The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies

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Presentation Outline

1. **Motivation and Scope**
2. **Approach and Transmission Study Sample**
3. **Results: Unit Cost of Transmission for Wind**
4. **Factors Potentially Affecting Unit Cost Estimates**
   a) Inherent Assumptions in Methodology on Unit Costs
   b) Amount of Incremental Generation Studied and Line Voltage
   c) Length of Transmission Lines
   d) Equipment Cost Assumptions
   e) Transmission Planning Study Methodologies and Objectives
5. **Comparison of Bottom-Up to Higher-Level Top-Down Studies**
6. **Policy Implications and Future Work**

Motivation and Scope

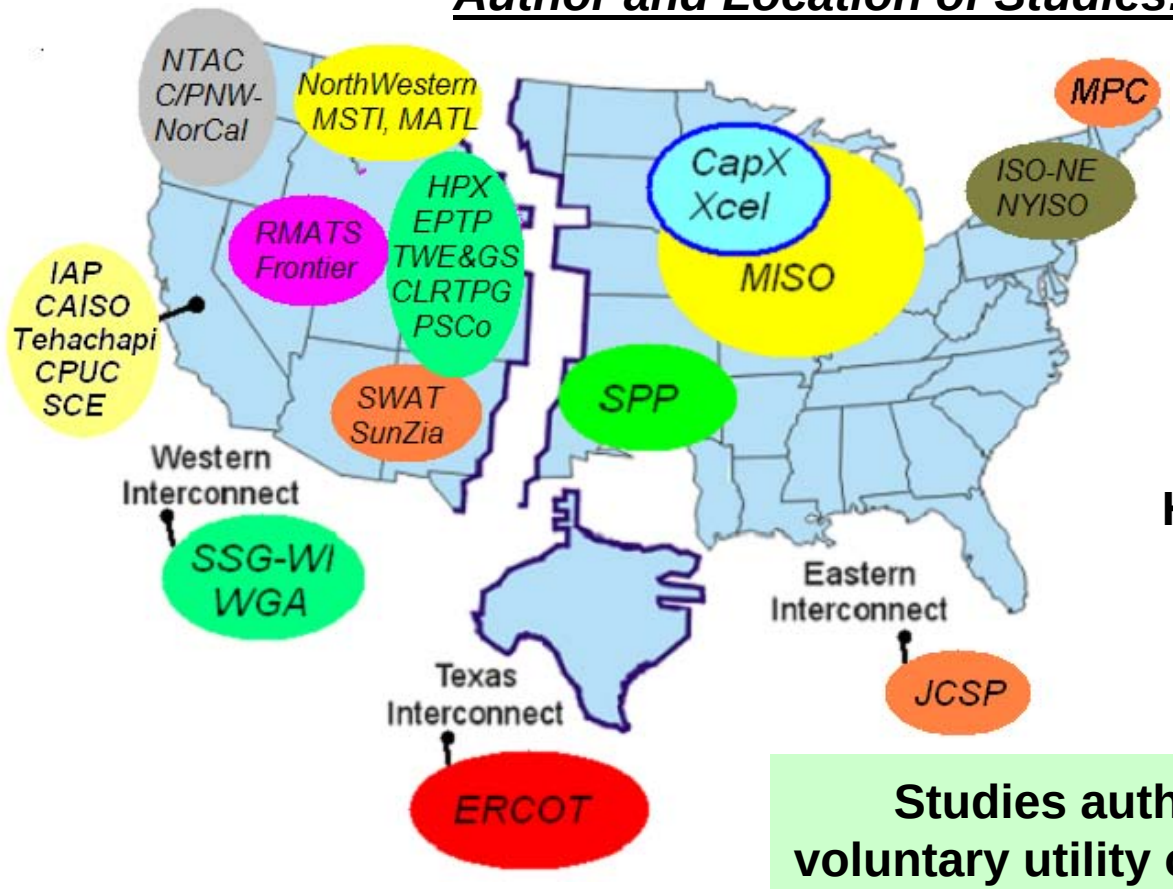
- **Motivations:** Rapid wind power development has been coupled with concerns about the need for substantial new transmission infrastructure. Institutional issues pose major obstacles to transmission construction, but also of concern is the potential cost of this infrastructure build out.
- **Objectives:**
  - Develop a better understanding of the transmission costs needed to access growing quantities of wind generation
  - Highlight differences in transmission planning approaches
  - Inform higher-level assessment models used to estimate the cost of wind deployment (e.g., WinDS, NEMS)
- **Intended Audiences:** Regulators and policymakers who need to assess potential transmission costs for accessing large quantities of wind energy; analysts and transmission planners who want to be more aware of the variety of wind transmission studies and study approaches

