



The Brattle Group

Evaluating the Economic Benefits of Transmission Investments

Johannes Pfeifenberger and Sam Newell

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Agenda

I. Background

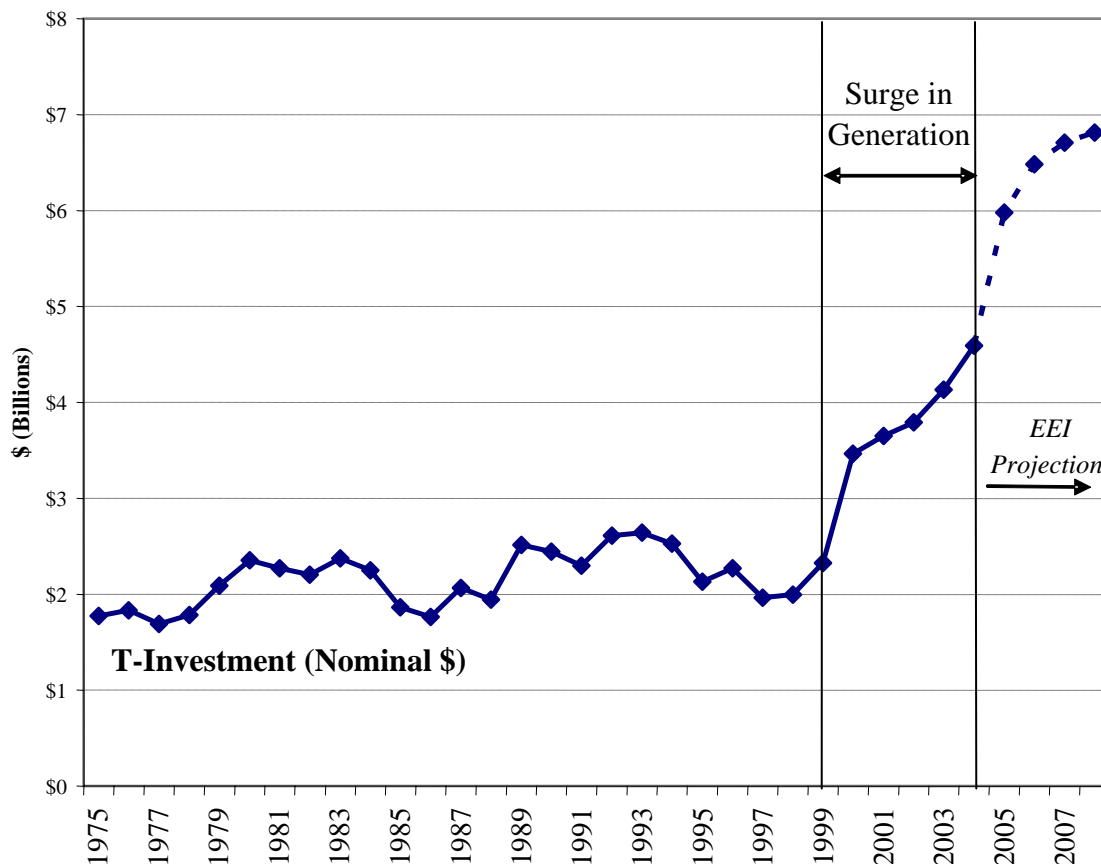
II. Limitations of Standard Economic Modeling Tools

III. Quantification of “Other Benefits”

IV. Conclusions

Background: Increasing Transmission Investments

Transmission Investments by Investor-Owned Electric Utilities



Source: The Brattle Group, EEI, FERC Forms 1.

