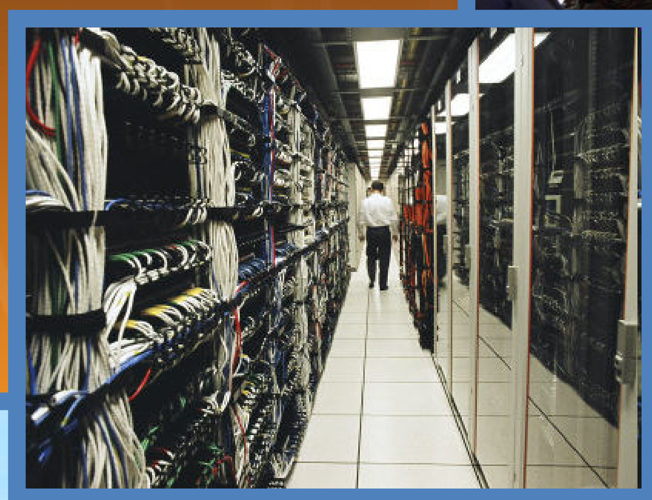
Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada



WIRES

(Working group for Investment in Reliable and Economic electric Systems)

In Conjunction with

The Brattle Group

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WIRES PREFACE

Infrastructure investment may not fire the imaginations of policymakers, but building strong strategic platforms for economic activity is critical to the future success of North America's economies. As financier Felix Rohatyn and former U.S. Senator Warren Rudman asserted a half-decade ago (Washington Post, December 13, 2005), "[t]he nation's infrastructure crisis is no less serious for being silent. [Fixing it] will improve our quality of life, our standard of living and our competitiveness." There is no more critical or strategic asset – not the interstate highway system, the railroads, our network of pipelines, or even the Internet – than the electric transmission system.

WIRES has long argued that the bulk power system is too important to ignore. We need not re-argue the point here that today's high-voltage transmission grid is facing major challenges – aging facilities, congestion that thwarts efficient markets, an outmoded regulatory structure, a lack of transmission where clean energy resources exist, and the prospect that resurgent electricity demand will over-stress the system. Unlike Rohatyn and Rudman, however, we expect that private capital, not government directives or taxpayer dollars, will be the primary instrument by which these challenges are met.

The following report makes an additional, immediately significant, point***: building a truly 21st Century electric transmission grid represents a major potential source of job creation over and above the long-term economic and reliability benefits of a more robust grid.*** While perhaps obvious, it is a matter worth emphasizing. Transmission is the 'great enabler' of competition and new technologies, and, by integrating generation and load, it creates wealth and enhances productivity. But even the simple act of constructing an adequate power system creates and sustains employment.

The Brattle Group has performed an important service by summarizing a variety of sources of information on this issue and providing a nation-wide estimate of the direct, indirect, and induced economic benefits of transmission manufacturing and construction. Even given this limited focus on the employment impacts of constructing transmission facilities, the numbers are impressive. Assuming the elimination or reduction of certain barriers to the planning, permitting, and cost recovery associated with transmission development, the study estimates that 150,000 to 200,000 full-time jobs could be created annually in the U.S. alone over the coming two decades by expanding and upgrading the grid. Another 20,000 to 50,000 jobs would be created in Canada each year.

The story does not end there, however. The Brattle Group sets forth the full set of benefits that transmission development provides. WIRES can only surmise that even greater economic rewards will therefore flow from transmission investment along these lines. However, only a study of all potential transmission projects could overcome the analytic challenges of reducing each of those benefits to specific estimates of the resulting economic activity and new jobs. That task is for another day.

However, in one area there already exists adequate information to venture estimates of transmission's additional potential economic benefit. It is fair to assume that, because many of our best renewable energy resources are "location constrained" (*i.e.*, tied to certain climatic, geologic, or topographic features that are not near major concentrations of electricity consumers), a great many wind, solar, geothermal, and other clean electric generation facilities will not be developed <u>unless</u> transmission capacity capable of delivering that energy to market – in sufficient quantities and in a way that mitigates the variability of those resources – is also developed. WIRES accepts that major transmission development is more likely to occur incrementally instead of through development of a mega-grid overlay but, either way, more transmission is needed, and its effect on the economy will be exponential in relation to its cost. For instance, the potential result of building transmission to facilitate the development of renewable power projects is arguably an additional 130,000 to 250,000 full-time jobs each year between now and 2030.

The Brattle Group estimates that the cost of a stronger and more extensive high-voltage grid that would underpin reliable and competitive wholesale power markets and serve new sources of electric generation will be between $240 billion to $320 billion over the next 20 years. These startling estimates beg an important question: Is that level of investment likely or inevitable? As this report shows, today's utility industry and new independent transmission developers have returned the industry to a positive course of investment in transmission after a period of under-investment. It remains to be seen, however, whether recurrent cycles of infrastructure growth and financial retrenchment and shifting public policy priorities – not to mention unnecessarily complex, duplicative, and expensive regulatory procedures that pre-date the emergence of regional bulk power markets – will perpetuate the uncertainties formerly experienced by transmission investors or whether that investment roller-coaster can be avoided in the future.

Today, restoring high levels of employment to American and Canadian workers is at the top of each nation's priorities. WIRES commends this report to policymakers at all levels of industry and government who are serious about addressing both the challenges posed by recession and the systemic problems with our energy policies and procedures. They would do well to remember some of the basic facts about the importance of electricity infrastructure. Forty percent of all energy consumed in the United States is in the form of electricity. Today's economy arguably depends more heavily on electric power than on oil and that trend would clearly accelerate if we electrify our transportation sector. As *National Geographic* (July 2010) recently opined:

> *We are creatures of the grid. We are embedded in it and empowered by it. The sun used to govern our lives, but now, thanks to the grid, darkness*

falls at our convenience. During the Depression, when power lines first electrified America, a farmer in Tennessee rose in church on Sunday and said . . . 'The greatest thing on earth is to have the love of God in your heart, and the next greatest thing is to have electricity in your house.' He was talking about a few light bulbs and maybe a radio. He had no idea. Juice from the grid now penetrates every corner of our lives, and we pay no more attention to it than to the oxygen in the air.

To that, we add only three words – **jobs, jobs, jobs!**

* * * *

Special thanks to Hannes Pfeifenberger and Delphine Hou, Principal and Associate of the Brattle Group respectively, for their insight and hard work.

This report exhibits the same high quality of other educational reports that our organization has undertaken: *Smart Transmission: Modernizing the Nation's High Voltage Transmission System* (2011); *Integrating Locationally-Constrained Resources Into the Transmission System: A Survey of U.S. Practices* (2008); *A National Perspective on Allocating the Cost of New Transmission Investment: Practices and Principles* (2007). These studies are available at www.wiresgroup.com. WIRES is always pleased to receive comments on these reports.

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May 2011

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Prepared for

WIRES

EMPLOYMENT AND ECONOMIC BENEFITS OF TRANSMISSION INFRASTRUCTURE INVESTMENT IN THE U.S. AND CANADA

EXECUTIVE SUMMARY

WIRES, also known as the **W**orking Group for **I**nvestment in **R**eliable and **E**conomic electric **S**ystems, asked *The Brattle Group* to estimate long-term transmission investment needs and associated employment, economic stimulus, and other benefits in the U.S. and Canada.

Our analysis shows that U.S.-wide transmission investment will likely range from $12 billion to $16 billion annually through 2030, assuming current barriers to planning, permitting, and cost recovery of regional transmission projects can be overcome. We estimate that this level of investment will stimulate $30 billion to $40 billion in annual economic activity (sales and resales of goods and services) and support 150,000 to 200,000 full-time jobs ("full-time equivalent" or "FTE" jobs) each year over this 20 year period. We have also identified C$45 billion in planned Canadian transmission investments through 2030, averaging C$5 billion annually over the next several years. This level of Canadian investment will support between 20,000 and 50,000 full-time jobs annually. Once operational, the expanded transmission infrastructure will also enable additional economic activity, such as the construction of renewable generation projects, which is estimated to support 130,000 to 250,000 full-time jobs in the U.S. during each year of the projected 20-year renewable generation construction effort.

In addition to these employment and economic stimulus benefits from constructing the facilities and manufacturing equipment, strengthening of the transmission grid provides important other benefits, including:

- Reduced transmission losses, production cost savings, enhanced wholesale power market competition and liquidity, and associated wholesale power price reductions;
- The economic value of increased reliability, insurance against high-cost outcomes under extreme market conditions, and increased flexibility of grid operations;
- Generation investment cost savings and access to lower-cost renewable generation;
- Reduced emissions and fossil fuel consumption; and
- Economic benefits from increased federal, state, and local tax income.

These operations-phase benefits of an enhanced transmission grid tend to be wide-spread geographically, diverse in their effects on individual market participants, occur over long periods of time (*i.e.*, several decades) and, as we show with several examples, more than offset the rate impacts of investment cost recovery.

This analysis differs from other studies of local employment benefits of transmission investments by assessing these benefits from a nation-wide perspective. To accomplish this, we first estimated the likely range of nation-wide transmission investments through 2030, starting with a detailed accounting of the near-term and likely long-term investment needs. We then measured the total employment and economic activity stimulated by the increased spending on transmission infrastructure (*i.e.*, manufacturing, construction, and services). This economic activity includes the impacts of transmission construction spending, manufacturing of transmission equipment, and supporting services.

Our analysis considers those impacts in three distinct categories. Direct effects represent the changes in employment and economic activity in the industries which directly benefit from the investment (*i.e.*, construction companies, transmission materials and equipment manufacturing, and design and engineering services). Indirect effects measure the changes in the supply chain and inter-industry purchases generated from the transmission construction and manufacturing activities (*e.g.*, suppliers to transmission equipment manufacturers). Induced effects reflect the increased spending on housing, food, clothing, and other services by those who are directly or indirectly employed in the construction of the transmission lines and substations. To quantify all of these impacts, we relied on the Minnesota IMPLAN Group Model, which is widely used by economists and policy analysts to estimate how investments affect every sector of a state's or region's economy.

These simulations show that every $1 billion of U.S. transmission investment supports approximately 13,000 full-time-equivalent ("FTE") years of employment and $2.4 billion in total economic activity. If the $1 billion is spent over the course of one year, this means the investment will support approximately 13,000 FTE jobs in that year. Furthermore, our analysis suggests that the average transmission investment from 2011 through 2030 will likely range from $12 billion to $16 billion per year or $240 billion to $320 billion over the next 20 years (in 2011 dollars) assuming current barriers to planning, permitting, and cost recovery of regional transmission projects can be overcome. A significant portion of this range will depend on the scope of future renewable portfolio standards and the type of renewable generation projects that will be developed.

As summarized in the table below, this level of U.S.-wide transmission investment supports 150,000 to 200,000 FTE jobs and $30 billion to $40 billion in annual economic activity. The table shows that approximately one-third of this employment benefit is associated with the direct construction and manufacturing of transmission facilities. Two-thirds of the total impact is associated with indirect and induced employment by suppliers and service providers to the transmission construction and equipment manufacturing sectors.

Annual Transmission Capital Cost	**Annual FTE Jobs Supported**		**Annual Total Economic Activity Stimulated**
(2011$ Billion)	Direct	Total	(2011$ Billion)
$12	51,000	150,000	$30
$16	68,000	200,000	$40

As noted, a portion of the projected transmission investments will also enable development of the renewable generation projects needed to meet existing and potential future state or federal Renewable Portfolio Standard ("RPS") requirements. This renewable generation investment is estimated by various studies to support approximately 2.6 million to 5 million FTE-years of employment, or on average 130,000 to 250,000 FTE jobs during each year over the projected 20-year renewable generation construction effort, in addition to the direct impacts of manufacturing and constructing the transmission itself. Additional employment benefits are associated with the operations phase of these projects.

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Johannes Pfeifenberger is a Principal and Practice Area Leader, and Delphine Hou is an Associate, both at *The Brattle Group*, an economic consulting firm with offices in Cambridge, Massachusetts; Washington, D.C.; San Francisco, California; London, England; Brussels, Belgium; and Madrid, Spain. The authors acknowledge the valuable contributions of WIRES members and would like to thank Gerald Deaver, Jolly Hayden, James Hoecker, Heath Knakmuhs, Hao Liu, and Autry Warren for helpful input, comments, and discussions. The opinions expressed in this article, as well as any errors or omissions, are solely those of the authors. The authors can be contacted at www.brattle.com.

I. INTRODUCTION

A robust transmission grid not only ensures reliable delivery of electricity but provides many other benefits such as reducing power production costs and transmission losses, fostering competition in electricity markets, facilitating renewable energy development, and providing insurance against extreme events such as local power shortages due to weather and other factors. Investment in transmission infrastructure also supports employment and stimulates the economy.

Despite a dearth in spending during and prior to the 1990s, the last decade has seen a steady and significant increase in transmission investment as reliability needs are getting addressed and aging facilities are being upgraded or replaced. However, meeting economic and public policy goals, in particular congestion relief and renewable energy standards, has created additional growing needs of transmission investment, underscoring the multi-faceted benefits of a robust transmission network, which the recent increase in investments has only started to address.

WIRES, also known as the **W**orking Group for **I**nvestment in **R**eliable and **E**conomic electric **S**ystems, asked *The Brattle Group* to estimate future transmission investment needs in the U.S. and Canada and analyze the employment, economic stimulus, and other benefits provided by these investments over the next 20 years.

The results of our analysis are presented in this report, which is organized as follows. Section II presents recent U.S. historical, near-term, and long-term transmission investments through 2030 as well as an estimate of projected transmission investments in selected Canadian markets. Section III summarizes existing transmission-investment-related employment and economic stimulus impact studies and presents our own analysis of these benefits on a national U.S. and Canadian scale. Section IV discusses and provides examples of the many other benefits of a robust transmission infrastructure, showing that these benefits can be significantly greater than costs. Finally, our conclusions are presented in Section V.

This study is focused on the employment and economic activity stimulated by transmission construction and manufacturing activities ("economic stimulus" benefits), which does not include the employment and economic stimulus effects from investments in distribution networks, generation facilities, or new businesses facilitated by improved infrastructure. However, we briefly address the employment benefits of renewable energy development facilitated by transmission investments. The report also discusses the full range of benefits that the improved transmission infrastructure provides during the long operating life of the transmission facilities—including increased reliability, reduced congestion and losses, and more competitive wholesale markets for electric power. While we are not able to provide a nation-wide estimate of the economic value of these operations-phase benefits due to their highly project- and location-specific nature, we present examples to document the potential magnitude of these benefits.

