in 10 years) is just met (given the assumed Credit/MW_i values)
   – Ideally, have demand curve that recognizes diminishing value of RA

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Wind Capacity Counting Methods:

Results in wind values of 12% to 33% for our ERCOT case study

- Capacity Factor During Peak Hours (an average)- PJM, NYISO & IESO
  - Attempts to consider load by choosing hours when high load typically occurs but too broad
- Median Output During Peak Hours – ISO-NE
  - Generally a better measure than average for skewed data, but still considered too many hours and not wind-solar interaction with load
- Top 5, Top 20 load hours - ERCOT
  - Considers load but not the load-wind-solar net effect
  - Not broad enough, could miss the net effect
- $50^{th}/10^{th}$ Percentile of seven days surrounding peak load – ENTSO-e
  - Not broad enough, could miss the net effect
- 70% of peak hours - CAISO
  - Again very broad, misses actual correlation with load
- ELCC – Effective Load Carrying Capability - MISO
  - Considers all 8760 hours net effect on reliability
  - Measured in time (LOLP & LOLE), not lost load (MWh)
  - Gives wind the same value in all hours

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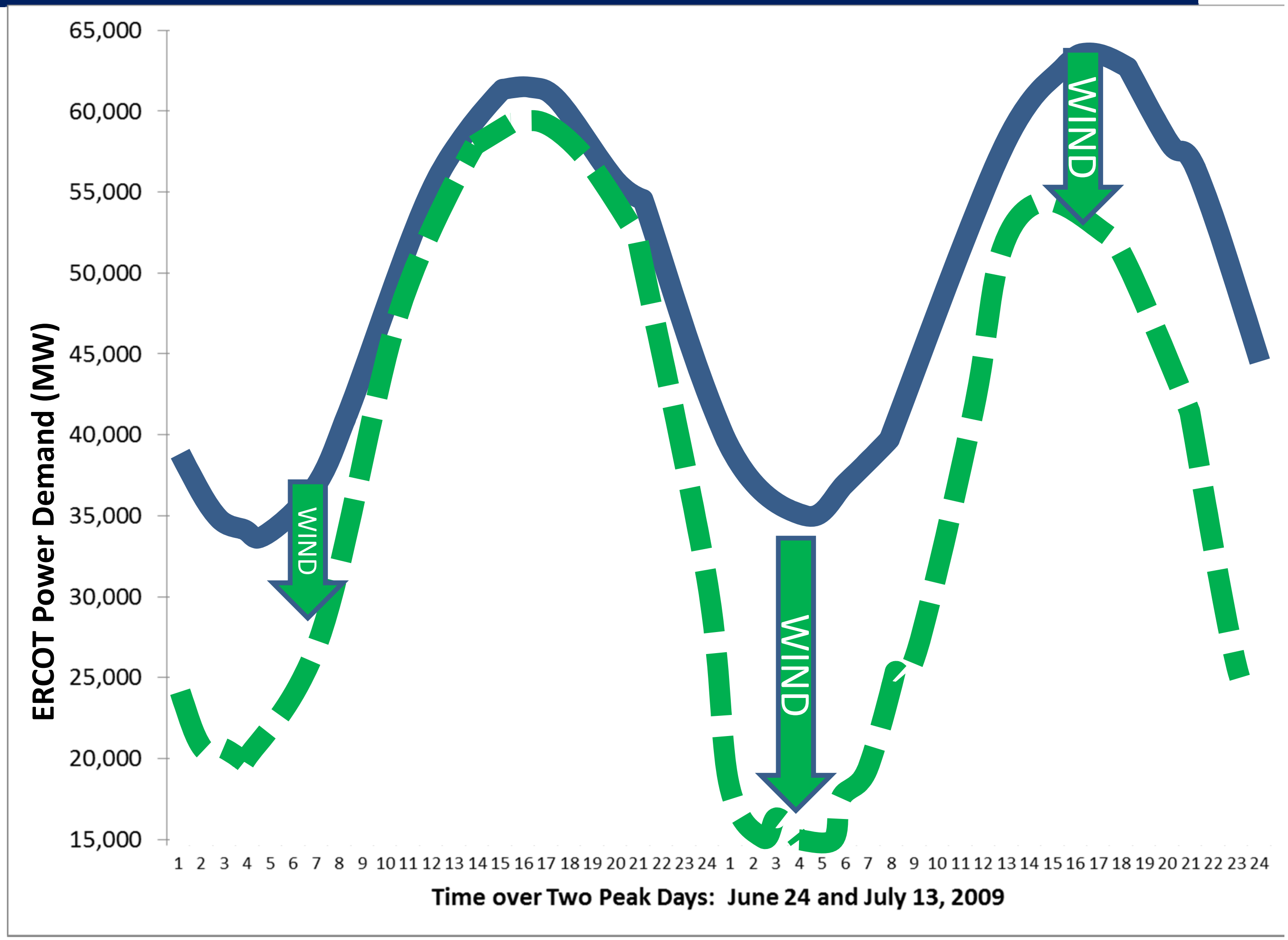
When Count Capacity?