- Transmission investment was flat (declining in real terms) for 20 years, until late 90s
- Significant increase in investment in 2000-04, coinciding with surge in generating capacity
- EEI survey of investor-owned utilities identified significant further increase in transmission investment

Reliability vs. Economic Justification

- **Most transmission investments are justified as “Reliability Projects”**
 - ▶ Clear-cut determination of “need” due to reliability standard (e.g., NERC criteria) or regulatory requirements (e.g., resource adequacy) without much second guessing
 - ▶ Potentially leaves out economically-sound investments in new transmission facilities and technologies
 - ▶ Missed opportunities to select reliability project alternatives based on economic value?
- **Relatively few “Economic Projects”**
 - ▶ Despite headlines and some large projects, relatively few economically-justified projects are underway
 - ▶ **Requires assessment of complex and often controversial interaction between transmission and power markets**
 - ▶ **Economic evaluation procedures are not sufficiently developed**

Opportunities for Transmission Technology

- **Significant opportunities for advanced transmission technologies**
 - ▶ Improved management of loop flow and congestion
 - ▶ Advanced technology to avoid or delay siting of new lines
 - ▶ Better reliability and improved system response
 - ▶ Economic value in addition to addressing immediate reliability concerns
- **Additional economic value offered by new technologies often not easily quantifiable with available modeling tools**

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Limits in Modeling Economic Benefits

- **Security-constrained dispatch simulation models are the primary tool used to assess economic benefits**
 - ▶ Measures changes in production costs, power flows, LMP, and congestion
 - ▶ Allows for different definitions of “benefits”, but provides incomplete picture of total transmission-related value
- **Limits of simulation models are easily overlooked**
 - ▶ Despite fancy modeling tools, results remain assumptions-driven (simplifications; short-term vs. long-term; contracts are often ignored)
 - ▶ Different metrics used to interpret results
 - ▶ Many “other benefits” not captured in modeling efforts

Most Models Do Not Address Important Benefits

- **Simulation models do not typically capture a wide range of transmission-related benefits:**

“The real societal benefit from adding transmission capacity comes in the form of enhanced reliability, reduced market power, decreases in system capital and variable operating costs and changes in total demand. The benefits associated with reliability, capital costs, market power and demand are not included in this [type of] analysis.”

(SSGWI Transmission Report, Oct 2003; emphasis added)

- **Still, potentially large but hard-to-quantify “other benefits” are too often dismissed as “qualitative,” “indirect” or “intangible”**
- **Narrow scope gets “baked” into RTOs’ C/B frameworks**
- **Can lead to rejection of desirable projects; can also create an exaggerated perception of winners and losers (e.g., high vs. low side of a constraint)**

Interpretation of Model Results Can Differ Widely

- **RTOs' cost-benefit metrics are increasingly relying on specific interpretations of modeling results**
- **Benefits to whom?**
 - ▶ Societal vs. customers vs. generators vs. transmission owner
 - ▶ System wide vs. zonal impacts
 - ▶ Market-based or cost-of-service-based generation
- **What types of benefits?**
 - ▶ Production costs vs. market prices
 - ▶ Dispatch costs vs. total resource costs
 - ▶ Congestion charges, FTR allocations, and losses
- **How do benefits vary over time and market conditions?**
 - ▶ Disproportional impact under stressed market conditions and extreme contingencies
 - ▶ Extrapolate short-term results of dispatch models or fully evaluate long-term resource cost impacts