To measure the employment and overall economic activity supported by transmission investments during the construction phase, we rely on a class of models known as input-output models. Input-output models are universally used by economists and policy analysts to estimate how specified investments affect every sector of a state's or region's economy. The model we employ is the well-known and widely-used IMPLAN Model of the Minnesota IMPLAN Group. It is used by the U.S. Army Corps of Engineers, U.S. Department of Commerce, the Bureau of Economic Analysis, the U.S. Department of Interior, the Bureau of Land Management, and the Federal Reserve System member banks, among others. Similarly, the industry reports we have surveyed as a complement to our nation-wide analysis rely on the same or similar input-output models, but applied them for regional or state level analyses. Our analysis differs from other studies of local employment benefits of transmission investments by assessing these benefits from a nation-wide perspective.

Although we do not address in detail the many challenges and barriers to transmission investments faced by the industry today such as the uncertainties associated with current regional planning, permitting, and cost recovery practices, we acknowledge that they exist. Unless mitigated, they will impair, perhaps dramatically, the ability of utilities and other private transmission providers to succeed in making needed improvements to the high-voltage system. We have addressed many of these matters in prior studies and presentations, which are listed in the bibliography provided in Appendix B.

II. TRANSMISSION INVESTMENT TRENDS

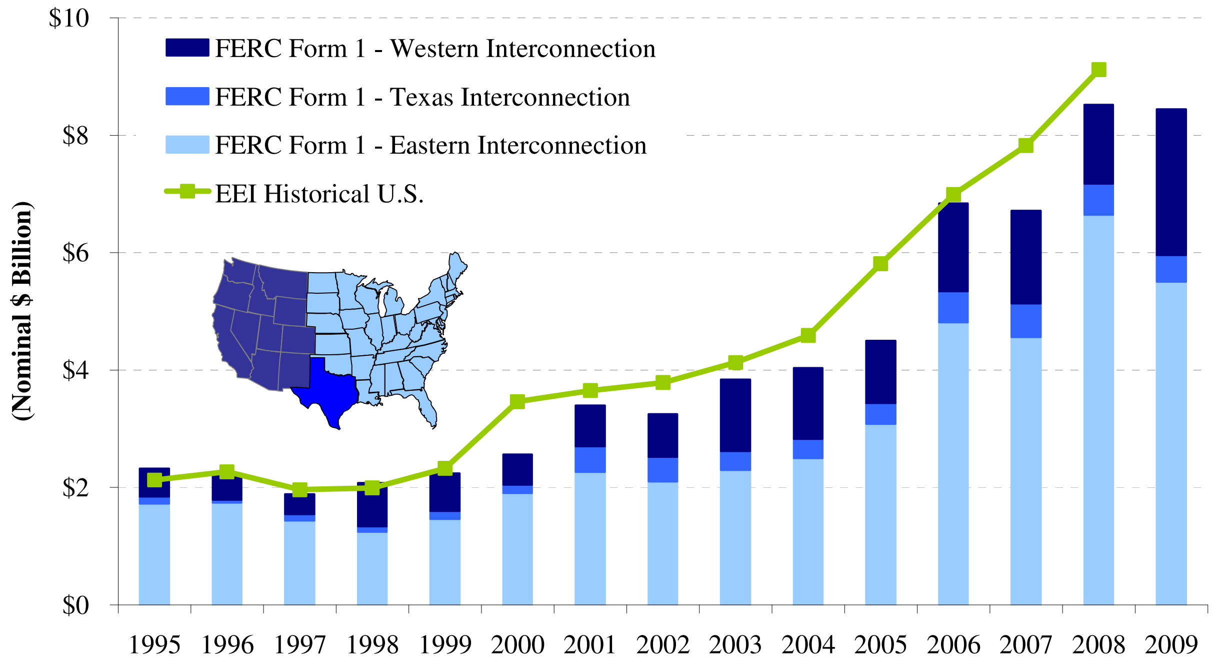
We first discuss the recent historical, near-term, and long-term transmission investment trends for the U.S. In addition to documenting and projecting investment levels, we also present investment by types of transmission ownership, voltage levels, region, and the circuit-miles of the projected build-out.

1. HISTORICAL U.S. TRANSMISSION INVESTMENTS

U.S. transmission investment has significantly increased over the last 10 years. As Figure 1 shows, investment by investor-owned utilities ("IOUs", including investor-owned transmission companies) has quadrupled from approximately $2 billion per year in the 1990s to $8 billion to $9 billion per year during 2008 and 2009.

As shown in more detail in Appendix A, approximately 70% of total U.S.-wide transmission investments are associated with transmission investments in the Eastern Interconnection compared with approximately 25% in the West and approximately 5% in Texas. As Figure 2 and Appendix A also show, investments by investor-owned entities account for 68% to 69% of total U.S.-wide investments. Transmission investments by cooperative, municipal, state, and federal power agencies account for just over 30% of total U.S. transmission investments.

Figure 1
Historical Transmission Investment by Investor-Owned Entities
(FERC Form 1 data reflects annual plant-in-service additions; EEI data reflects annual construction expenditures; both reported in nominal dollars)



Sources and Notes:
The Brattle Group's analysis of FERC Form 1 data compiled in Ventyx's Velocity Suite. EEI data from the Edison Electric Institute. FERC Form 1 and EEI data do not include transmission investment by cooperative, municipals, state/federal power agencies, and some merchant developers.

2. PROJECTED NEAR-TERM U.S. INVESTMENT: 2011-2015

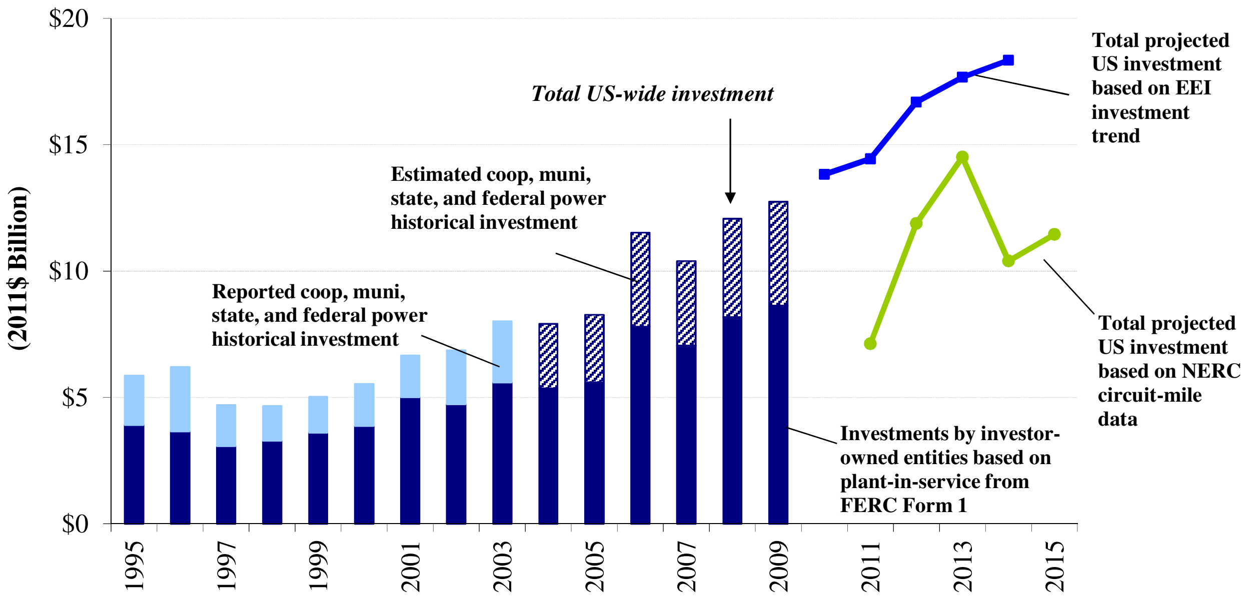
Figure 2 documents historical and projected U.S.-wide transmission infrastructure investments for 1995 through 2015 based on a composite of individual transmission data collected from various industry sources. The investment levels are inflation-adjusted to reflect 2011 dollar values.

Historical investment data for investor-owned entities is available through 2009. Investment data for all other transmission owners is available only through 2003, which required us to estimate investments for 2004 through 2009 based on historical average investment shares and projected future circuit-mile additions by investor-owned and other transmission owners.[1]

[1] Historical investment trends are based on FERC Form 1 for 1995-2009 investments by investor-owned entities (shown as dark blue bars in Figure 2) and RUS Form 12 and EIA Form 412 for cooperative, municipals, and state and federal transmission owners for 1995-2003 (shown as light blue bars). For non-investor-owned investment from 2004-2009, we relied on NERC's average projected percentage of non-IOU investments (32% of total) based on circuit-mile data reported in EIA Form 411 (shown as the striped blue bars). We then applied the inflation derived from the Handy-Whitman index to the reported nominal

Figure 2 also shows projected U.S. transmission investments through 2015 based on: (1) projected capital expenditure growth rates from the Edison Electric Institute ("EEI")[2] applied to total 2009 U.S.-wide transmission investment levels; and (2) estimated investment requirements associated with transmission circuit-mile additions from reports that transmission owners provide to the North American Electric Reliability Corporation ("NERC") on a voluntary basis. Additional details about data sources and our projections are presented in Appendix A.

Figure 2
Total Estimated Historical and Projected Transmission Investment (2011$)



Sources and Notes:
1995-2009 historical additions to plant-in-service by IOUs (FERC Form 1 reporting entities); 1995-2003 historical plant additions by cooperative/municipal, federal/state power agencies, and other transmission owners based on RUS Form 12 and EIA Form 412 through 2003; 2004-2009 estimated plant additions by cooperative, municipal, federal and state power agencies, and other transmission owners based on share of projected circuit-miles in EIA Form 411; 2010-2015 estimates of forecasted total plant additions (blue line) based on EEI projections; 2011-2015 estimate of forecasted plant additions (green line) based on NERC/EIA Form 411 and EEI project survey cost estimates (for facilities ≥100kV only). Analysis of FERC Form 1 based on data compiled in Ventyx's Velocity Suite. All nominal dollars restated in 2011 dollars based on the Handy-Whitman Index of Public Utility Construction Costs up through 2009 and the EIA's *2011 Annual Energy Outlook* projected inflation thereafter.

The range between the blue and green lines documents some of the uncertainty in annual transmission investment levels, ranging from a low of approximately $8 billion a year to a possible high that may exceed $18 billion per year. Considering overall trends and the limitation of the available data sources, we estimate that U.S.-wide transmission investments will likely

dollar amounts and restated all costs in 2011$. This yields a total investment amount of approximately $13 billion in 2009 (in 2011$).

2 EEI projects $45.1 billion of investments in the transmission system from 2010 to 2013 (See Appendix A). We offset the 2008-2013 capital expenditures by one year to account for the lag in plant-in-service reporting to derive annual growth rates for 2009-2014.

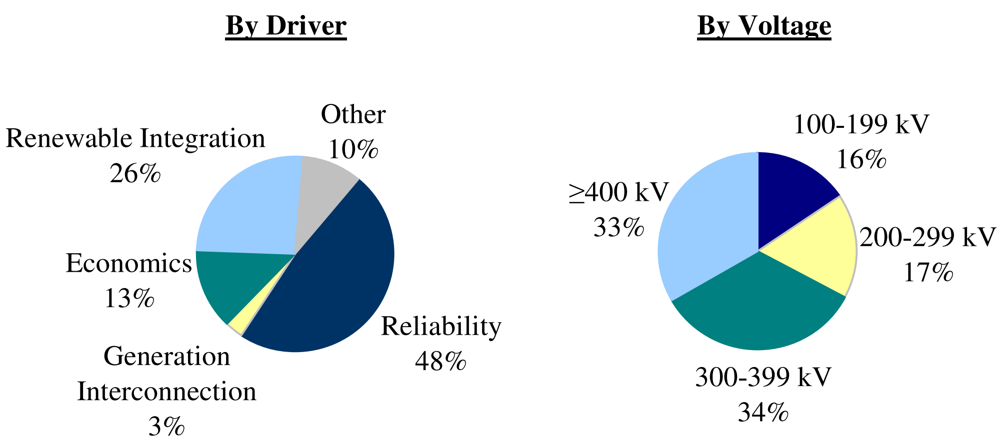
average between $12 billion to $16 billion annually over the five years through 2015. This yields a projected total investment of $60 billion to $80 billion for the entire 2011-2015 period.

3. DRIVERS AND VOLTAGE LEVELS OF U.S. TRANSMISSION INVESTMENTS

Historically, reliability needs and generation interconnection needs were the main drivers of transmission investments. Moving forward, reliability will continue to be a significant driver. Figure 3 shows the breakdown of U.S. transmission investments by driver as reported by NERC in its circuit-mile data for 2011-2015.

As shown in Figure 3, reliability needs have been identified as the main driver for almost half of all projected circuit-mile additions for 2011-2015, although this includes at least some projects that address reliability needs associated with the integration of renewable generating resources. Approximately 40% of reported circuit-mile additions is driven by "economic" (*e.g.,* congestion relief) justification and "renewable integration" requirements. Note, however, that this categorization of main investment drivers is greatly dependent on the often inconsistent judgment of main drivers by individual transmission owners, which reflects the fact that most major transmission projects address multiple needs and provide a variety of benefits, ranging from reliability, to congestion relief, and renewable integration.

Figure 3
Reported Drivers of Projected Circuit-Miles of Transmission Additions
(2011-2015 as reported voluntarily to NERC and in EIA Form 411 by IOUs, coop/munis, state/federal power agencies, ISOs/RTOs, and merchant developers)



Total 2011-2015: 22,669 circuit-miles

Sources and Notes:
Based on drivers as reported in EIA Form 411. No adjustments have been made to projects in one category (*e.g.*, reliability) which may ultimately be built to satisfy more than one driver (*e.g.*, renewable integration).

As also shown in Figure 3, two-thirds of all reported circuit-mile additions through 2015 are facilities operating at a voltage level above 300 kV, which indicates significant investments in regional transmission facilities. The remaining one-third of total circuit-mile additions are facilities at voltage levels between 100 kV and 300 kV. Not reflected in these data are additional investments associated with transmission facilities operating at voltage levels below 100 kV.

4. PROJECTED LONG-TERM U.S. INVESTMENT: 2016-2030

Table 1 summarizes recently published national and regional analyses of U.S. transmission investment needs. For each of the listed studies, the table reports the time horizon, the scope of the study (*e.g.*, region of analysis and primary driver), projected transmission investment amounts, and our calculation of average annual investment in 2011 dollars.

As shown, the Edison Foundation report previously prepared by *The Brattle Group* (item 1) projected $300 billion of transmission investments from 2010 through 2030 (in nominal dollars). This amounts to an annual average of $11 billion in investments per year in 2011 dollars after adjusting for inflation. This projection reflects total transmission investments at all voltage levels and types of transmission facilities (*i.e.,* transmission line and substations) for both investor-owned and other transmission owners.