Approach

- Review 40 transmission planning studies from across the U.S. that involve wind; study dates range from 2001 to 2008
- Attribute transmission costs to wind by share of nameplate capacity of incremental wind additions (capacity-weighted)
- Estimate the implied unit cost of transmission for wind: total transmission cost attributed to wind divided by incremental wind generation capacity
- Analyze differences in amount of incremental generation, length of transmission, study objectives and methodologies, and transmission equipment cost assumptions that may contribute to wide range in implied unit costs of transmission
- Compare results to two scenarios of 20% wind electricity in the U.S., and the treatment of wind transmission in NEMS

Geographic Location of Studies in Sample

Author and Location of Studies:



Examples of:

Detailed Studies:

Xcel, Tehachapi

Exploratory Studies:

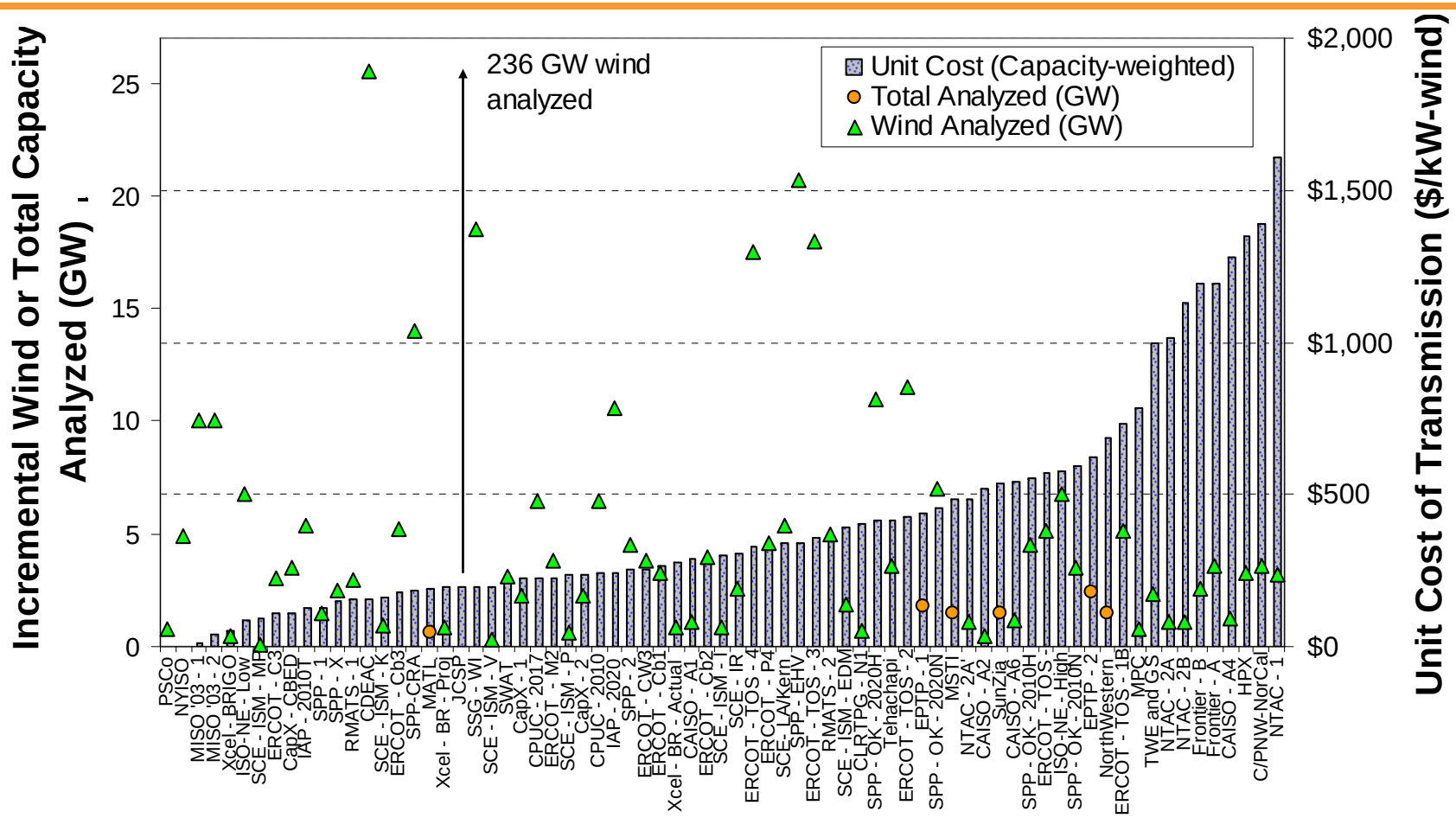
ERCOT, SPP, CapX

Highly Conceptual Studies:

Frontier, HPX, MISO

Studies authored by ISO/RTOs, voluntary utility organizations, State-led organizations, and individual utilities

Range in Transmission Cost for Wind Is Vast, but Most Are Less than $500/kW



Unit cost of median study-scenario is $300/kW; 15 - 23% of the installed cost of a wind plant

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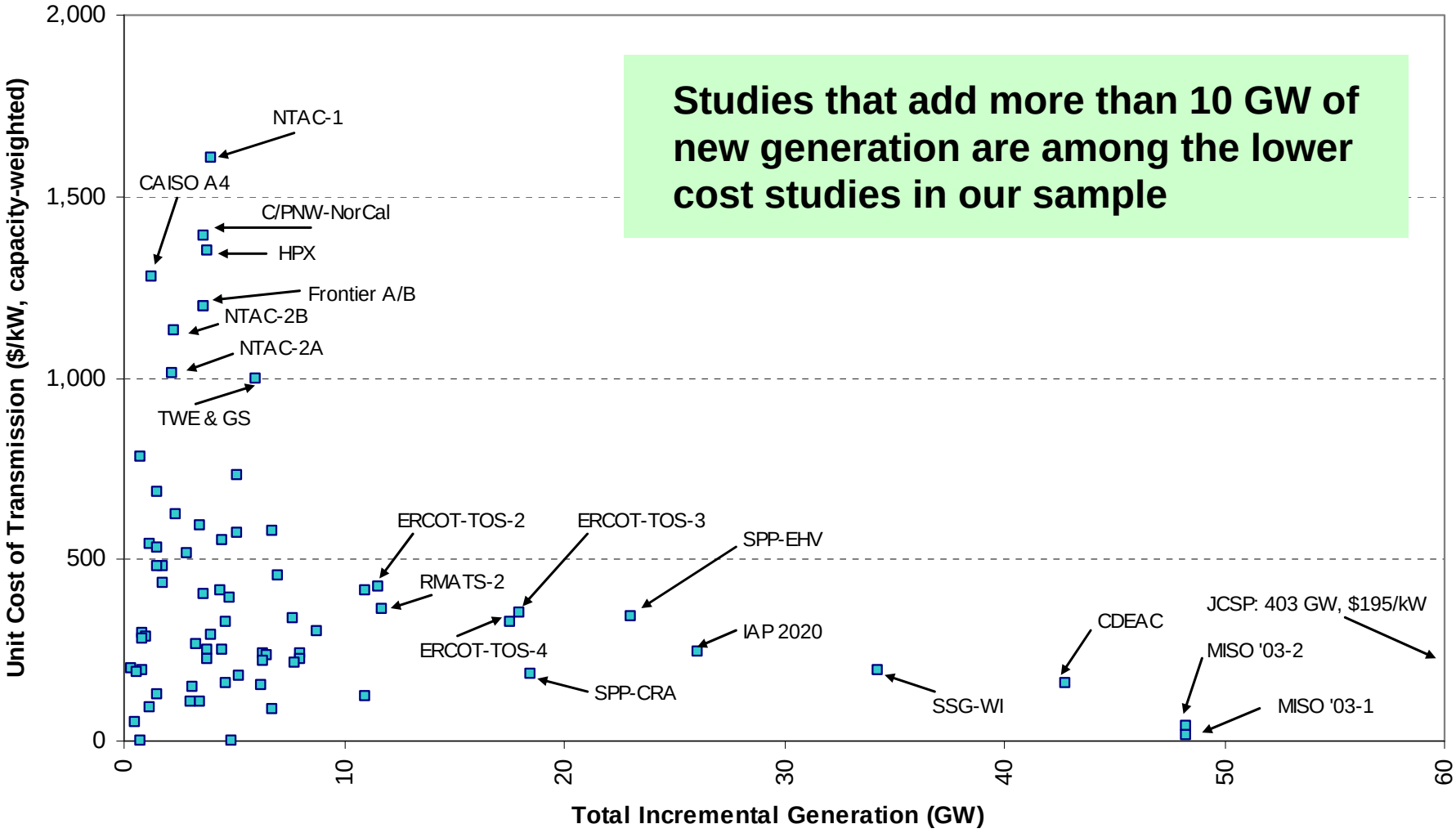
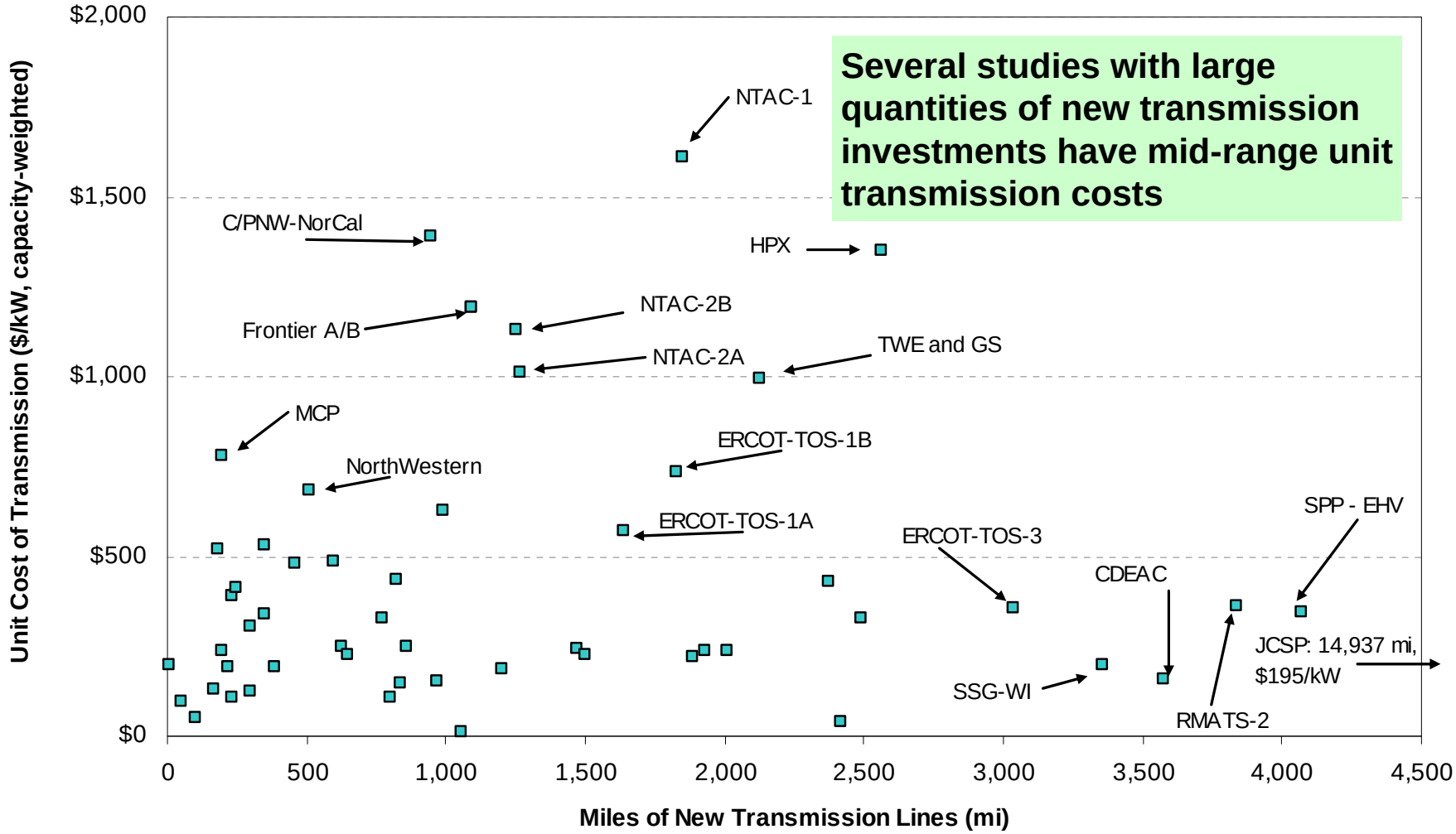
Inherent Assumptions Tend to Overstate Cost Attributable to Wind