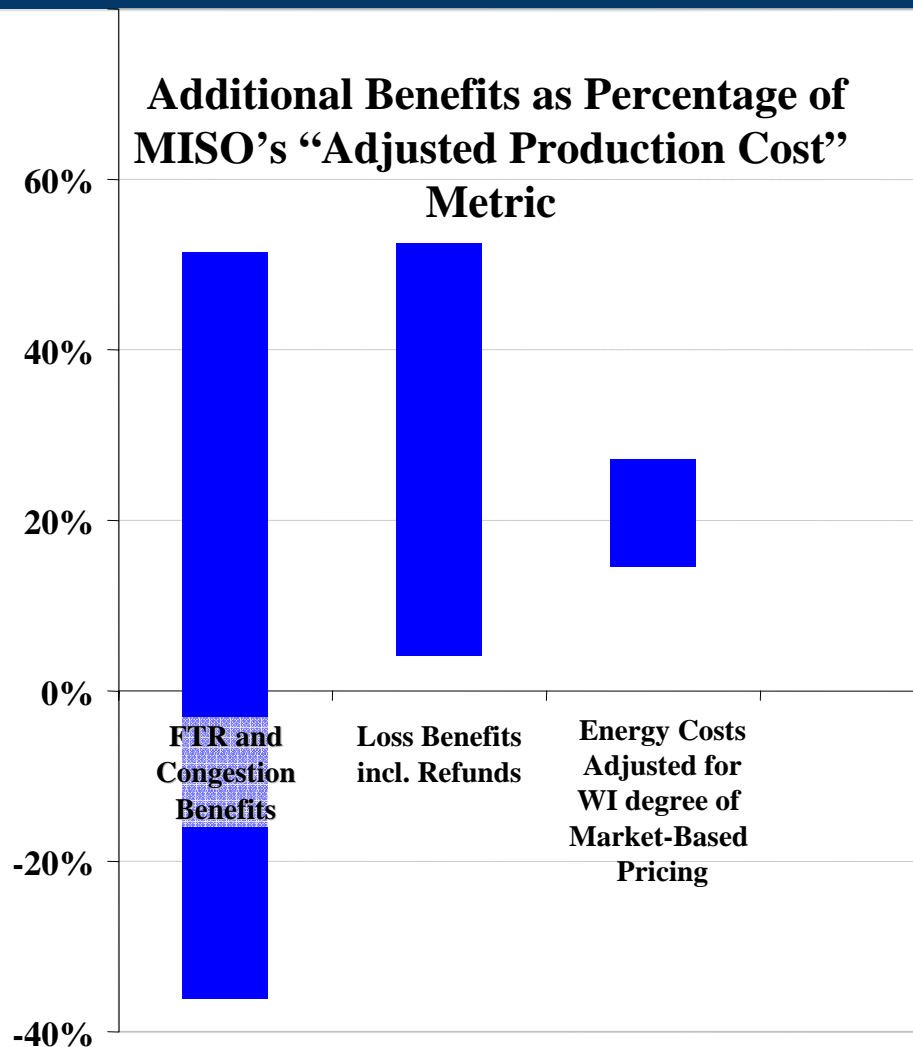
Examples of Alternative Benefit Metrics

- **CAISO TEAM methodology**
 - ▶ Simulation-based Consumer, Producer, and Transmission Owner benefits combined into WECC Societal, WECC Modified Societal, CAISO Ratepayer, and CAISO Participant perspectives
 - ▶ Quantifies expected benefits over a wide range of uncertainties
 - ▶ Explicit efforts to quantify “other” transmission-related benefits
- **MISO metrics** (purely based on dispatch model results)
 - ▶ Adjusted Production Cost
 - ▶ Load LMP (LLMP)
 - ▶ 70% adjusted production costs + 30% Load LMP
- **Impact on utility cost of service (developed for Wisconsin)**
 - ▶ Production costs of utility-owned generation assets
 - ▶ Plus market purchase costs less off-system sales revenues
 - ▶ Plus congestion charges and marginal losses
 - ▶ Less revenues from allocated FTRs and loss refunds
 - ▶ Plus “other” transmission-related benefits

Post-Processing of Metrics is Often Needed

- **Congestion and FTRs**
 - ▶ Expansions reduce congestion and add feasible FTRs
 - ▶ Benefits also depend on extent to which congestion is hedged through existing allocations of FTRs
 - ▶ Can add or subtract 50% depending on market conditions, metric (e.g., production costs vs. LMP), and treatment of imports
- **Losses often not adequately addressed**
 - ▶ Do modeled losses change with transmission investments?
 - ▶ Are marginal losses and loss refunds considered?
 - ▶ Can add 25% to production cost savings (subtract 5-10% from Load LMP savings) plus capacity value of reduced peak load
- **Cost-of-service vs. market-based generation**
 - ▶ Market structure matters!
 - ▶ Can change utility/customer impact by 50%

Example: Post-Processing of “Adjusted Production Cost” Metric in Transmission Study by Brattle and ATC



Source: Preliminary results from analysis of the Paddock-Rockdale project, ATC, 3/07.