Time of load peak may not have highest risk

- ***Gross Peak:*** **Wind given high credit**
- ***Net Peak:*** **Wind actually provides little capacity**



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Market Designs Considered & Potential Distortions

- **ERCOT system, existing coal & new other capacity, USDOE costs, 10 yrs of load, wind, & solar data**
- **Economic ideal: Let customer decide, no price cap → prices can reach VOLL = $10,000/MWh**
  - **No capacity market (reserve margin constraint)**
- ***Market simulations* include:**
  - Energy market *price cap*
    - $1200/MWh in market simulations << VOLL
  - Capacity Mechanisms *to make up for overly tight price cap*
    - Various Capacity Credit rules
    - "WCap", "SCap" = wind, solar capacity credit
  - RPS
- **Distortions:**
  - Gen mix
  - Costs
  - *Not* reliability; in each case, adjust RM to achieve optimal EUE (MWh "unserved energy")

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Marginal Capacity Credits

		Capacity Credit (% Installed Capacity) in Optimal Solution	
Resource	Annual Capacity Factor	Optimal 0% RPS	Optimal 40% RPS
Wind Site 1	36.7%	--	8.6%
Wind Site 2	34.5%	--	12.5%
Wind Site 3	42.3%	7.6%	4.0%
Solar Site 1	27.6%	--	28.2%

Locational variation

Diminishing returns

Optimal RM: -1.8% -7.5%

RM is negative because of diminishing returns (marginal RA contribution < average RA contribution)

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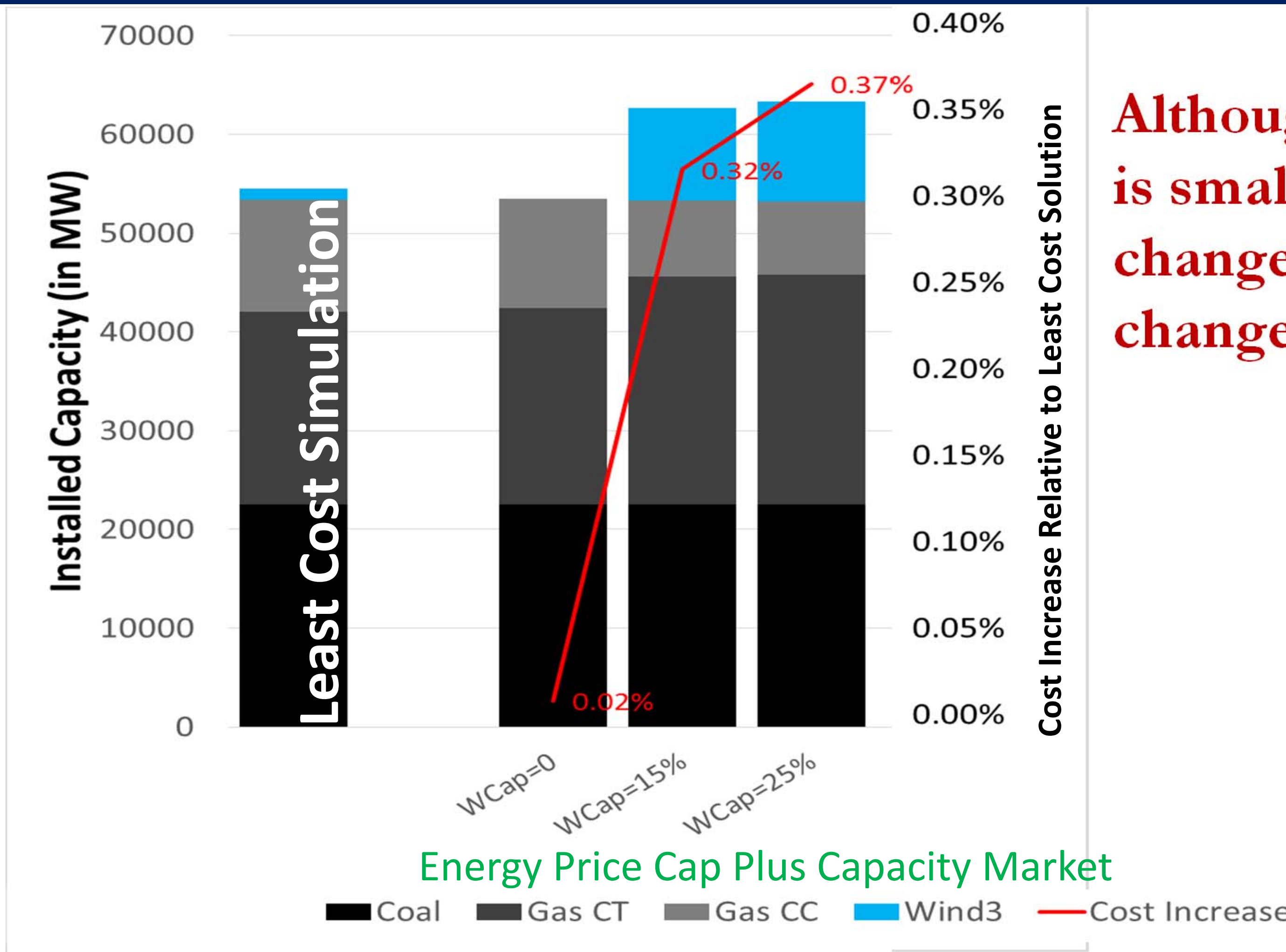
Market Simulations:
Generation Mix & Cost Distortions with 0% RPS