The next data set (item 2 in Table 1) provides ranges of transmission investments to integrate renewable (wind and utility-scale solar) generation to meet increasing renewable energy policy requirements under currently-effective state-level RPS requirements and a hypothetical 20% federal RPS. These investment ranges are based on low, mid-point, and high estimates for the costs of regional transmission upgrades.[3] The resulting transmission investment requirement ranges from $3.1 billion to $5.5 billion per year to meet existing state level RPS. This range would increase to $6.3 billion to $10 billion per year if a 20% federal RPS or equivalent additional state-level requirements were implemented. Additional details about this analysis are presented in Appendix A.

The Eastern Wind Integration and Transmission Study ("EWITS," listed as item 3 in Table 1) is the most recent publication in a series of transmission and renewable energy studies released by the Department of Energy and its National Renewable Energy Laboratory ("NREL"). Though EWITS is focused on transmission expansion to interconnect renewables, its analysis also added traditional fossil fuel-fired generation to meet resource adequacy requirements (net of energy efficiency measures), in addition to an assumed baseline of transmission upgrades. EWITS analyzed a reference scenario to meet existing state-level RPS as well as three scenarios to meet a 20% federal RPS with a combination of on- and off-shore wind generation through 2024. However, EWITS estimated transmission investment requirements (incremental to a baseline of transmission upgrades to meet near-term reliability and renewable energy needs) only for voltage levels at 345 kV and higher and focused only on the Eastern Interconnection. We have consequently scaled the EWITS data to reflect total U.S. investment at 345 kV and higher based on the projected Eastern Interconnection's share of total U.S.-wide transmission investments, which is a range up to 70%. This yields a 2015-2024 transmission investment need for facilities

[3] We assume that 80% of incremental renewable generation needs will require system-level transmission upgrades ranging from $300/kW to $600/kW of installed renewable generation capacity. In addition to these system-level transmission cost, we assume renewable generators will incur $100/kW of interconnection costs.

at voltage levels of 345 kV and above of $4.6 billion to $8.6 billion per year under the state RPS scenario and between $9.5 billion to $14 billion per year under the federal RPS scenarios.

Table 1
Summary of Long-Term U.S. Transmission Investment Studies

	Source *(Author)*	Data or Study Time Horizon	Scope Description	Total Investment ($ Billion)	Adjustments Made for Ave Annual Data	Annual U.S. Investment (2011$ Billion)
[1]	*Transforming America's Power Industry (The Brattle Group)*	2010-2030	• Region: U.S. • Investor: all • Equipment: all lines and related • Driver: all • Status: new builds	$298 (Nominal)	Annualized; converted to 2011$	$10.8
[2]	"Transmission Investment and Cost Allocation: What are the Options?" *(The Brattle Group)*	Approx. 2013-2025	• Region: U.S. • Investor: all • Equipment: all lines and related • Driver: RPS based on current state or 20% federal mandate • Status: new builds	$40 - $70 (2010$) *state RPS* $80 - $130 (2010$) *federal RPS*	Annualized; converted to 2011$	$3.1 - $5.5 $6.3 - $10
[3]	*Eastern Wind Integration and Transmission Study (NREL)*	Approx. 2015-2024	• Region: Eastern Interconnect • Investor: all • Equipment: all lines and related ≥345 kV • Driver: RPS based on current state or 20% federal mandate as well as meeting resource adequacy requirements • Status: new builds incremental to baseline	$31 (2009$) *state RPS* $65 - $93 (2009$) *federal RPS*	Scaled to entire U.S.; annualized; converted to 2011$	$4.6 - $8.6 $9.5 - $14

Sources and notes:

[1]: The Brattle Group, *Transforming America's Power Industry: The Investment Challenge 2010-2030*, prepared for The Edison Foundation, November 2008.

[2]: The Brattle Group, "Transmission Investment and Cost Allocation: What are the Options?" presented at the ELCON Fall Workshop by Johannes Pfeifenberger, October 26, 2010.

[3]: National Renewable Energy Laboratory, *Eastern Wind Integration and Transmission Study*, January 2010.

The variation in transmission investment estimates shown in Table 1 illustrates the still significant uncertainty about renewable resource integration requirements, which reflects both uncertainty about the ultimate scope and magnitude of renewable portfolio standards and the transmission costs associated with renewable resource development scenarios. Considering that many of the lowest-cost renewable resources are distant from load centers, significant transmission investments would be cost effective to reach these low-cost resources.[4] A

4 A 10 percentage point differential in the annual capacity factor of wind generation (*e.g.*, accessing wind in a 40% capacity factor location compared to a 30% capacity factor location) is worth approximately $600/kW in incremental "break-even" transmission investments. (For example, see *Wind Energy Transmission Economics*, prepared for WPPI Energy by Burns and McDonnell, March 2010, pages 1-2.)

potentially significant portion of these investments would be required to meet reliability standards and to upgrade or replace aging existing facilities even in the absence of RPS standards.

In addition to the high-level studies of likely investment levels summarized above, a substantial number of individual transmission projects have already been proposed to address the identified needs. Figure 4 is based on project-level data we have collected for over 130 mostly conceptual and often competing projects, including early-stage merchant transmission proposals, each with at least $100 million in investment requirements.

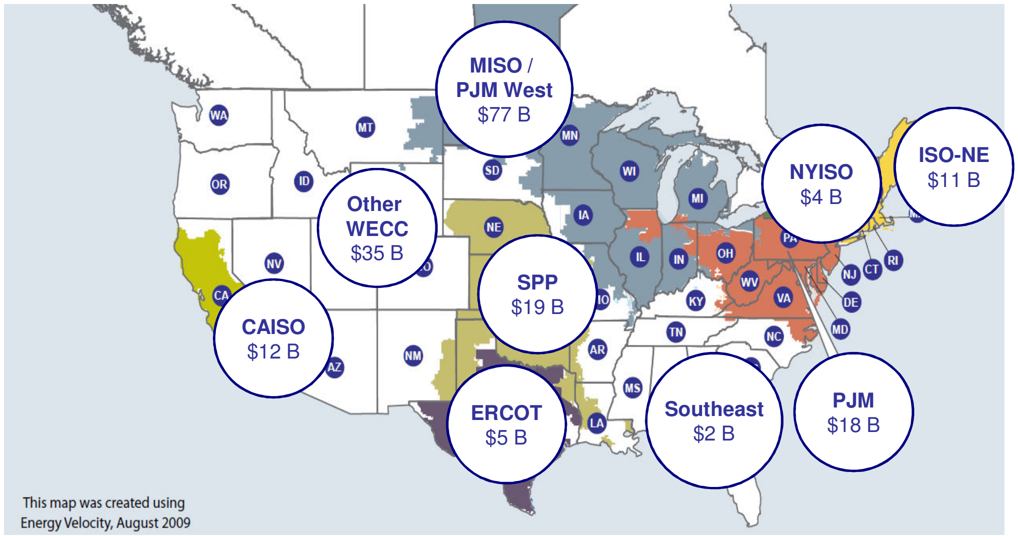
The total investment need for this collection of proposed and conceptual projects amounts to approximately $180 billion. A significant proportion of these proposed projects are driven by large-scale renewables integration needs. As the table below the map in Figure 4 shows, only approximately $25 billion of these projects have already been approved in the transmission plans of regional transmission organizations ("RTOs"). We estimate that of the remaining $150 billion in proposed and often still highly conceptual transmission projects that are not even considered in regional planning processes yet, approximately one-third to one-half will not be realized due to overlaps with competing projects, planning and cost allocation challenges, and high costs. While we cannot predict exactly which challenges will arise in specific cases, we have netted out $70 billion of overlapping or competing projects, for a total net investment need of over $80 billion in non-overlapping proposed and conceptual projects that are not already in RTO-approved transmission plans. Combined with approximately $25 billion in RTO-approved projects, the identified transmission projects represent a U.S. investment need of approximately $110 billion. If all of these planned and conceptual projects were to be realized over the 2015 to 2025 time frame, the annual investment requirement would be approximately $11 billion per year.

It is difficult to project long-term transmission investment needs considering the many uncertainties and investment barriers faced by the industry today. These uncertainties span a broad range of considerations from policy- and environment-related concerns such as renewable portfolio standards, carbon policies and other environmental requirements, to uncertainties associated with maintaining reliability such as retirement and additions of conventional generation sources and investments required to upgrade or replace aging existing transmission lines and equipment. As we discuss briefly at the end of this section, the industry also faces significant barriers to the planning, permitting and cost recovery of transmission projects, in particular with respect to regional (*i.e.*, multi-state) build-outs.

The annual transmission investment levels indicated in Figure 4 and Items 2 and 3 in Table 1 exclude "baseline" investments in transmission facilities such as reliability projects, new transmission needed for local load serving purposes (including transmission facilities at lower voltage levels), and the replacement or upgrades of aging transmission and substation facilities. We believe these baseline investment needs will be at least equal to the transmission investment levels observed in the 1990s, a decade of minimal investment, or about $5 billion annually as shown in Figure 2.

In other words, a wind plant in a 40% capacity factor location is more cost-effective than a 30% capacity factor location if the *additional* transmission cost does not exceed $600/kW of wind capacity.

Figure 4
$180 Billion of Planned and Conceptual U.S. Transmission Projects*



		$ Billion	*Share of Total*
[1]	**Total Projects Shown**	**$182**	*100%*
[2]	*Projects Approved in RTO Plans*	*$26*	*14%*
[3]	*Projects Not Yet Approved by RTOs*	*$156*	*86%*
[4]	**Adjustment for Overlapping Projects**	**($73)**	
[5]	**Total Net of Overlapping Projects**	**$109**	*60%*

Sources and Notes:

[1]: Project data collected by *The Brattle Group* from multiple public sources and aggregated to the regional level. Project data collected by *The Brattle Group* from multiple public sources and aggregated to the regional level. Includes highly conceptual, merchant, and often competing proposals, the majority of which are not yet approved or not even evaluated in regional planning processes.

[2]: Projects approved in RTO plans are a subset of [1]. Percentage is of total in [1].

[3]: Projects not yet approved in RTO plans are a subset of [1]. Percentage is of total in [1].

[4]: Based on analysis by *The Brattle Group*, an adjustment was made to net out overlapping projects based on the similarity of proposed plans but no analysis was performed on the merits of competing projects.

[5]: [1] + [4]. Total net of overlapping projects does not reflect the likelihood of success for each project or a projection of future investment.

* Total dollar values indicate investment interest, not investment need. Includes conceptual, merchant, and often competing proposals greater than $100 million each, most of which are not yet approved or being evaluated in regional planning processes. For example, projects in the Southwest Power Pool ("SPP") include RTO-sponsored build-outs such as the Priority Projects, overlapping or competing proposals such as Prairie Wind and Tallgrass, and still conceptual proposals such as the Plains & Eastern Clean Line merchant project originating in SPP. Similarly, for the Midwest ISO and western PJM footprint ("MISO/PJM West"), both the Regional Generation Outlet Study and the SMARTransmission overlays are included. Net of competing and overlapping projects, the total investment volume (which still includes highly conceptual projects) is approximately $11 billion for SPP and $22 billion for MISO.

Based on these baseline transmission investment needs and the transmission investments identified in Table 1 and Figure 2, the longer-term transmission investment needs will likely be consistent with the identified 2011-15 investment trends. As a result, *we estimate that long-term investments through 2030 will be consistent with the near-term U.S. investment levels of $12 billion to $16 billion per year on average. This means total transmission investments from 2011 through 2030 must be expected to range from $240 billion to $320 billion (in 2011 dollars), depending on the resolution of the identified uncertainties, such as the ultimate scope of future RPS standards and related regional transmission need and the reduction of existing barriers to efficient development.*

5. CANADIAN TRANSMISSION INVESTMENTS THROUGH 2030

We have not conducted a comprehensive analysis of transmission investments in Canada but, instead, provide a summary of transmission investments reported in provincial transmission plans over various time periods reaching out as far as 2030. Table 2 summarizes these provincial transmission plans, which identify C$45 billion in planned transmission projects. As also shown in Table 2, the sum of average annual investment levels for the individual plans yields an investment level of C$5.2 billion per year. These transmission investment projections likely underestimate the total Canadian investments because the data does not reflect nation-wide investment activities and cost estimates have not yet been released for several transmission projects currently under study.

The projected Canadian transmission investments are collected from a variety of sources, such as independent system operators (*e.g.,* Alberta Electric System Operator, New Brunswick System Operator), large provincial utilities (*e.g.,* BC Transmission Corporation, Hydro-Québec), and provincial governments (*e.g.,* Provinces of Newfoundland & Labrador and Ontario). Therefore, data across these sources vary in terms of time frame, level of certainty, and inflation adjustments to the reported dollar amounts.

The level of investment shown in Table 2 reflects a significant increase from historical investment levels as noted in several of the reviewed transmission plans. For example, Nova Scotia Power's *2011 Annual Capital Expenditure Plan* shows that 2006 through 2009 transmission investments were only in the $9.2 million to $23 million range while 2011-2015 investment levels are projected to range from $69 million to $77 million annually. This upward trend of transmission investment needs mirrors the U.S. experience.

These sources also show increased investment to support renewable development as in the case of the C$1.83 billion Southern Alberta Transmission Reinforcement ("SATR") project to integrate up to 2,700 MW of additional wind generation, recently approved by the Alberta Utilities Commission. In addition, significant transmission investment needs are projected to support the development of large new hydroelectric resources such as the Bipole III transmission project for the Conawapa Dam hydro project (Manitoba) and the Labrador-Island and Maritime Links to support generation development at Muskrat Falls (Newfoundland & Labrador).

Table 2
Transmission Investments in Canadian Markets*

	Province	Reporting Entity	Time Frame	Est. Total Investment (C$ Million)	Ave. Annual Investment (C$ Million)
[1]	British Columbia	BC Transmission Corporation	2010-2020	$5,300	$482
[2]	Alberta	Alberta Electric System Operator	2010-2017	$14,500	$1,813
[3]	Saskatchewan	SaskPower	2009-2019	$1,481	$135
[4]	Manitoba	Manitoba Hydro	2009-2020	$3,156	$263
[5]	Ontario	Province of Ontario	2010-2030	$9,000	$429
[6]	Quebec	Hydro-Québec	2009-2013	$7,800	$1,560
[7]	New Brunswick	New Brunswick System Operator	2010-2020	$64	$6
[8]	Nova Scotia	Nova Scotia Power, Inc.	2011-2015	$356	$71
[9]	Newfoundland & Labrador	Province of Newfoundland & Labrador	2011-2017	$3,300	$471
			Total	$44,957	$5,229

Sources and Notes:

[1]: British Columbia Transmission Corporation, *F2010 and F2011 Transmission System Capital Plan* , November 2008, "Table 2-1: Changes from F2009 Capital Plan," p. 2-2. Includes Growth Capital Portfolio, Sustaining Capital Portfolio, BCTC Capital Portfolio, and SDA costs from British Columbia Hydro, the parents company of BC Transmission. Investment year dollars not specified.