- **Assumption 1. Any non-wind generation shares responsibility for new transmission investments**
  - Tends to understate cost of transmission for wind, but analysis indicates this limitation has little effect
- **Assumption 2. Transmission in high-wind future only benefits new generators, and does not relieve pre-existing congestion or defer reliability investments**
  - Tends to overstate cost
- **Assumption 3. Transmission is sized to handle new generators studied in scenario (rather than over-sizing in anticipation of future generator development not considered in scenario)**
  - Tends to overstate cost
- **Assumption 4. Business-as-usual reference case requires no new transmission**
  - Tends to overstate cost

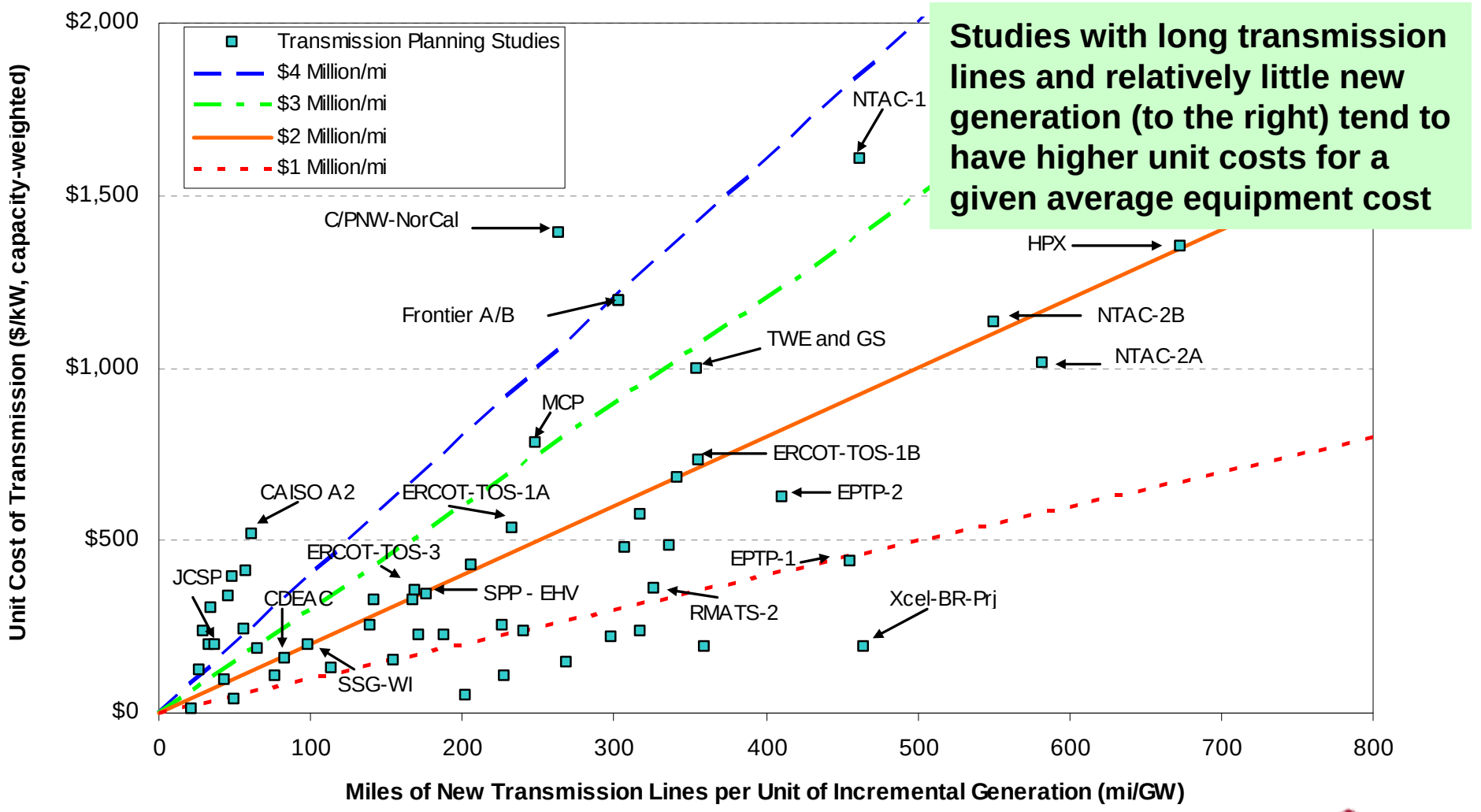
Unit Transmission Costs of Wind Do Not Appear to Increase with Higher Levels of Wind Additions