- Post-processing of adjusted production costs for estimated FTR coverage of congestion, marginal losses, and degree of market based pricing
- Range shown as defined by 6 futures (out of 7 analyzed) in which the project’s benefits were positive
- Energy cost adjustment and competitiveness benefits can be much larger (multiples) in states that rely more heavily on market-based pricing of generation

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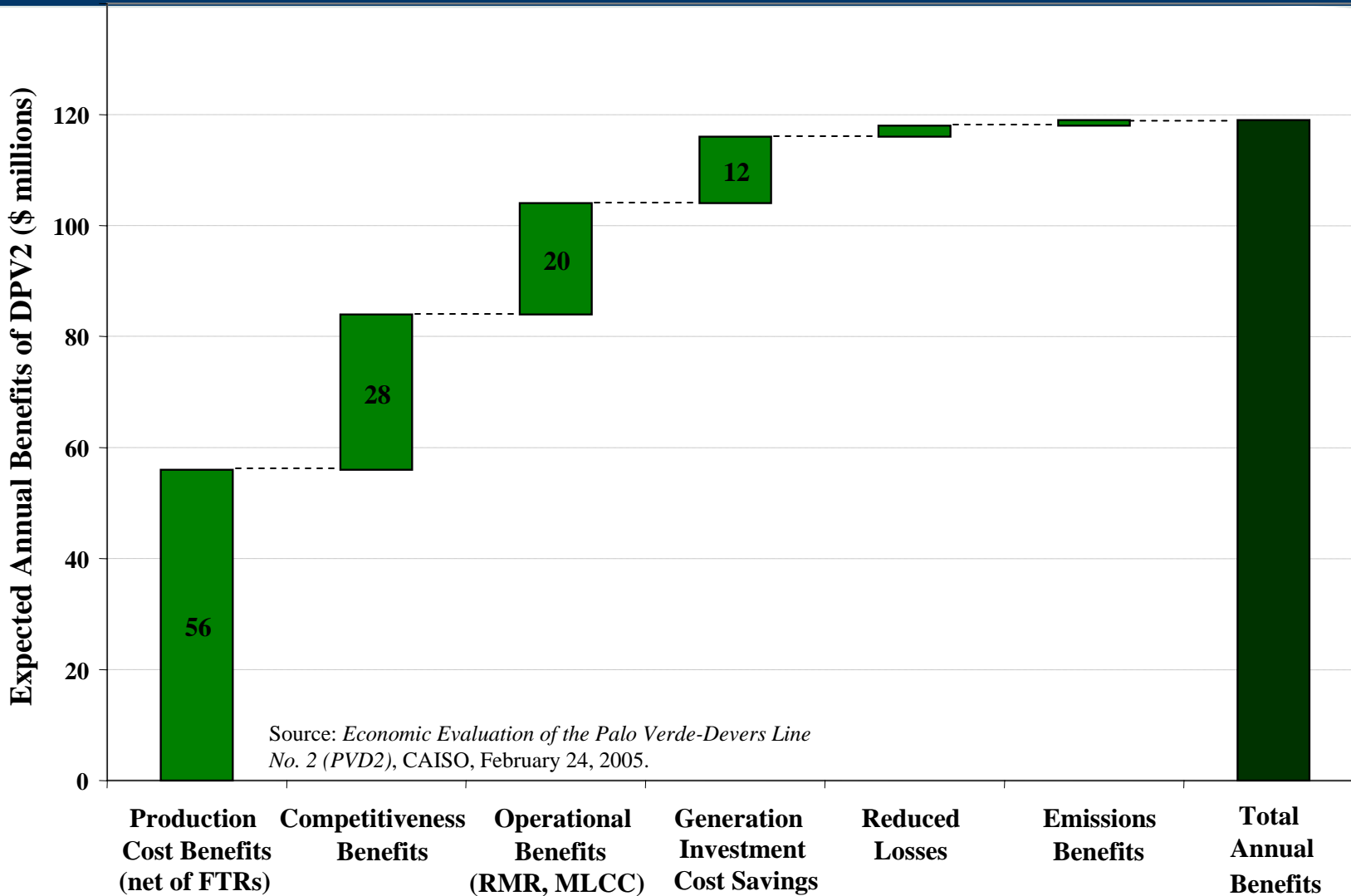
“Other Benefits” of Transmission Investments