[2]: Alberta Electric System Operator, *AESO Long-term Transmission System Plan 2009* , June 2009. Reflects 2008$.

[3]: SaskPower, "Power Infrastructure Projects: Transmission & Distribution." Available at: http://www.saskpower.com/sustainable_growth/projects/ (accessed February 28, 2011). Not all projects had cost estimates. SaskPower, "Powering A Sustainable Energy Future: The Electricity and Conservation Strategy for Meeting Saskatchewan's Needs," presented to the Standing Committee on Crown and Central Agencies, October 6, 2009. Investment year dollars not specified.

[4]: Manitoba Hydro, *2010/11 & 2011/12 General Rate Application* , transmission category under "Table 6.1.1: Summary of Electric Capital Expenditure Forecast CEF09-1" and transmission and Bipole III Transmission Projected under "Table 6.1.2: Major New Generation and Transmission Capital Expenditure Forecast CEF09-1," pp. 2-3. Investment year dollars not specified.

[5]: Province of Ontario, *Ontario's Long-Term Energy Plan* , "Figure 13: Estimated Capital Cost of Long-Term Energy Plan: 2010-2030 ($ Billions)," p. 55. Investment year dollars not specified.

[6]: Hydro-Québec, *Hydro-Québec Strategic Plan: 2009-2013* , "Appendix 4: Investment Program 2009–2013 Hydro-Québec TransÉnergie," p. 45. Investment year dollars not specified.

[7]: New Brunswick System Operator, *10-Year Outlook: An Assessment of the Adequacy of Generation and Transmission Facilities in New Brunswick 2010-2020* , July 2010, pp. 26-31. Cost estimate reflects the mid-point of $46 to $82 million, the cost estimate range based on categories of costs provided in "Table 9: Transmission Project Cost Categories." Does not include transmission infrastructure upgrades currently under study. Investment year dollars not specified.

[8]: Nova Scotia Power, Inc., *2011 Annual Capital Expenditure Plan,* p. 823. Investment year dollars not specified.

[9]: Province of Newfoundland & Labrador, "Backgrounder - Quick Facts - Muskrat Falls Development Generation and Transmission." Available at: http://www.gov.nl.ca/lowerchurchillproject/backgrounder_7.htm (accessed February 28, 2011). Costs only include The Labrador-Island Link ($2.1 billion) and the Maritime Link ($1.2 billion). Costs for transmission related to Muskrat Falls development are not provided separately from generation. Investment year dollars not specified.

* The Conference Board of Canada recently reported approximately C$36 billion in transmission investments across several Canadian provinces but does not include certain long-term investments in Ontario and Québec and projects such as the Labrador-Island Link and the Maritime Link.

6. BARRIERS TO TRANSMISSION INVESTMENT

As noted, our estimates of transmission investment levels are in part contingent on the resolution of transmission investment barriers related to regional planning, permitting and siting, and cost recovery. These investment barriers are well documented and we have addressed them in prior studies and presentations.[5] These investment barriers are magnified for many of the multi-state, multi-purpose transmission projects that have been proposed in the context of recent U.S. regional transmission planning efforts.

Permitting and siting of transmission facilities has long been challenging due to opposition over visibility impacts and other environmental concerns. Because permitting is subject to the jurisdictions of individual states and federal land management agencies, this challenge is magnified for regional transmission projects that require permits from multiples states and agencies. Aside from these siting and permitting challenges, significant investment barriers exist due to (1) the lack of consistency among and experience with regional planning processes for transmission projects justified by economic and public policy considerations and (2) the frequent absence of cost recovery mechanisms for such regional transmission projects.[6]

Most of the currently available transmission planning and cost recovery methodologies were designed and work well for traditional single-utility, single-state projects built to satisfy reliability needs. Some of these methodologies have been expanded to a regional scope by RTOs and successfully applied to reliability-driven regional projects and conventional generator interconnection requests. However, with some notable exceptions, such as in the Southwest Power Pool, existing transmission planning and cost recovery methodologies often do not apply to multi-state, regional or inter-regional projects that, in addition to maintaining grid reliability, may be needed to relieve transmission congestion, increase electricity market efficiency, and support renewable integration cost effectively.

If unresolved, these barriers will reduce or delay transmission investments relative to our projections and, as a consequence, reduce reliability, decrease market efficiency, and undermine the industry's ability to meet public policy requirements, such as state-level renewable portfolio standards.

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5 For example, see The National Electrical Manufacturers Association, "Siting Transmission Corridors—A Real Life Game of Chutes and Ladders" October 2010; Pfeifenberger, "Easier Said Than Done: The Continuing Saga of Transmission Cost Allocation," presented to Harvard Electricity Policy Group, February 24, 2011; Pfeifenberger, "Transmission Planning: Economic vs. Reliability Projects," EUCI Conference, Chicago, October 13, 2010; and Pfeifenberger, Fox-Penner, Hou, "Transmission Investment Needs and Cost Allocation: New Challenges and Models," *The Brattle Group*, presented to FERC Staff, Washington, DC, December 1, 2009.

6 The Federal Energy Regulatory Commission has issued a Notice of Proposed Rulemaking ("Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities," Docket RM10-23, 131 FERC ¶ 61,253, issued June 17, 2010) which seeks to address these planning and cost allocation barriers.

III. JOBS AND ECONOMIC STIMULUS BENEFITS OF TRANSMISSION INVESTMENT

The following analysis of the employment and economic stimulus benefits associated with transmission construction first summarizes existing studies of such benefits for individual regional and state-level transmission projects. We then present our analysis of U.S.-wide and Canadian employment and economic stimulus benefits associated with the annual transmission investments previously identified in Section II of this report. Additional economic benefits related to transmission upgrades are then discussed in Section IV.

1. SURVEY OF EMPLOYMENT AND ECONOMIC STIMULUS BENEFIT STUDIES

Employment and economic stimulus benefits of transmission investments are associated with both the construction and manufacturing activities as well as, though to a much smaller extent, the ongoing operations and maintenance of the transmission facilities during the entire life of the assets, which generally exceeds 40 years. Our analysis focuses only on the ongoing construction-phase impacts, considering the fact that we project $12 billion to $16 billion in annual U.S.-wide and additional Canadian transmission construction activities during each of the next 20 years. While the construction of individual facilities may only take one to several years, this 20-year outlook for national transmission investments means that the continuous investment stream will support a substantial number of long-term construction and manufacturing related employment and economic activity. While this report, consistent with all reports we reviewed, focuses only on employment impacts from the construction of transmission facilities, we briefly address employment and economic stimulus benefits of construction activities facilitated by the transmission investments, such as the development of renewable and other generation, at the end of this section.

To measure the employment and overall economic activity supported by transmission investments, studies rely on a class of models known as input-output models.[7] Input-output models are universally used by economists and policy analysts to estimate how specified investments affect every sector of a state's or region's economy. They are based on detailed economic data on how goods and services are produced and consumed. An input-output model rebalances the overall economy after an increase in expenditures on particular types of products (*e.g.*, construction activities and electric transmission equipment), so that the quantity produced equals the quantity consumed for every industry.

The majority of the studies we surveyed relied on the well-known and widely-used IMPLAN Model of the Minnesota IMPLAN Group to estimate the employment and economic stimulus benefits of transmission investments.[8] Like similar other models, IMPLAN specifically

7 Some of the studies did not utilize full input-output models but relied on the "economic multipliers" taken from these models. Nonetheless, the multipliers are consistent with input-output models and assumptions.

8 The IMPLAN (IMpact analysis for PLANing) economic impact modeling system is developed and maintained by the Minnesota IMPLAN Group ("MIG"), which has continued the original work on the system done at the University of Minnesota in close partnership with the U.S. Forest Service's Land and Management Planning Unit. IMPLAN divides the economy into 440 sectors and allows the user to specify the expenditure allocations associated with a given expansion in demand to all relevant parts of the local economy in order to derive the economic impacts—changes in employment, earnings, and economic

considers how much of the consumed products and services are supplied from each sector of a given state or regional economy. Only activities that occur in that state or region are counted towards the measured economic impact. IMPLAN quantifies economic impacts in a number of categories including: (1) the number of jobs supported in the region (in full-time-equivalent years or "FTE-years" of employment);[9] and (2) the economic activity generated in the region (*i.e.*, increased "economic output" as measured in total sales and resale revenues of businesses within the study region). Since these models report economic activity as the sum of the value of all goods and services sold at each level of the supply chain (*i.e.*, sales and resale revenues), the reported economic output refers to the total flow of money that occurs throughout the local economy. The measured impacts are the cumulative (undiscounted) number of jobs (or FTE-years of employment or FTE jobs each year), and overall economic activity (in constant dollars) associated with investing in transmission projects over the entire construction phase.

IMPLAN, like other input-output models, reports employment and economic stimulus benefits as "direct," "indirect," and "induced" impacts. Direct effects represent the changes in employment and economic activity in the industries which directly benefit from the investment (*i.e.*, construction companies, transmission materials and equipment manufacturing, and design services). Indirect effects measure the changes in the supply chain and inter-industry purchases generated from the transmission construction and manufacturing activities (*e.g.*, suppliers to transmission equipment manufacturers). Induced effects reflect the increased spending on food, clothing, and other services by those who are directly or indirectly employed in the construction of the transmission lines and substations. Employment supported by each of the three activities represents discrete net gains to the economy if the labor force is not being utilized elsewhere in the economy absent the projects. If the rate of unemployment is low, new jobs would not necessarily be created. Instead, employees might simply be shifting jobs from less desirable other sectors of the economy.

We were able to identify and review nine recent studies of the employment and economic stimulus benefits of transmission investments, covering a wide range of regions in the U.S. as well as portions of Canada.[10] Table 3 summarizes the results from these studies. For each of

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output. According to the U.S. Department of Agriculture, currently "over 1,500 clients across the country use the IMPLAN model, making the results acceptable in inter-agency analysis." In 2009, the U.S. Army Corps of Engineers Civil Works program utilized IMPLAN employment multipliers "to estimate the potential number of jobs preserved or created" by the American Recovery and Reinvestment Act of 2009. In addition, the U.S. Department of Commerce, the Bureau of Economic Analysis, the U.S. Department of Interior, the Bureau of Land Management, and the Federal Reserve System member banks are also among the agencies that utilize IMPLAN for economic impact analysis.

9 IMPLAN employment impacts are reported as full-time-equivalent ("FTE") job years, that is, 2,080 hours of full employment. For example, reporting 100 FTE years of employment could mean 200 full-time jobs supported for 6 months, 100 jobs supported for a year, or 10 jobs supported for 10 years.

10 There are several other studies discussing transmission-investment-related benefits to the regional or national economies, which are not included on our summary due to insufficient detail contained in or the different nature of these studies. For example, see Build Energy America!, *Quarter Million Backbone Jobs*, February 24, 2011; Idaho National Laboratory, *The Cost of Not Building Transmission: Economic Impact of Proposed Transmission Line Projects for the Pacific NorthWest Economic Region*, July 2008;

Additional studies only recently brought to our attention and not summarized in the following discussion include: The Perryman Group, *The Potential Impact of the Proposed Plains & Eastern Clean Line Transmission Project on Business Activity in the US and Affected States*, June 2010; Development these studies the table summarizes the simulation model used, the region studied, project details, total transmission capital cost, and the proportion of total investment that is spent locally (*i.e.*, not imported).

The employment and economic stimulus impacts quantified in these studies are summarized in Table 4. The table shows both direct and total construction-period employment (expressed in FTE-years of employment, representing FTE jobs supported for one year) and total economic activity. To allow for a meaningful comparison, we report employment and economic activity per million dollars of total transmission investment (columns [D] through [F]). As Table 4 shows, the employment impacts reported in these studies range from a low of 2 FTE-years of total employment supported per million dollars of investment to a high of 18 FTE-years per million of investment (shown in column [E]), with a majority of studies showing that each million dollars of transmission investment supports 5 to 8 FTE-years of local employment. Economic output per million dollars of total transmission capital cost ranges from a low of $0.2 million to $2.9 million (shown in column [F]). These results vary considerably based on the extent to which materials and equipment can be (or are assumed to be) supplied from within the study region. For example, transmission construction in smaller states with a more limited manufacturing base (*e.g.*, South Dakota) will be associated with fewer in-state employment benefits than larger, more industrial states (*e.g.*, Texas). In other words, smaller study areas and less local manufacturing (*i.e.*, more imports) result in lower *local* (*i.e.*, in-region) benefits.

To adjust for the differences in local manufacturing versus imports (*i.e.*, manufacturing outside the study regions) across these studies, columns [G] through [I] of Table 4 report employment and economic activity results per million dollars of local (in-region) spending. As shown, the employment impacts reported in these studies range from a low of 3 FTE-years of total employment supported per million dollars of local spending to a high of 18 FTE-years per million of investment, with a majority of studies showing that each million dollars of local spending supports 11 to 14 FTE-years of local employment. Finally, the last column of Table 4 shows that each million dollars in local spending stimulates on average approximately $1.4 million to $1.8 million in total economic activity (measured in total sales and resale revenues of local businesses).

Strategies, *An Economic Impact Study of the Proposed Grain Belt Express Clean Line*, September 17, 2010; and Center on Globalization, Governance & Competitiveness, Duke University, U.S. *Smart Grid: Finding New Ways to Cut Carbon and Create Jobs*, April 19, 2011.