Although cost impact is small, wind mix changes (gas mix changes minimally)

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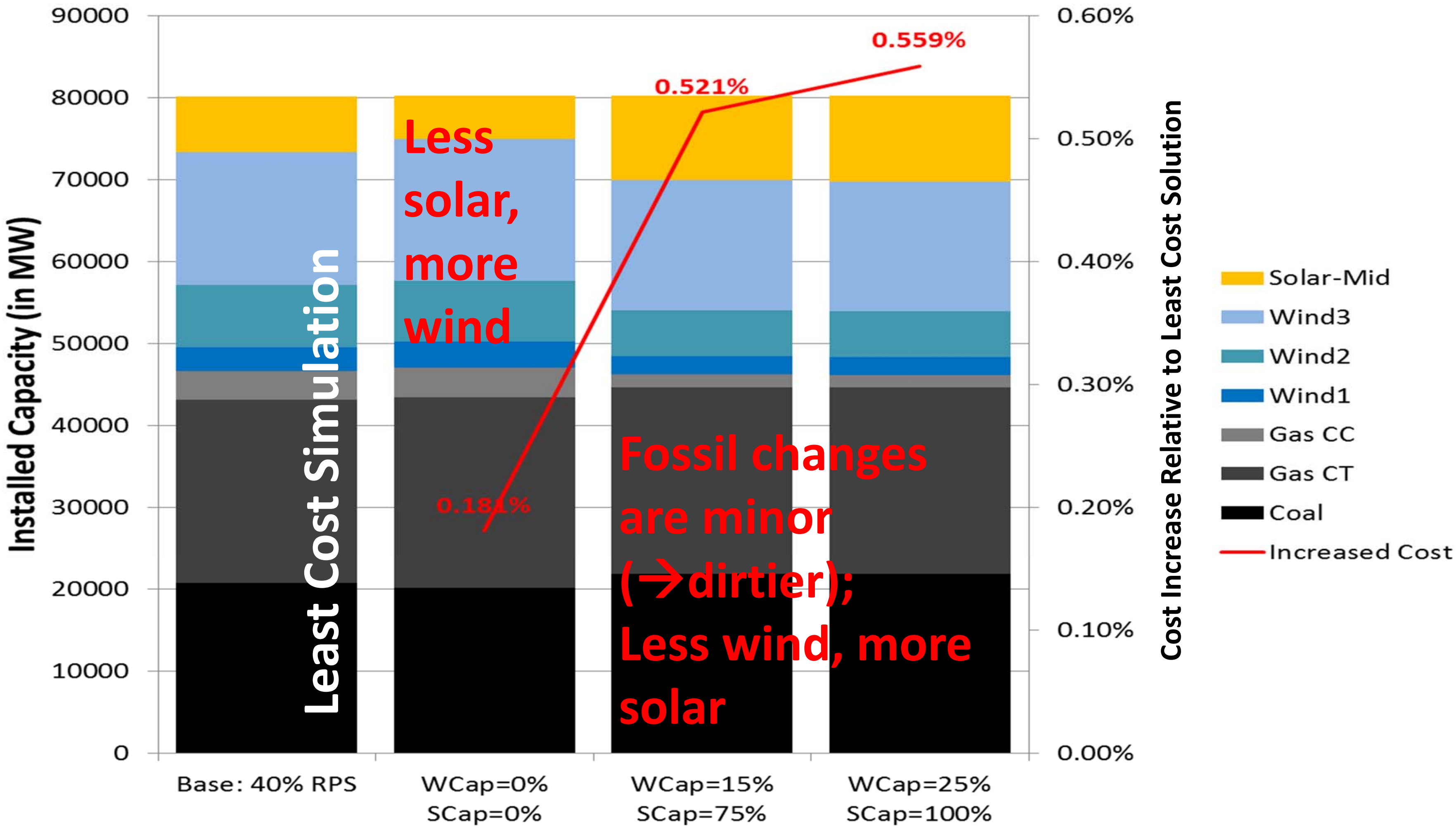
Distortions due to Capacity Credits under 40% RPS



Conclusions

Each resource (individual plant) should receive a capacity credit equal to its <u>marginal</u> contribution, accounting for temporal shifts in Net Peak Load

- Savings could amount to ~0.5% of system cost

Implementing probabilistic RA criteria is challenging in WECC:

- Not just a "convolution" of plant outages/load
  - huge hydro role; reregulation constrained by environmental rules
  - flexibility limits (ramps, max # starts,…)
- Transmission constraints can strongly affect
- Cannot interpret LOLP/EUE as actual load interruptions due to operator actions; just an ordinal index that can be used to rank plans in terms of reliability