Unit Transmission Costs Do Not Unambiguously Increase with Increasing Transmission Length



Unit Transmission Costs Increase when Long Lines Are Added with Relatively Little New Generation



Studies with long transmission lines and relatively little new generation (to the right) tend to have higher unit costs for a given average equipment cost

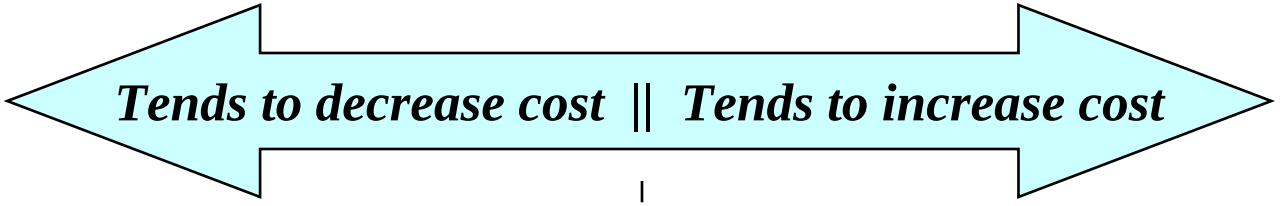
Equipment Cost Assumptions Vary Widely Across Studies

Equipment	Minimum Cost	Maximum Cost	Unit	Number of samples
Transmission Lines				
765 kV (no description)	2.0	3.2	($million/mi)	5
500 kV (single circuit)	1.5	2.2	($million/mi)	6
500 kV (double circuit)	2.0	3.5	($million/mi)	5
500 kV (no description)	0.8	2.6	($million/mi)	10
HVDC Line (800kV)	3.7		($million/mi)	1
HVDC Line (345 - 500kV)	1.1	3.0	($million/mi)	8
HVDC Undersea Cable	4.0		($million/mi)	1
345 kV (single circuit)	0.6	1.5	($million/mi)	4
345 kV (double circuit)	1.0	2.3	($million/mi)	5
345 kV (no description)	0.5	2.2	($million/mi)	10

*Additional 230 kV, 115 kV, and associated equipment cost estimates are available in the report.

Variations influenced by regional factors, when the study was conducted, and the level of detail used in the equipment cost estimates. Differences likely contribute to a portion of the variation in unit costs of transmission.

Variations in Methodology, and the Characteristics of the Grid, May Affect Unit Transmission Costs



General framework:	Congestion focused	Deliverability focused
Objective of building new transmission:	Economically reduce congestion costs created by the addition of new generation	Accommodate the full nameplate capacity of any new generation during a peak snapshot in time
Treatment of wind energy:	Accounts for the expected generation characteristics of wind energy	Treats all new generation the same based on the nameplate capacity of the resource
Transmission system characteristics:	Integrated network of highly connected transmission	Sparsely interconnected transmission lines

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Higher-Level Studies of Wind Transmission Broadly Agree with Mid-Range of Unit Costs from Our Sample

Higher-level study:	Wind capacity:	Implied unit cost of transmission for wind:
20% Wind Energy by 2030: AEP 765 kV Overlay	200 – 400 GW	$150 – 300/kW
20% Wind Energy by 2030: Wind Deployment System (WinDS)	290 GW	$207/kW
Annual Energy Outlook 2008 projections for 2030: National Energy Modeling System (NEMS)	40 GW	$450/kW* *Estimate includes base transmission cost ($316/kW) and long-term multipliers ($133/kW)

Unit cost of median study-scenario in our sample is $300/kW

Policy Implications and Future Work

- **Range of transmission costs for wind implied by studies in our sample is vast:** Total range in unit costs across sample is from $0 to $1,500/kW. More comparative work is needed to understand how differences in study objectives, methodologies, and assumptions can impact the resulting cost estimates.
- **Mid-range implied unit transmission costs for wind, though not insignificant, are also not overwhelming:** The median cost of transmission for wind among all scenarios in our sample is $300/kW; roughly 15% of the current cost of building a wind project or 23% of the cost of building a wind project in the early 2000s.
- **Little evidence that higher levels of wind penetration require dramatically increased unit transmission costs:** Confirmed by two top down scenarios of 20% wind energy in the U.S., the JCSP study of 20% wind energy in the Eastern Interconnection, and by a number of bottom-up studies that add greater than 10 GW of new generation.

For more information…

Download the report:

http://eetd.lbl.gov/ea/ems/re-pubs.html

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