Table 3
Summary of Recent Studies on Employment and Economic Impacts Of Transmission Investments

	Study Sponsor (Author, if different)	Model Used	State(s) / Region	Project Details	Total Transmission Capital Cost ($ Million)	% Local Spending
[1]	AltaLink *(Angevine)*	Alberta multipliers	Alberta & Rest of Canada	AltaLink's estimated capital spending program from 2010-2015		
				Alberta	C$6,109	75%
				Rest of Canada Outside of Alberta	C$6,109	75%
[2]	ATC LLC *(NorthStar Economics)*	IMPLAN	WI	Two completed transmission projects		
				1. 138 kV Femrite-Sprecher	$16	46%
				2. 345 kV Arrowhead-Weston	$321	100%
[3]	CapX2020 *(UMD Labovitz School)*	IMPLAN	MN, ND, SD, WI	Five major 230 kV and 345 kV transmission projects (>700 miles)	$1,773	100%
[4]	Central Maine Power *(University of Southern Maine)*	REMI	ME	Maine Power Reliability Program (500 miles of 345 kV)	$1,543	81%
[5]	Montana Department of Labor & Industry	IMPLAN	MT	Six major projects planned or under construction in Montana		
				1. 230-500 kV projects employing out-of-state contractors	$3,137	11%
				2. 230-500 kV projects employing in-state contractors	$1,263	33%
				3. Combined impact of projects employing in- and out-of-state contractors	$4,401	17%
[6]	Perryman Group	USMRIAS	TX	CREZ transmission	$5,000	100%
[7]	South Dakota Wind Energy Association *(Stuefen Research)*	IMPLAN	SD	Eastern South Dakota 345 kV transmission	$169	25%
[8]	SPP *(The Brattle Group)*	IMPLAN	SPP	Various Priority Projects under analysis		
				1. Group 1 - 765 kV operated at 345 kV w/ low in-region spending	$1,282	47%
				2. Group 1 - 765 kV operated at 345 kV w/ high in-region spending	$1,282	74%
				3. Group 2 - Combination 345 kV w/ low in-region spending	$1,136	47%
				4. Group 2 - Combination 345 kV w/ high in-region spending	$1,136	73%
[9]	Wyoming Infrastructure Authority *(NREL)*	JEDI based on IMPLAN	WY	Combination of two 500 kV HVDC, two 500 kV HVDC, and multiple 230 kV HVAC collector system lines with substations	$4,150	33%

Sources and Notes:

[1]: Angevine Economic Consulting Ltd., *The Economic Impacts of AltaLink Capital Spending and Operations 2010-2015*, prepared for AltaLink, September 30, 2010. Total transmission capital costs include spending in Canada outside of Alberta but do not include AFUDC and are provided in Canadian 2010$. "Rest of Canada Outside of Alberta" impacts reflect AltaLink's capital spending on other provinces.

[2]: NorthStar Economics, Inc., *The Economic Impact of Electric Power Transmission Line Construction in the Midwest,* prepared for American Transmission Company, LLC, March 2009. Expenditures listed for Arrowhead-Weston line is assumed to be spent 100% in Wisconsin based on costs included in Appendix 3. Dollar figures assumed to be in 2007$.

[3]: UMD Labovitz School, Skurla, J.A., *et al*., *The Economic Impact of Constructing Five Electric Power Lines in Minnesota, North Dakota, South Dakota and Wisconsin, 2010-2015*, prepared for CapX2020, November 2010. Dollar figures all in 2010$.

[4]: University of Southern Maine, Colgan, C., *Economic Impacts of the Proposed Maine Power Reliability Program*, February 2009. Dollar figures expressed in nominal dollars and provided without adjustment above.

[5]: Montana Department of Labor and Industry, Wagner, B., *Employment and Economic Impacts of Transmission Line Construction in Montana*, July 30, 2010. 2007$ estimated capital expenditure restated in 2010$, the same year dollars as impact data provided in study.

[6]: The Perryman Group, *Winds of Prosperity*, May 2010. In-state allocation to Texas is assumed to be 100%. Total transmission capital cost reflects an estimate only. Dollar figures assumed to be in 2009$.

[7]: Stuefen Research, LLC, *The South Dakota Wind Blueprint-Envisioning One Thousand Megawatts of New Capacity: An Economic Impact Analysis*, prepared for South Dakota Wind Energy Association, September 2010. Dollar figures all in 2010$. Reflects corrected total in-state impact as communicated by the author.

[8]: The Brattle Group, Jobs and Economic Benefits of Transmission and Wind Generation Investments in the SPP Region, prepared for SPP, March 2010. Dollar figures all in 2010$.

[9]: National Renewable Energy Laboratory, *Economic Development from New Transmission and Generation in Wyoming*, prepared for the Wyoming Infrastructure Authority, March 2011. Dollar figures all in 2010$.

Table 4
Employment and Economic Impacts of Transmission Investments per Million Dollars of Total and Local Spending

	Study Sponsor	Project Summary	% Local Spending	Based on Total Transmission Capital Cost: FTE-Years of Employment Per $ Million		Based on Total Transmission Capital Cost: Total Economic Output Per $ Million	Based on Local Spending: FTE-Years of Employment Per $ Million		Based on Local Spending: Total Economic Output Per $ Million
				Direct	Total	($ Million)	Direct	Total	($ Million)
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]
[1]	AltaLink	AltaLink's estimated capital spending							
		Alberta	75%	5	7	N/A	7	9	N/A
		Rest of Canada Outside of Alberta	75%	N/A	3	N/A	N/A	3	N/A
[2]	ATC LLC	Two completed projects							
		1. 138 kV Femrite-Sprecher	46%	N/A	5	$0.7	N/A	11	$1.5
		2. 345 kV Arrowhead-Weston	100%	N/A	8	$1.4	N/A	8	$1.4
[3]	CapX2020	Five major transmission projects	100%	7	13	$1.9	7	13	$1.9
[4]	Central Maine Power	Maine Power Reliability	81%	4	6	N/A	5	7	N/A
[5]	Montana Department of Labor & Industry	Six major projects planned or under construction in Montana							
		1. Out-of-state contractors	11%	1	2	$0.2	11	17	$1.7
		2. In-state contractors	33%	2	5	$0.6	7	14	$1.7
		3. In- and out-of-state contractors	17%	2	3	$0.3	9	16	$1.7
[6]	Perryman Group	CREZ transmission	100%	N/A	18	$2.9	N/A	18	$2.9
[7]	South Dakota Wind Energy Association	Eastern South Dakota 345 kV transmission	25%	1	3	$0.3	8	11	$1.3
[8]	SPP	Various Priority Projects							
		1. Group 1 - low in-region	47%	4	7	$0.9	8	14	$1.8
		2. Group 1 - high in-region	74%	5	8	$1.3	6	11	$1.7
		3. Group 2 - low in-region	47%	4	7	$0.8	8	14	$1.8
		4. Group 2 - high in-region	73%	5	8	$1.2	6	11	$1.7
[9]	Wyoming Infrastructure Authority	Combination of 500 kV HVDC, 500 kV HVDC, and 230 kV HVAC	33%	5	5	$0.4	14	15	$1.3

Sources and Notes:

For full source citations, please refer to Table 3.

[1]: "Rest of Canada Outside of Alberta" impacts reflect AltaLink's capital spending on other provinces. The study provided a value-added impact which is not reflected in the table above.

[3]: Direct output assumed to be local spending.

[4]: The study provided a value-added impact which is not reflected in the table above.

[5]: Direct output assumed to be local spending.

[6]: The study provided a value-added impact which is not reflected in the table above.

[9]: NREL "direct" employment data have been adjusted by adding "indirect" impacts to align with other IMPLAN study definitions.

While most studies report "total economic output" as the measure of economic activity, several of these other studies quantified the "value added" of economic impacts—which only captures the final value of sales, similar to a measure of gross domestic product ("GDP")[11]—rather than total economic output, which adds up all sales and resales of products and services. Because these two metrics are not directly comparable, we have reported total economic output as the measure of economic activity quantified by the majority of these studies.

In addition to employment and economic output, input-out models can also estimate the personal income earned by employees, local tax revenues, lease payments to local landowners, and stimulus to individual industries. Not all of the studies quantified these additional benefits and direct comparisons would be difficult due to variations in local wage rates, sales taxes, and property taxes. Nonetheless, selected additional results from these studies include the following:

- In Wyoming, approximately an additional 520 full-time operating and maintenance jobs are estimated to be created once construction of a proposed $4.2 billion transmission expansion is completed.[12]
- In Montana, annual wages associated with power line and related structures construction averaged $65,300 compared with an average of $33,760 across all industries;[13]
- Based on construction spending of $1.7 billion for the group of projects sponsored by CapX2020, total federal and state tax revenues are estimated to be $92 and $52 million, respectively;[14]
- AltaLink estimated that a total of C$304 million will be paid to landowners for right-of-way procurement during the 2010-2015 investment cycle;[15] and
- The construction of $1.1 billion to $1.2 billion of transmission projects in SPP will increase revenues of local natural gas and electric utilities by $12 million to $23 million due to the increase in economic activity.[16]

These estimates are not "net" benefits, however. This is the case because the quantified economic stimulus benefits do not consider the economic costs of recovering the transmission

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11 For example, assume one unit of product A is needed as an input to make one unit of product B; product A sells for $5 and product B sells for $10. If transmission expansion increases demand for product B by one unit, then the total output measure of economic activity combines both the $10 output increase for product B and the $5 output increase for input A, resulting in a $15 increase of total output. However, the increase in demand cannot expand gross domestic product by more than $10 in this case, which is the value of the increased sales of the "final" product (*i.e.*, product B).

12 National Renewable Energy Laboratory, *Economic Development from New Transmission and Generation in Wyoming*, prepared for the Wyoming Infrastructure Authority, March 2011, p. 37.

13 Montana Department of Labor and Industry, Wagner, B., *Employment and Economic Impacts of Transmission Line Construction in Montana*, July 30, 2010, p. 2.

14 UMD Labovitz School, Skurla, J.A., *et al.*, *The Economic Impact of Constructing Five Electric Power Lines in Minnesota, North Dakota, South Dakota and Wisconsin, 2010-2015*, prepared for CapX2020, November 2010.

15 Angevine Economic Consulting Ltd., *The Economic Impacts of AltaLink Capital Spending and Operations 2010-2015*, prepared for AltaLink, September 30, 2010.

16 *The Brattle Group*, *Jobs and Economic Benefits of Transmission and Wind Generation Investments in the SPP Region*, prepared for SPP, March 2010.

investments through utility rates or taxes, nor do they capture *any* of the other transmission-related benefits discussed in Section IV. Moreover, the employment and economic stimulus benefits estimated in these types of studies do not include any additional employment and economic stimulus benefits associated with the fact that the transmission investments may (1) provide the infrastructure necessary to attract new businesses to a region (as noted in the report by American Transmission Company discussed below), and (2) allow the development of renewable generation resources that would not be possible or economic without the upgraded transmission capabilities (as also discussed further below).

2. U.S.-Wide Analysis of Employment and Economic Stimulus Benefits of Transmission Investment

The studies summarized in Table 3 and Table 4 provide only a state-level or regional perspective of the employment and economic stimulus benefit of transmission investment. To estimate U.S.-wide benefits associated with the $12 billion to $16 billion range of annual transmission investment we project for the next 20 years, we conducted our own analysis with a nation-wide rather than local (*i.e.*, state or regional) employment, supply, and manufacturing perspective. We also used the IMPLAN model based on national multipliers and the generic transmission project assumption shown in Table 5.

The estimates of transmission costs in Table 5 reflect generic assumptions across all voltage levels for four major categories of costs: on-site construction labor (40%); materials (45%); design, permitting, engineering, and project management fees (10%); and right of way cost or lease payments (5%). These estimates of costs by category are derived from several studies including SPP, NREL, and discussions with industry participants. The cost breakdown is not meant to reflect actual project component percentages but rather reflect an average over broad categories of transmission-related investments. For example, based on a survey of regional transmission plans, a substation may be built every 50 to 300 miles of transmission lines. This wide range reflects the different requirements for different voltages, different regions of the country, whether or not the investment is for a new line or an upgrade to existing facilities, and if transformation is needed. The cost component assumptions in Table 5 are consistent with approximately one substation with transformation for every 100 miles of transmission lines.

Within the materials category, we have differentiated between costs for transmission lines, towers, and substation structures versus transformers and switch gear. Materials for transmission lines are largely comprised of the towers, structures, and related components (60%) typically made of steel, and the wires and wire components (35%) which are typically made of aluminum. The remaining 5% is comprised of other building materials such as concrete and gravel. Substations with transformation include electrical components such as transformers and circuit breakers (70%) with the remaining costs allocated to the substation structures (25%), often comprised of steel components, and building materials (5%). The combined line-and-substation materials costs (reflecting approximately one substation with transformation per 100 miles of transmission) are assumed to be comprised of: 50% for towers and structures; 25% for wires; 20% for transformers and circuit breakers; and 5% other building materials.

Table 5
Generic Transmission Investment Cost Breakdown
(Represents average across all voltages and investment types, assuming approximately one substation with transformation for every 100 miles of transmission)

Category	Cost Share By Category	Domestic Content
Materials	**45%**	61%
Construction Labor	**40%**	100%
Design / Permitting / Engineering / Project	**10%**	100%
Right of Way	**5%**	100%
Total	**100%**	**82%**
Detailed Materials Breakdown		
Transmission line		
Towers & structures	*60%*	
Wires	*35%*	
Other building materials	*5%*	
	100%	
Substation w/ transformation		
Transformers & circuit breakers	*70%*	
Structures	*25%*	
Other building materials	*5%*	
	100%	
Transmission line & substation		
Towers & structures	*50%*	65%
Wires	*25%*	65%
Transformers & circuit breakers	*20%*	35%
Other building materials	*5%*	100%
	100%	

Sources and Notes:
Analysis by *The Brattle Group* based on literature survey and input from industry participants.

Based on conversations with industry participants, U.S. domestic manufacturing of certain materials varies greatly depending on voltage level and equipment type. For example, we understand there is limited domestic manufacturing of transmission-level transformers and none at the 765 kV voltage level. We have assumed that the domestic supply of towers, structures, and wires accounts for approximately 65% of total equipment needs (with the remaining 35% imported). For transformers and circuit breakers we assume only 35% would be supplied domestically on average across all voltage levels. All other materials and major cost categories are assumed to be 100% sourced domestically. This means, approximately 82% of total services, materials, and equipment used in the construction of transmission facilities is assumed to be supplied domestically.

We have applied these cost and domestic sourcing assumptions and simulated a $1 billion transmission investment with IMPLAN.[17] The results of this analysis are reported in the first row of Table 6. As shown, every $1 billion of U.S. transmission investment supports approximately 12,700 FTE-years of employment and stimulates approximately $2.4 billion of economic activity.

As Table 6 also shows, of the 12,700 total job years, approximately 4,300 are supported by the direct spending on design, construction, and equipment; while the remainder is supported by indirect activities (*i.e.*, suppliers to the transmission construction and equipment manufacturing sectors) and induced activities (*i.e.*, jobs created by the increased spending on food, clothing, and other services by those who are directly or indirectly employed).

Table 6
Comparison of U.S.-Wide and Regional
Jobs and Economic Output Impacts from Transmission Construction

	Study Sponsor *(Author)*	Model Used	State(s) / Region	Project Details	Total Transmission Capital Cost	% Local Spending	FTE Jobs Per $ Billion of Transmission Capital Cost		Total Economic Output Per $ Billion of Transmission Capital Cost
					($ Billion)		Direct	Total	($ Billion)
[1]	WIRES *(The Brattle Group)*	IMPLAN	U.S.	Total U.S. transmission industry investment across all voltage levels and sponsor types	$1	82%	4,275	12,696	$2.4
[2]	Survey of Studies *(Various)*	IMPLAN and others	Regional and state-level	Major in-service, under construction, and proposed transmission projects	~$25	11-100%	1,000 - 7,000	2,000 - 18,000	$0.2 - $2.9

Sources and Notes:
[1]: See Table 5 for cost assumptions.
[2]: See Table 3 for full source citations.