Other benefits frequently not captured in simulation analyses but potentially applicable to specific transmission projects include:

- Enhanced market competitiveness
- Enhanced market liquidity
- Reliability benefits
- Added operational benefits
- Insurance and risk mitigation benefits
- Capacity benefits
- Long-term resource cost advantage
- Synergies with other transmission projects
- Impacts on fuel markets
- Environmental benefits
- Fiscal benefits from construction and taxes

Potential overlaps create risk of omissions as well as double counting

Example: CAISO Found Total Benefits of DPV2 are More than Double its Production Cost Benefits



Market Competitiveness Benefits

- **New transmission enhances competition (especially in load pockets) by broadening set of suppliers with access to loads**
 - ▶ Impacts structural measures of market concentration (HHI, PSI)
 - ▶ Various approaches are available to translate improvements in these structural measures into potential changes in market prices
 - ▶ Size of impact differs in restructured and non-restructured markets
- **Can substantially reduce market prices during tight market conditions**
 - ▶ We found competitiveness benefits can range from very small to multiples of the production cost savings, depending on
 1. fraction of load served by cost-of-service generation
 2. the generation mix and load obligations of market-based suppliers
 - ▶ CAISO estimated competitiveness benefits can average 50% to 100% of energy cost benefits (for DPV2 and Path 26 Upgrade), with very wide range (5% to 500%) depending on future market conditions

Market Liquidity Benefits

- **Limited power market liquidity is costly to participants in both restructured and non-restructured markets**
- **Added transmission can increase liquidity of trading hubs or allow access to more liquid trading hubs**
 - ▶ Lower bid-ask spreads
 - ▶ Increased pricing transparency, reduced risk of overpaying
 - ▶ Improved risk management
 - ▶ Improved long-term planning, contracting, and investment decisions
- **Quantification is challenging but benefit can be sizeable**
 - ▶ Bid-ask spreads for bilateral contracts at less liquid hubs are 50 cents to \$1.50 per MWh higher than at more liquid hubs
 - ▶ At transaction volumes of 10 to 100 million MWh per quarter at each of 30+ trading hubs, even a 10 cent reduction of bid-ask spreads saves \$4 to \$40 million per year and trading hub

Reliability Benefits

- **Reliability has economic value**
 - ▶ Average value of lost load easily exceed \$5,000 to \$10,000 per MWh
 - ▶ ***Reliability cost = (expected unserved energy) x (value of lost load)***
 - ▶ About 24 outages per year with curtailments in 100-1,000 MW range, 5 in 1,000-10,000 MW range, and 0.25 in 10,000+ MW range
- **Even “economic” projects tend to improve reliability**
 - ▶ Increases options for recovering from supply disruptions and transmission outages
 - ▶ For example, DPV2 would reduce load drop requirements of certain extreme contingencies by 2300 MW (i.e., \$10-\$100 million benefit for each avoided event)
- **Models tend to understate unserved energy**
 - ▶ EUE/LOLP models often consider only generation reliability, not probability of transmission outages
 - ▶ Dispatch models do not cover full range of possible outcomes; generally also ignore transmission outages and voltage constraints

Added Operational Benefits

- **New transmission projects can reduce certain reliability-related operating costs**
 - ▶ Examples are out-of-merit dispatch costs, reliability-must-run costs, unit commitment costs (RMR, MLCC, RSG, etc.)
 - ▶ These transmission-related operating costs can be a multiple of total congestion charges
 - ▶ Added transmission can also reduce costs by increasing flexibility for maintenance outages, switching, and protection arrangements
- **Dispatch models do not generally capture these costs**
 - ▶ RMR generating units not generally modeled as must-run
 - ▶ RMR costs not explicitly considered
 - ▶ Transmission outages (planned or forced) not generally modeled
- **CAISO estimated operational benefit of DPV2 would add 35% to energy cost savings**