A comparison of these results with the state and regional results from the studies summarized in Table 4 shows that our estimate of U.S.-wide impacts are at the high end of the range of results from the regional and state-level studies. This is consistent with the larger geographical footprint of our analysis, which means fewer resources are "imported" into the study area. This effect of considering a larger region also exists when comparing county and state-wide analyses. As noted in a comparison of county- and state-level impacts:

> [T]his is an issue of geographical region, rather than method… [An analysis] at the state level, rather than at the county level, will result in higher employment

[17] IMPLAN is based on a linear production function without assuming any economies of scale. Therefore, a basic investment amount of $1 billion will be the same as $12 billion divided by 12.

estimates and greater economic impact because a greater percentage of the capital investment is spent within the region.[18]

As shown in Table 7, applying the estimated employment and economic stimulus benefits to the estimated $12 billion to $16 billion in annual U.S. transmission investments shows that this level of investment supports between 150,000 and 200,000 domestic FTE jobs each year. Approximately one-third (51,000 to 68,000) of these jobs are supported *directly* by domestic construction, engineering, and transmission component manufacturing activities. As also shown, the total economic output (*i.e.*, total sales and resales of businesses) stimulated by this level of investment ranges from $30 billion to $40 billion per year.

Table 7
Employment and Economic Output Impacts Based on $12 to $16 Billion Annual Transmission Expenditures

Annual Transmission Capital Cost	Annual FTE Jobs Supported		Annual Total Economic Activity Stimulated
(2011$ Billion)	Direct	Total	(2011$ Billion)
$12	51,000	150,000	$30
$16	68,000	200,000	$40

Additional employment benefits are created during the operations phase. For example, a recent study by NREL shows that approximately 125 operating and maintenance jobs are created per $1 billion of transmission additions. Based on our estimates of $12 billion to $16 billion in annual U.S.-wide transmission investments, this will add 1,500 to 2,000 full-time O&M jobs each year, growing to 30,000 to 40,000 additional full-time positions by 2030.

While we have not conducted a detailed analysis of the additional jobs and economic output from factors such as wind generation investments made possible by transmission upgrades, an estimate of these impacts can be derived from the Department of Energy's ("DOE's") *20% Wind Energy by 2030* study. The DOE analyzed the impact of investing $495 billion (2006$) in wind generation from 2007 through 2030 to support 20% wind energy penetration nation-wide. This study utilized the Jobs and Economic Development Impact ("JEDI") model, which was developed by NREL with multipliers based on the IMPLAN model. The DOE found that every $1 billion of wind generation investment supports a total of approximately 12,500 FTE-years of employment. We estimate that approximately 100,000 MW of additional wind generation is needed to satisfy existing state RPS requirements and 190,000 MW of additional wind generation would be needed to meet a 20% federal RPS requirement, assuming at least 20% of renewable needs would be provided by resources that do not require transmission upgrades. At an average cost of $2,100/kW of installed wind capacity, the total additional wind generation investment requirement would be $210 billion to $400 billion. This level of renewable generation investment will consequently support approximately 2.6 million to 5 million FTE

[18] Montana Department of Labor and Industry, Wagner, B., *Employment and Economic Impacts of Transmission Line Construction in Montana*, July 30, 2010, p. 3.

years of employment in total or, on average, 130,000 to 250,000 full-time jobs during each year of the projected 20-year renewable generation construction effort. Additional employment benefits will be associated with the approximately 20-year operations phase of these projects.

3. Canadian Employment and Economic Stimulus Benefits of Transmission Investment

While we have not undertaken an independent analysis of Canadian employment and economic stimulus benefits of transmission investment, we are able to estimate these impacts by applying the result of the AltaLink-sponsored study summarized in Table 4 to the identified Canadian transmission investment activities summarized in Table 2. The AltaLink study estimated that for every C$1 million in total transmission investment, approximately 7 FTE jobs are supported within the province and an additional 3 FTE jobs are supported in the rest of Canada. Applying these 10 FTE jobs per million dollars of investment to the C$45 billion of transmission plans identified for the next 20 years yields a total of 450,000 FTE-years of employment, or an average of 22,500 full-time jobs each year during the 20 year construction period. Considering that Canadian transmission investments average C$5.2 billion over the next several years (for which more complete data is available), the higher near-term level of investment would support 52,000 full-time jobs annually within Canada.

IV. ADDITIONAL BENEFITS OF TRANSMISSION INVESTMENTS

Once transmission facilities are constructed and placed in service, they support a wide range of additional benefits, from increased reliability, to decreased transmission congestion, to renewables integration, and increased competition in power markets. These benefits of major transmission investments often are wide-spread geographically across multiple utility service areas and states, are diverse in their effects on market participants, and occur and change over the course of several decades. The benefits we derive from today's transmission grid, such as the ability to operate competitive wholesale electricity markets, could barely be imagined when the facilities were built three or four decades ago.

It is important to recognize that the scope of transmission-related benefits extends beyond the main driver of a particular investment. For example, transmission investments are often driven by the need to address reliability concerns and, thus, help increase the reliability of the power system. Reliability benefits were consequently often viewed as the primary source of benefits. However, with the emergence of transmission projects targeted to relieve transmission congestion or to integrate renewable generation projects, it is increasingly understood that transmission investments provide a wide range of benefits, such as reducing the cost of supplying electricity or allowing the integration of lower-cost renewable resources. Thus, while many transmission investments may be driven primarily by a single concern, such as reliability, congestion relief, or renewable integration, the benefits of these transmission investments generally extend well beyond the benefit associated with the primary investment driver. For example, reliability-driven projects will also reduce congestion and often support the integration of renewable generation. Similarly, a transmission project driven by congestion relief objectives will generally also increase system reliability or help to avoid or delay reliability projects that would otherwise be needed in the future. It is the interrelated but collateral nature of these benefits that often makes them difficult to quantify. There are a number of studies quantifying the economic value of benefits for individual transmission projects, which we use to indicate the potential magnitude of these benefits in the following discussion.

The post-construction assessment of the Arrowhead-Weston transmission line in Wisconsin, which was energized by American Transmission Company ("ATC") in 2008, provides a good example of the broad range of benefits associated with an expanded transmission infrastructure. The primary driver of the Arrowhead-Weston line was to increase reliability in northwestern and central Wisconsin by adding another high voltage transmission line in what the federal government designated at the time as "the second-most constrained transmission system interface in the country."[19] The project addressed this **reliability** issue by adding 600 MW of carrying capacity and **improving voltage support**, the impact of which was noticeable in both Wisconsin and in southeastern Minnesota.[20] By also **reducing congestion**, ATC estimated that the line allowed Wisconsin utilities to decrease their power purchase costs by $5.1 million annually, saving $94 million in net present value terms over the next 40 years.[21] Similarly, ATC estimated that $1.2 million were saved in **reduced costs for scheduled maintenance** since the Arrowhead-Weston line went into service.[22] The high voltage of the line (345 kV) also **reduced on-peak energy losses** on the system by 35 MW, which **reduced new generation investments** equivalent to a 40 MW power plant. The reduced losses also avoid generating 5.7 million MWh of electricity, which **reduces CO_2 emissions** by 5.3 million tons over the initial 40-year life of the facility.[23] In addition, the transmission line has the capability to deliver hydro resources from Canada and wind power from the Dakotas and interconnect local renewable generation to **help meet Wisconsin's RPS requirement**. The construction of the line **supported 2,560 jobs**, generated $9.5 million in **tax revenue**, created $464 million in total **economic stimulus** and will provide **income to local communities** of $62 million over the next 40 years.[24] The increased reliability of the electric system has provided **economic development benefits** by improving operations of existing commercial and industrial customers and attracting new customers.[25] Lastly, the Arrowhead-Weston line also provides **insurance value against extreme market conditions** as was illustrated in a NERC report which noted that if Arrowhead-Weston had been in service earlier, it would have **averted blackouts** in the region which impacted an area that stretched from Wisconsin and Minnesota to western Ontario and Saskatchewan, affecting hundreds of thousands of customers.[26]

The magnitude and range of the benefits discussed in ATC's study substantially exceed the range of benefits typically quantified or discussed in most transmission cost-benefit analyses. This is the case because the broad range of transmission-related benefits and long time frame over which such benefits accrue often makes it very difficult to quantify the full extent of these benefits. As the FERC noted in a recent order:

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19 American Transmission Company LLC, *Arrowhead-Weston Transmission Line: Benefits Report*, February 2009, p. 7.
20 *Id.*, p. 7.
21 *Id.*, p. 7.
22 *Id.*, p. 7.
23 *Id.*, p. 9.
24 *Id.*, pp. 15-16.
25 *Id.*, p. 8.
26 *Id.*, p. 12.

> [C]ost-benefit analyses often evaluate benefits at a distinct point in time. Because power flows change constantly with fluctuations in generation and load, as well as the addition of new transmission facilities, generation resources, and loads to the system, such static analyses cannot capture all benefits over time. Therefore, relying solely on the costs and benefits identified in a quantitative study at a single point in time may not accurately reflect the [benefits] of a given transmission facility, particularly because such tests do not consider any of the qualitative, (*i.e.*, less tangible) regional benefits inherently provided by an EHV transmission network. No single analytical study can reflect future needed expansions to the electric grid to support regional power flows as system conditions change and the manner in which the function of earlier expansions will change once integrated with future expansions.[27]

While the focus of this report is to estimate the employment and economic stimulus impact from the initial transmission investment, it is important to understand the full range of benefits that the improved transmission infrastructure provides during the operations-phase of the facilities. Because these operations-phase benefits are highly specific to the nature of individual projects and the regional power market in which they operate, a nation-wide estimate of the additional economic benefits associated with the overall investment levels we have identified is not possible without project-specific analyses. However, we provide examples from analyses that have quantified and considered some of these benefits in the context of individual transmission projects. As these examples document, the operations-phase benefits of transmission investments often significantly exceed the cost of the projects. The remainder of this study addresses these electricity market and related operations-phase benefits of transmission investments in more detail.

1. Production Cost Savings, Wholesale Price Reductions, and Reduced Transmission Losses

The most commonly quantified "economic" benefits of transmission investments are reductions in simulated fuel and other variable operating costs of power generation (generally referred to as "production cost" savings) and the impact on wholesale electricity market prices (generally referred to as locational marginal prices or "LMPs") at load-serving locations of the grid. These **production cost savings** and "**Load LMP benefits**" are typically estimated with production cost simulation models that simulate generation dispatch and power flows subject to defined transmission constraints. In a recent assessment of RTO performance by the FERC, the majority of RTOs cited reduced congestion as a main benefit from expanding transmission capacity. For example, PJM noted that market simulations of recently approved high voltage upgrades indicate that the upgrades will reduce congestion costs by approximately $1.7 billion compared to congestion costs without these upgrades.[28]

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27 Federal Energy Regulatory Commission, *Order Accepting Tariff Revisions*, Docket No. ER10-1069-000, June 17, 2010 for SPP's "Highway/Byway" cost allocation methodology (Highway/Byway Methodology).

28 Federal Energy Regulatory Commission, *2011 Performance Metrics for Independent System Operators and Regional Transmission Organizations*, Appendix H: PJM, April 7, 2011, p. 275.

The addition of new transmission facilities will also generally **reduce energy losses** incurred in the transmittal of power from generation resources to loads. Due to limitations in simulation models, the full benefits associated with reduced transmission losses are not generally captured in estimates of production cost savings.[29] The economic benefits associated with the extent to which major transmission projects reduce transmission losses can be surprisingly large. For example, the economic benefits of reduced losses associated with a single 345 kV transmission project in Wisconsin were sufficient to offset roughly 30% of the project's investment costs.[30] Similarly, in the case of a recently proposed 765 kV transmission project, the present value of reduced system-wide losses equated to roughly *half* of the project's cost.[31]

While production-cost savings are easily quantified with standard production cost simulation models, it is often not understood that these models quantify only the short-term dispatch-cost savings of system operations. They cannot capture a wide range of other transmission-related benefits, including generation-related investment-cost savings. For example, as a Western Electric Coordinating Council ("WECC") planning group recognized:

> 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 production cost simulation] analysis.[32]

In fact, the "benefits associated with reliability, capital costs, market power and demand" are often omitted entirely in many transmission cost-benefit analyses because they are not readily quantifiable with standard simulation tools. Because these benefits are often more difficult to quantify than production cost and Load LMP impacts, these "other" benefits are sometimes discounted as "soft" benefits and often dismissed as "unquantifiable" or "intangible" benefits.

Table 8 lists a number of these often-overlooked transmission-related benefits. We briefly summarize the nature and magnitude of these other benefits in the following discussion.[33]

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29 The benefit of reduced transmission losses is not generally reflected in estimates of production cost savings because such market simulation are almost universally based on static transmission loss assumptions that do not reflect the fact that transmission upgrades will reduce the total quantity of energy that needs to be generated to make up for these losses.

30 American Transmission Company, LLC, *Planning Analysis of the Paddock-Rockdale Project*, April 5, 2007, pp. 4 (project cost) and 63 (losses benefit).

31 Pioneer Transmission, LLC, Formula Rate and Incentive Rate Filing, FERC Docket No. ER09-75, at p. 7 (January, 26, 2009). These benefits include both the energy and capacity value of reduced losses.

32 SSGWI Transmission Report for WECC, October 2003.

33 For a more detailed discussion of the benefits listed in Table 8 see, for example, Pfeifenberger, "Transmission Planning: Economic vs. Reliability Projects," EUCI Conference, Chicago, October 13, 2010.

Table 8
Often Overlooked "Other" Transmission Benefits

1. Enhanced market competitiveness	Additional market benefits
2. Enhanced market liquidity	
3. Economic value of reliability benefits	Reliability/operational benefits
4. Added operational and A/S benefits	
5. Insurance and risk mitigation benefits	
6. Capacity benefits	Investment and resource cost benefits
7. Long-term resource cost advantage	
8. Synergies with other transmission projects	
9. Impacts on fuel markets	External benefits
10. Environmental and renewable access benefits	
11. Economic benefits from construction and taxes	

2. Additional Wholesale Electricity Market Benefits

Production cost simulations generally assume generation is bid into wholesale markets at variable operating costs, which does not take into account for the fact that bids will include mark-ups over variable costs, particularly in real-world wholesale power markets that are less than perfectly competitive. Thus, wholesale power market benefits of transmission investments will generally exceed the benefits quantified in cost-based simulations.