Insurance and Risk Mitigation Benefits

- **Even if a range of “scenarios” is simulated in economic analysis, new transmission can offer additional “insurance” benefits**
 - ▶ Helps avoid high cost of infrequent but extreme contingencies (generation or transmission) not considered in scenarios
 - ▶ Willingness to incur a risk premium to diversify resource mix, reduce range of outcomes in scenarios, and extreme contingencies (risk aversion of customers and regulators)
- **Insurance and risk mitigation value can be quantified:**
 - ▶ Calculate probability-weighted market price and production cost benefits through dispatch simulation of extreme events
 - ▶ Additional reliability value (EUE x VOLL)
 - ▶ Potential additional risk mitigation value if project diversifies resource mix and reduces the cost variances across scenarios

In recent case, value of insurance against high energy costs during extreme events (even ignoring reliability and risk premium) added as much as 25% to production cost savings

Capacity Benefits

- **New transmission can reduce installed capacity and reserve requirements**
 - 1. *Reduced system losses during peak load*** reduces installed capacity requirement
 - On a recently-evaluated transmission project, loss related capacity benefits on average added 5% to 10% to production cost savings.
 - 2. *Added import capability*** may improve LOLE and, as a consequence, allow to reduce local reserve margin requirements or satisfy requirement by improving deliverability of resources
 - Reduced reserve margin or resource adequacy requirements often difficult to attribute to individual transmission projects
 - Still, benefits can be large if a project were to trigger such a reduction (e.g., \$8 million annually if Wisconsin reserve margin requirements could be reduced from 18% to 17%)

Long-term Resource Cost Advantage

- **Impact of transmission on total resource costs (capital and operating) may not be captured in simulation**
 - ▶ Simulations with and without the transmission project, but generally for fixed generation system
 - ▶ Dispatch models do not generally capture capital costs of resources nor the facilitation of unique low-cost generating options
- **New transmission can lower total resource costs**
 - ▶ Make feasible physical delivery from generation in remote locations that may offer a variety of cost advantages:
 - lower fuel costs (e.g., mine mouth coal plants)
 - better capacity factors (e.g., renewables from wind-rich areas)
 - lower land, construction, and labor costs
 - access to valuable unique resources (e.g., pumped storage)
 - lower environmental costs (e.g., carbon sequestration options)

Risk: double counting of capacity and congestion cost benefits

Advantage of lower-cost remote resource can exceed higher transmission-related costs (incl. congestion and losses)

Synergies with other Transmission Projects

- **Individual transmission projects can provide significant benefits through synergies with other transmission investments**
 - ▶ For example, construction of DPV2 improves the economics and feasibility of TransWest Express and Project Zia
 - If failure to site DPV2 delays TransWest Express, each year of delay may forego \$200-300 million in low-cost imports to AZ
 - Transmission to access renewables in New Mexico (Project Zia) also may be uneconomic if California markets cannot be reached
 - ▶ Construction of the Tehachapi transmission project (to access 4,500 MW of wind resources) allows low-cost upgrade of Path 26 and provides additional options for future transmission expansions
- **Economically justified transmission projects may avoid or delay the need for (or reduce the cost of) future reliability projects**

Impacts on Fuel Markets

- **Transmission can reduce fuel demand and prices**
 - ▶ Through dispatch of more efficient plants
 - ▶ Through integration of resources that don't use the particular fuel.
For example, Western transmission projects (Tehachapi, Frontier, TransWest Express) each have the potential to reduce Southwestern natural gas demand by several percent through additional renewable or clean coal generation
- **As a substitute to transporting fuel, transmission projects can benefit fuel transportation markets**
 - ▶ “Coal by wire” can help reduce railroad rates (e.g., in the West)
 - ▶ Accessing generation on the unconstrained side of pipelines
- **These fuel market benefits can be wide-spread**
 - ▶ Additional reductions in generation costs and power prices if fuel is on the margin (e.g., natural gas in the Wouthwest and East Coast)
 - ▶ All fuel users outside the electric power industry benefit as well