Transmission investments can **enhance the competitiveness of wholesale electricity markets** by broadening the set of suppliers that compete to serve load. While the magnitude of savings depends on market concentration and how much load is served at market-based rates (rather than through cost-of-service regulated generation), studies have found that the economic value of increased competition can reach 50% to 100% of a project's costs.[34] This benefit is explicitly considered in the California ISO's economic transmission planning methodology.[35] ISO New England also recently noted that increased transmission capacity into constrained areas such as Connecticut and Boston have significantly reduced congestion, "thereby significantly reducing the likelihood that resources in a submarket could benefit from the exercise of market power."[36]

Similarly, limited liquidity of wholesale electricity markets also impose transaction costs and price uncertainty on both buyer and sellers. These transactions costs and price uncertainties are higher in markets with less liquidity. Transmission expansion can **increase market liquidity** by increasing the number of buyers and sellers able to transact with each other. This will lower the bid-ask spreads of electricity trades, increase pricing transparency, and provide better clarity for long-term planning and investment decisions. For example, we found that bid-ask spreads for bilateral trades at less liquid hubs are 50 cents to $1.50 per MWh higher than the bid-ask spreads

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34 For example, see California ISO, *Transmission Economic Assessment Methodology* ("TEAM"), June 2004.

35 *Id.*

36 Federal Energy Regulatory Commission, *2011 Performance Metrics for Independent System Operators and Regional Transmission Organizations*, Appendix F: ISO New England, April 7, 2011, p. 106.

at more liquid hubs.[37] At transaction volumes ranging from less than 10 million to over 100 million MWh per quarter at each of more than 30 electricity trading hubs, even a 10 cent per MWh reduction of bid-ask spreads due to a transmission-investment-related increase in market liquidity saves $4 million to $40 million per year and trading hub, which would amount to transactions cost savings of approximately $500 million annually on a nation-wide basis.

3. RELIABILITY AND OPERATIONAL BENEFITS

Transmission investments, even if not driven by reliability concerns, will generally increase reliability on the power system. This increase in reliability provides economic value by **reducing service curtailments** and avoiding high-cost outcomes during extreme system conditions. The cost of reliability problems and their "expected unserved energy" can be measured with estimates of the "value of lost load," which can exceed $5,000 to $10,000 per curtailed MWh.[38] The high value of lost load means that avoiding even a single reliability event that would result in blackout is worth ranging from tens of millions to billions of dollars.

In addition to reducing the frequency and magnitude of possible blackouts, transmission investments can also **reduce reliability-related operating costs**, which tend to add significantly to congestion costs but are often not captured in production cost simulations.[39] Transmission can also **reduce the demand and cost of ancillary services**, a benefit which will grow in importance as the penetration of variable generation resources such as wind expands.

By also reducing the high generation dispatch and power purchase costs incurred during reliability events or challenging market conditions, transmission upgrades provide **insurance against extreme events,** such as unusual weather conditions, fuel shortages, or multiple generation and transmission outages. For example, the Chair of the CAISO's Market Surveillance Committee estimated that if significant additional transmission capacity had been available during the California energy crisis from June 2000 to June 2001, its value would have been as high as $30 billion over this 12 month period.[40] Similarly, a detailed analysis of the insurance benefit of a 345 kV transmission project found that the project's probability-weighted savings from reducing the impacts of extreme events equated to approximately 20% of the project's costs.[41]

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37 Before the Arizona Power Plant and Transmission Line Siting Committee, Docket No. L-00000A-06-0295-00130, Case No. 130, Oral Testimony on behalf of Southern California Edison Company re: economic impacts of the proposed Devers-Palo Verde No. 2 transmission line, September and October, 2006, p. 39.

38 *Id.,* pp. 30-32. This reliability cost can be thought of as: (expected unserved energy) x (value of lost load).

39 Examples are out-of-merit dispatch costs, reliability-must-run costs, and reliability unit commitment costs (referred to with acronyms such as RMR, MLCC, RSG).

40 Professor Frank Wolak, as quoted in California ISO, *Transmission Economic Assessment Methodology*, June 2004, p. ES-9.

41 American Transmission Company, LLC, *Planning Analysis of the Paddock-Rockdale Project*, April 5, 2007, pp. 4 (project cost) and 50-53 (insurance benefit).

4. INVESTMENT AND RESOURCE COST BENEFITS

Transmission projects can provide "investment and resource cost benefits" by displacing or delaying otherwise needed capital investment, **allowing the integration of lower-cost generation resources**, and reducing the cost (or increasing the value) of subsequent transmission projects. For example, transmission investments that allow the integration of wind generation in locations with a 40% average annual capacity factor reduce the investment cost of wind generation by *one quarter* compared to the investment requirements of wind generation in locations with a 30% capacity factor.[42] Transmission investments may also allow the development of generation with lower fuel costs (*e.g.*, mine mouth coal plants or natural gas plants built in locations that offer higher operating efficiencies), better access to valuable unique resources (*e.g.*, hydroelectric or pumped storage options), or lower environmental costs (*e.g.*, better carbon sequestration and storage options). Similarly, a robust transmission network provides additional **resource planning flexibility** in addressing unexpected shifts in fuel costs, changes in public policy objectives, or uncertainties in the location and amount of future generation additions and retirements.[43] This also includes optionality and flexibility in terms of leveraging lowest cost supply and demand side resources in the future.

Additional generation capacity investment savings also are provided by reducing losses during peak load and, through added transfer capabilities, the diversification of renewable generation. Recent studies show that **peak-loss-related capacity benefits** can add 5% to 10% to estimated production cost savings.[44] The Eastern Wind Integration and Transmission Study ("EWITS") showed that regional transmission overlays can **increase the capacity value of wind generation** by roughly 5 percentage points (*i.e.*, from an average of 23% without regional transmission upgrades to 28% with regional upgrades).[45] Similarly, regional overlays can diversify the geographic footprint of intermittent renewable and balancing generation resources, which leads to lower renewable balancing costs. If we conservatively assume that the **renewable generation balancing benefit** of an expanded regional grid reduces balancing costs by only $1/MWh of wind generation to a range of $3 to $5 per MWh,[46] nation-wide annual savings would exceed $250 million for 100,000 MW of wind generation at 30% capacity factor.

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42 For example, see *Wind Energy Transmission Economics*, prepared for WPPI Energy by Burns and McDonnell, March 2010, page 1-2, Figure 2.

43 For example, *Brattle Group* experts recently estimated that emerging environmental regulations will likely result in the retirement of over 50,000 MW of coal-fired generation, with much of it located in the Midwest and Texas. (Celebi *et al.*, *Potential Coal Plant Retirements Under Emerging Environmental Regulations*, *The Brattle Group*, December 8, 2010.)

44 Based on *Brattle* analysis of CAISO, *Economic Evaluation of the Palo Verde-Devers Line No. 2 (PVD2)*, February 24, 2005; and American Transmission Company LLC, *Planning Analysis of the Paddock-Rockdale Project*, April 2007.

45 National Renewable Energy Laboratory, *Eastern Wind Integration and Transmission Study* ("EWITS"), January 2010, p. 203. 23% is the average cross a range of 19% to 27% and 28% is the average across a range of 26% to 30% for the existing and overlay results, respectively.

46 *Id.*, estimating renewable generation balancing costs after regional transmission upgrades on p. 46 (in 2009 dollars) and p. 163 (in 2024 dollars). See also U.S. Department of Energy, *2009 Wind Technologies Market Report*, August 2010, p. 65, reporting renewable integration balancing costs from various studies ranging from $2/MWh to $8/MWh.

Added regional transfer capacity can also **allow reductions in local reserve margin requirements** while maintaining reliability standards. For example, the Public Service Commission of Wisconsin found that "the addition of new transmission capacity strengthening Wisconsin's interstate connections" was one of three factors that allowed it to reduce the planning reserve margin requirements of Wisconsin utilities from 18% to 14.5%.[47]

Finally, individual transmission projects can provide significant investment cost benefits through **synergies with or reducing the cost of future transmission projects**. While projects may be proposed to reduce congestion or integrate renewable generation, they may also avoid, delay, or reduce the cost of future reliability and other transmission projects. For example, the California ISO found that its renewable-integration-driven transmission project in the Tehachapi region of southern California also allowed the low-cost upgrade of a congested transmission path (Path 26) and provided additional options for future transmission expansions.[48] The sizing and configuration of projects built today can also create valuable options that allow for more flexible and lower-cost transmission expansion in the future.

5. External Benefits

Transmission investments often create benefits beyond reducing the delivered wholesale cost of power. These "external" benefits include **impacts on fuel markets** (reduced fuel prices)**, environmental benefits** (reduced emissions)**, and reducing the cost of public policy requirements** (such as the cost of renewable generation). For example, the Southwest Power Pool estimated that transmission investment that allow for the interconnection of additional wind generation would lead to a reduction of regional natural gas prices, a customer benefit that offset approximately one quarter of the transmission costs.[49] External benefits also include the employment and economic activity benefits discussed in Section III of this study.

* * *

Figure 5, Figure 6, and Figure 7 summarize examples of transmission benefit-cost analyses that identified and quantified a number of the transmission-related benefits discussed above. As shown, the total economic benefits quantified for these transmission projects exceed their costs by 60% to 70%. Thus, the projects are expected to result in wholesale electricity market benefits significantly in excess of transmission-related rate increases.

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[47] Public Service Commission of Wisconsin order in Docket 5-EI-141, filed October 10, 2008, p. 5. Two other changes that contributed to this decision were the introduction of the Midwest ISO as a security constrained, independent dispatcher of electricity and the development of additional generation in the state.

[48] California ISO, *Transmission Economic Assessment Methodology*, June 2004, p. 9-21. Tehachapi region referred to as Kern County.

[49] Southwest Power Pool, *SPP Priority Projects Phase II Report, Rev. 1, Summary of Economic Result*, April 2010.

Figure 5
Total Benefits Quantified for SPP's Priority Projects

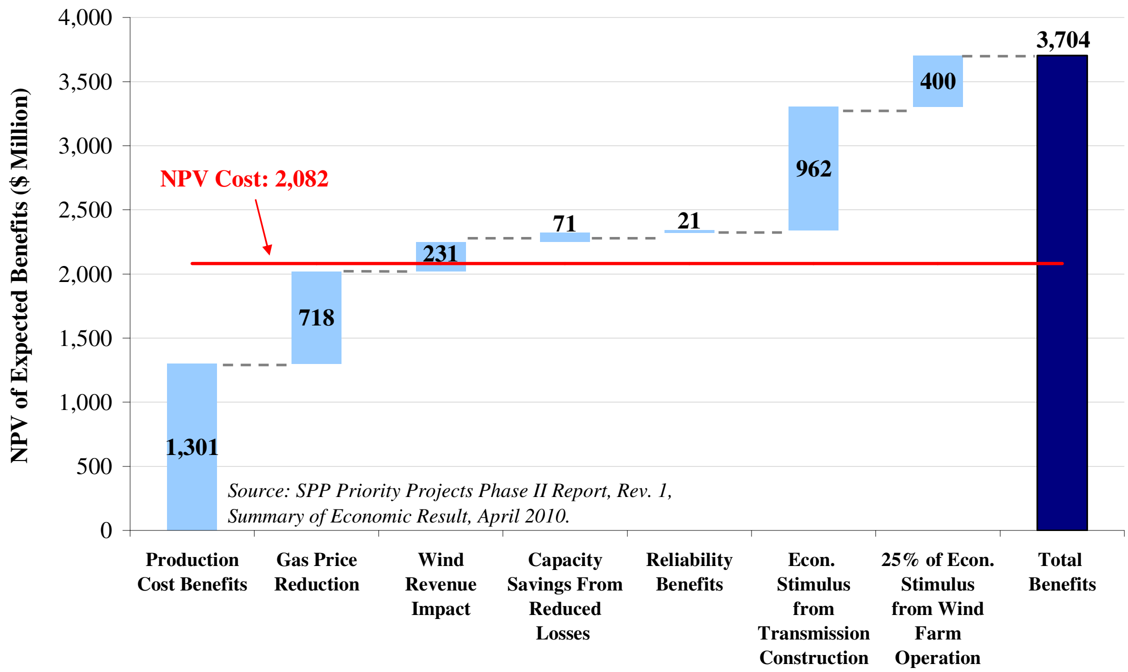


Figure 6
Total Benefits Quantified for ATC's Paddock-Rockdale Project
(Note: production cost benefits alone exceeded project costs in 5 out of 7 scenarios)