Environmental Benefits

- **New transmission can reduce emissions by avoiding dispatch of high-cost, inefficient generation**
 - ▶ Can reduce SO₂, NO_x, particles, mercury, and CO₂ emissions by allowing dispatch of more efficient or renewable generation
 - DPV2 estimated to reduce WECC-wide NO_x emissions from power plants by 390 tons and natural gas use by 6 million MMBtu or 360,000 tons CO₂ per year (worth \$1-10 million/yr)
 - Tehachapi transmission project to access 4,500 MW of wind generation
 - ▶ Can also be environmentally neutral or even result in displacement of cleaner but more expensive generation (e.g., gas-fired)
- **Local-only or regional/national benefits?**
 - ▶ Reduction in local emissions may be valuable (e.g., reduced ozone and particles in heavily populated areas) irrespective of regional/national impact
 - ▶ May not reduce regional/national emissions due to cap and trade (but could reduce the cost of allowances)

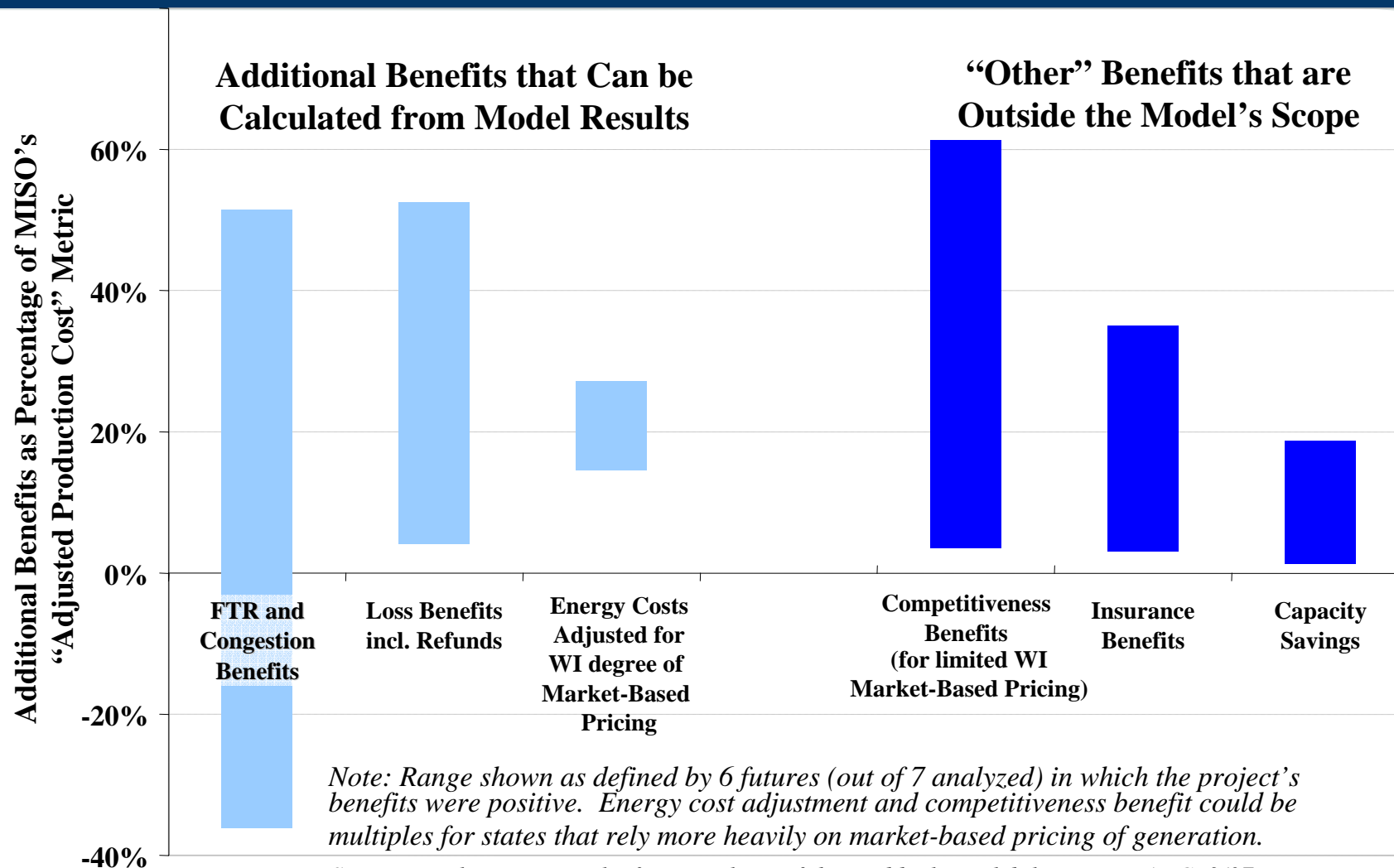
Fiscal Benefits from Construction and Taxes

- **Approval of some transmission projects often is dependent on support by “other” states and local governmental entities**
- **May warrant quantification of fiscal benefits (jobs and taxes) to these entities**
 - ▶ Economic value of construction activities
 - ▶ Increased property taxes for counties
 - ▶ State taxes on generator profits and natural gas use

Can amount to tens of millions of dollars

- **These benefits can be important if entities along transmission path do not receive certain other economic benefits of transmission expansion**

Example: Adders to MISO “Adjusted Production Cost” Metric in Transmission Cost-Benefit Study by Brattle and ATC



Source: Preliminary results from analysis of the Paddock-Rockdale project, ATC, 3/07.

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The Challenge of “Economic” Transmission Projects

- **Significant opportunities to improve transmission grid and power markets through “economic” transmission projects**
 - ▶ Most projects justified based on “reliability” or regulatory mandates
 - ▶ Economic projects face extra hurdle in demonstrating “need”
- **Generation dispatch simulation models have emerged as the standard tool to quantify economic benefits**
 - ▶ Excellent tool, but results are no better than modeling assumptions
 - ▶ Measured transmission-related benefits also greatly dependent on geographic scope and choice of benefit metrics
 - ▶ Models do not address a wide range of transmission-related “other benefits” that can be very large but are too often dismissed as “qualitative”, “indirect” or “intangible”
 - ▶ Narrow scope gets baked into RTOs’ C/B frameworks. Are these models becoming the hammers that make us only see the nails?

Importance of Addressing “Other Benefits”

- **The benefits easily quantified with dispatch models may be sufficient to justify a transmission investment without the need to address any “other benefits”**
- **Still, addressing these “other benefits” can be critical:**
 - ▶ Certainly necessary before an informed decision can be made if easy-to-quantify benefits are less than project costs
 - ▶ Sometimes also needed to show net benefits in regions or zones for which the dispatch models suggest adverse impacts
 - By not considering all benefits, dispatch models tend to create an exaggerated perception of winners and losers (e.g., on the high vs. low side of the transmission constraint)
- **Our experience quantifying these benefits shows they can easily double simulated production cost savings**
 - ▶ The worst assumption is to assume these “other benefits” are zero just because they are hard to quantify

Bio and Contact Information

Hannes Pfeifenberger is a Principal of The Brattle Group, where he co-manages the firm's utility practice. He is an economist with a background in electrical engineering and twenty years of experience in the areas of regulatory economics and finance. He advises companies and governmental agencies on subject areas such as industry restructuring, transmission access and cost-benefit analyses, ratemaking and incentive regulation, competitive analyses, financial valuation, and litigation support. He has published widely, assisted clients in the formulation of business and regulatory strategy, submitted expert testimony to the U.S. Congress, courts, arbitration panels, and regulatory agencies, and provided analytical support in mediation, arbitration, settlement, and stakeholder processes.

Mr. Pfeifenberger holds an M.A. in economics and finance from Brandeis University and an M.S. in power engineering and energy economics from the University of Technology, Vienna, Austria.

Johannes P. Pfeifenberger
Samuel A. Newell
The Brattle Group
44 Brattle Street
Cambridge, MA 01890
617-864-7900
www.brattle.com