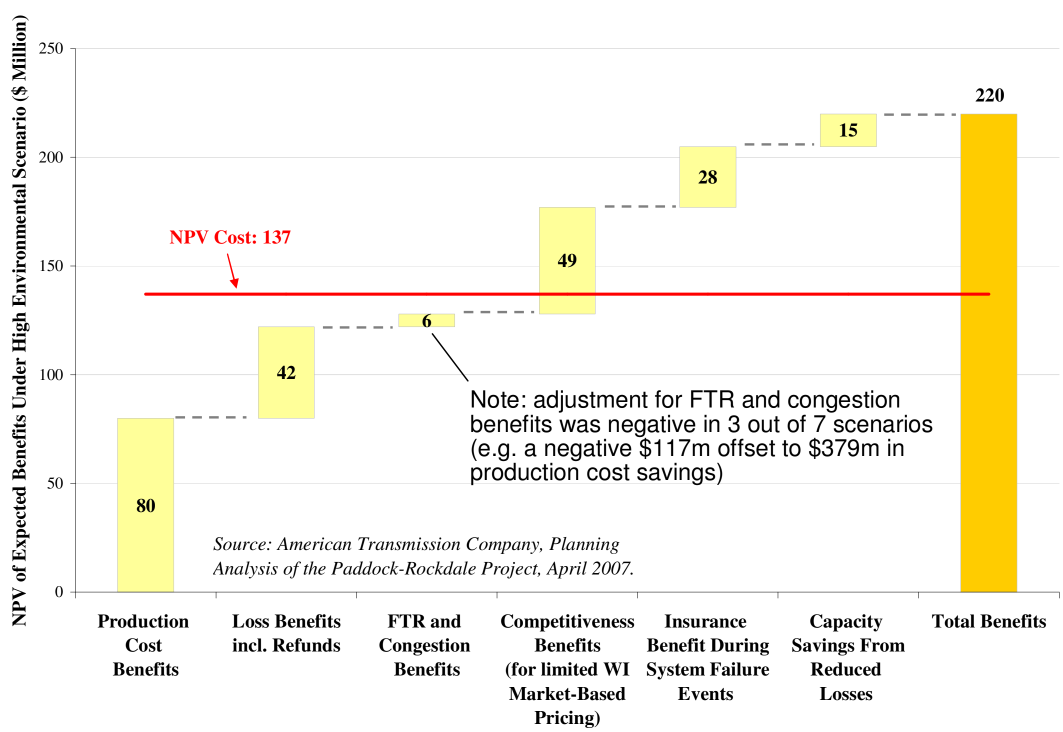
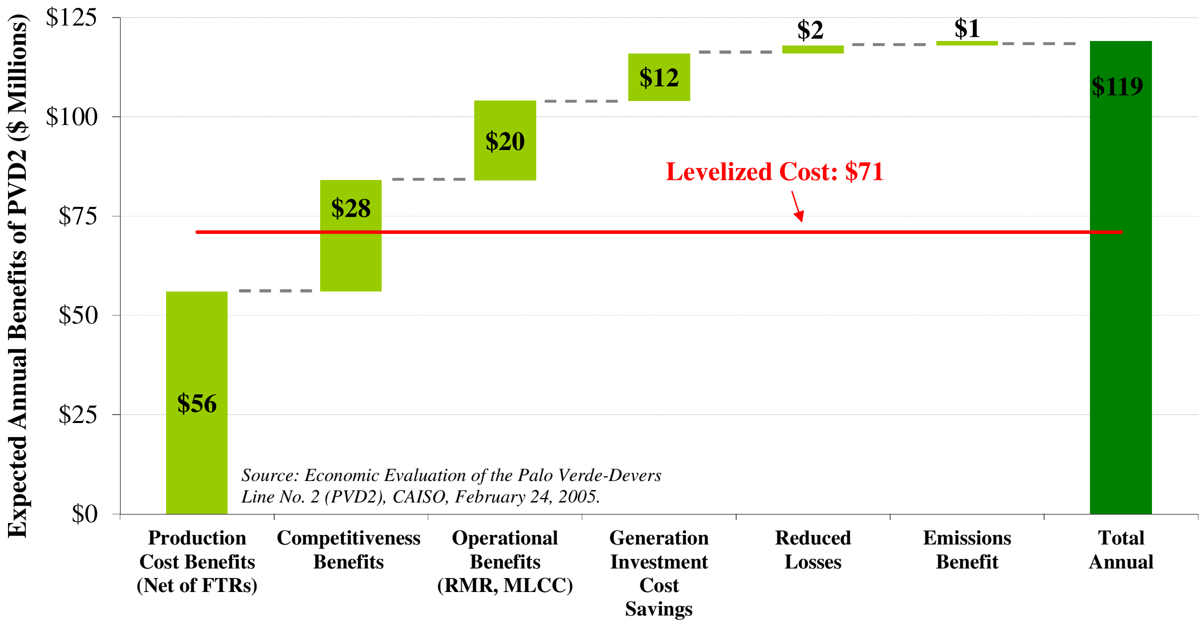


Figure 7
Total Benefits Quantified for Southern California Edison's Palo Verde-Devers 2 Project



V. CONCLUSIONS

Based on recent historical transmission investment data and projections from a variety of industry sources, we estimate that U.S.-wide transmission investments will average approximately $12 billion to $16 billion per year through 2015, with a total investment of approximately $60 billion to $80 billion over the next five years. Our analysis also shows that this $12 billion to $16 billion range of average annual U.S. transmission investments projected for the next five years will likely continue through 2030. This means total transmission investments from 2011 through 2030 are expected to range from $240 billion to as much as $320 billion (in 2011 dollars). *Whether* future transmission investments will fall within this range is conditional on overcoming a number of existing barriers to regional transmission investments. *Where* future investments fall within this range in part depends on the resolution of uncertainties, such as renewable energy policy requirements.

Canadian transmission investments are estimated at approximately C$5.2 billion annually over the next several years, with a total of approximately C$45 billion in already-identified transmission projects through 2030.

As discussed in Section IV of our report, the benefits of transmission investments are broad in scope (*i.e.*, ranging from production cost savings to regional reliability to increased competition in wholesale power markets), wide-spread geographically (*i.e.*, multiple states or regions), diverse in their effects on individual market participants, and occur over a long period of time (*i.e.*, several decades). One such benefit is the employment and economic activity stimulated by the transmission investment itself, which includes benefits from both construction and manufacturing activities.

Our U.S.-wide economic analysis shows that every billion dollars of transmission infrastructure investment supports approximately 13,000 full-time-equivalent ("FTE") years of employment and $2.4 billion in total economic activity (*i.e.*, the sales and resales of goods and services). These results mean that the projected $12 billion to $16 billion of annual U.S. transmission investments will support approximately 150,000 to 200,000 full-time jobs and $30 billion to $40 billion in annual economic activity. Approximately one-third of this employment benefit is associated with the "direct" construction and manufacturing of transmission facilities. Two-thirds of the total impact is associated with "indirect and induced" employment by suppliers and service providers to the transmission construction and equipment manufacturing activities. The investments associated with the identified Canadian transmission projects are estimated to support approximately 50,000 full-time jobs per year on average over the next several years and over 20,000 full-time jobs per year through 2030 based on already-planned transmission investments.

A portion of the projected transmission investments will also enable development of the renewable generation projects needed to satisfy existing state and potential future federal RPS requirements. This renewable generation investment will additionally support approximately 2.6 million to 5 million FTE years of employment, or on average support 130,000 to 250,000 full-time jobs during each year of the projected 20-year renewable generation construction effort. Additional employment benefits are associated with the approximately 20-year operations phase of these projects.

Appendix A
Additional U.S. Transmission Investment Data and Assumptions

This appendix provides additional details on the data and assumptions used to derive the historical, near-term, and long-term U.S. transmission investment levels discussed in Section II of this report.

1. HISTORICAL U.S. INVESTMENT

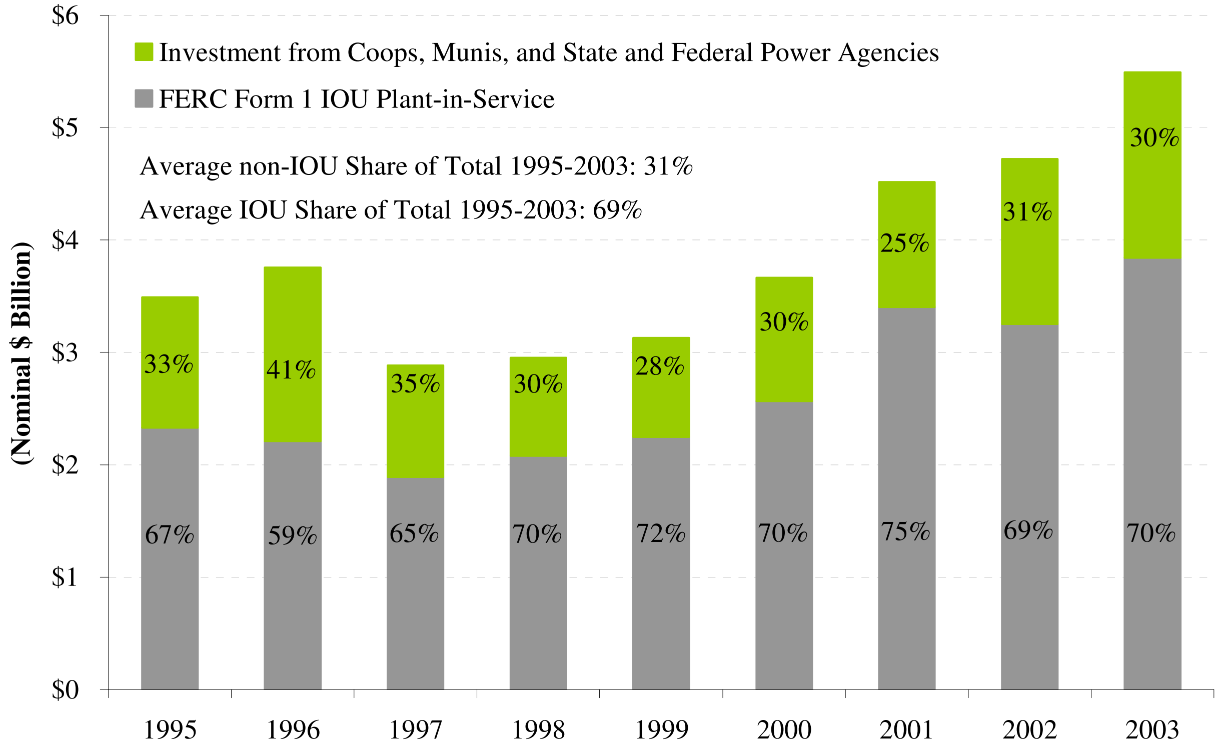
Historical U.S. investment for investor-owned utilities shown in Figure 1 (Section II of our report) is based on data collected by the Federal Energy Regulatory Commission ("FERC") and the Edison Electric Institute ("EEI"). FERC collects these data for all major FERC-jurisdictional electric utilities. The EEI, an association of shareholder-owned electric companies, collects and periodically publishes historical transmission capital expenditures based on surveys of its members. The most recent publicly available data were released in 2010. The FERC and EEI data sets are very similar in terms of reporting entities and include investment in facilities at all transmission voltage levels as well as substations and other equipment. However, the FERC Form 1 data reflect annual additions to plant-in-service, while the EEI data reflect annual capital expenditures. Because at least some of the capital expenditures often are made one or several years before the plant is actually placed into service, the FERC plant additions data will "lag" behind EEI capital investment data. Figure 1 indicates that this lag averages approximately one year.

We also collected transmission investments for entities that are not investor-owned from the Rural Utilities Service ("RUS")[50] for generation and transmission cooperatives and the Energy Information Administration ("EIA")[51] for municipal utilities and state and federal power agencies. Data from RUS are available through 2008 but EIA's data are available only through 2003, after which the data were no longer collected. For years in which there were overlapping data, we have found that investment from these non-investor-owned transmission providers range from approximately $1 billion to $2 billion per year (in nominal dollars) as shown in Figure 8 below. Figure 8 also shows that investment by non-investor-owned transmission providers (green bars) are approximately 31% of total U.S. transmission investments from 1995 through 2003 with little annual variation from that average.

This means transmission additions by investor-owned entities (as shown in Figure 1) account for approximately 69% of total U.S. transmission investments.

50 RUS Form 12: Operating Report – Financial.
51 EIA Form 412: Annual Electric Industry Financial Report (discontinued in 2003).

Figure 8
1995-2003 Historical Total Transmission Investment

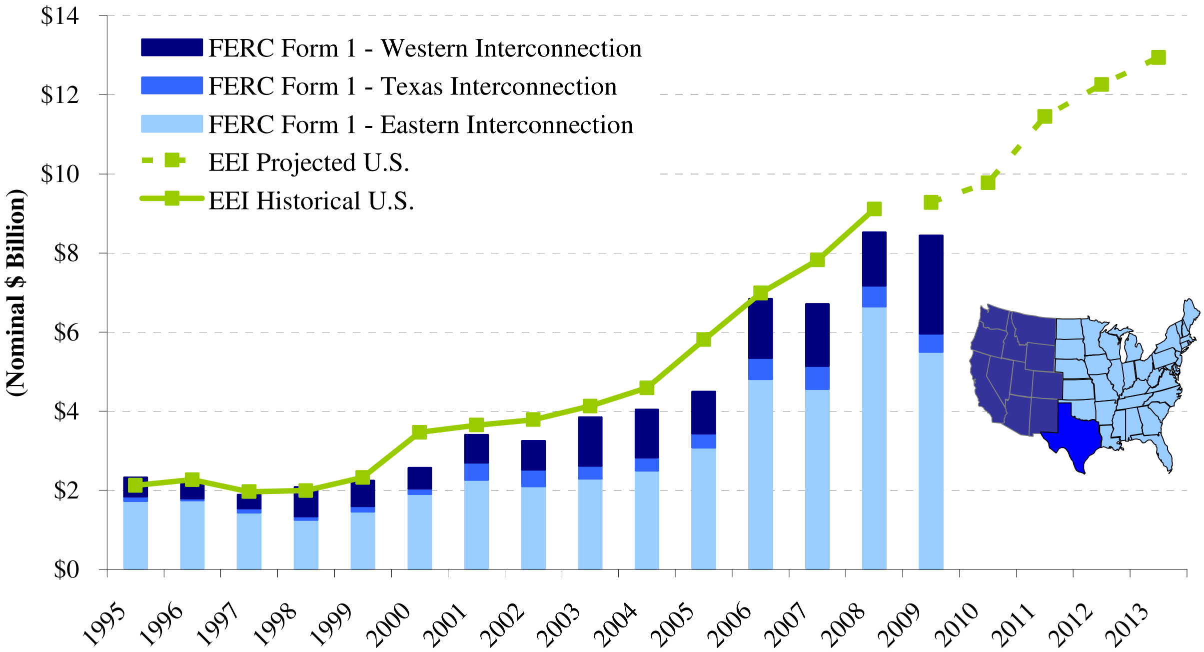


2. PROJECTED NEAR-TERM INVESTMENT: 2011-2015

In addition to historical data, EEI also periodically publishes projected near-term transmission capital expenditures based on surveys of its investor-owned members.[52] The most recent detailed 2010 projection for expenditures between 2009 through 2013, shown in Figure 9, reflects the continuation of the increasing investment trend up to $13 billion by 2013 (in nominal dollars).

[52] Edison Electric Institute, "Actual and Planned Transmission Investment by Shareholder-Owned Utilities (2004-2013)", 2010 and "Transmission Projects: At A Glance," March 2011.

Figure 9
1995-2013 Historical and Projected Transmission Investment by Investor Owned Entities (Nominal $)
(FERC Form 1 data reflects plant-in-service additions; EEI data reflects annual construction expenditures)



Data of projected U.S.-wide transmission additions through 2019 covering all transmission owner types are available from the North American Electric Reliability Corporation ("NERC"). These data, as reported in EIA Form 411,[53] only provide projected "circuit-miles" of transmission additions rather than investment dollars. Furthermore, reporting of projected circuit-mile additions in EIA Form 411 is voluntary and, consequently, incomplete. The data reflect projects that are "under construction," "planned," or "conceptual" but tend to miss newly-proposed projects that may have been discussed only in the last few years. Therefore, the volume of reported circuit-mile additions drops off quickly after five years. These data also only include transmission lines above 100 kV and the "circuit-mile" metric necessarily excludes investments in substations and related facilities.

The NERC transmission line data indicate that almost 23,000 circuit-miles of high-voltage transmission lines are projected to be placed into service by investor-owned, cooperative, municipal, state and federal transmission providers, including merchant transmission developers.[54] Of these additions, approximately 68% are planned and proposed by investor-owned transmission providers as shown in Figure 10 below. This closely matches the 69%

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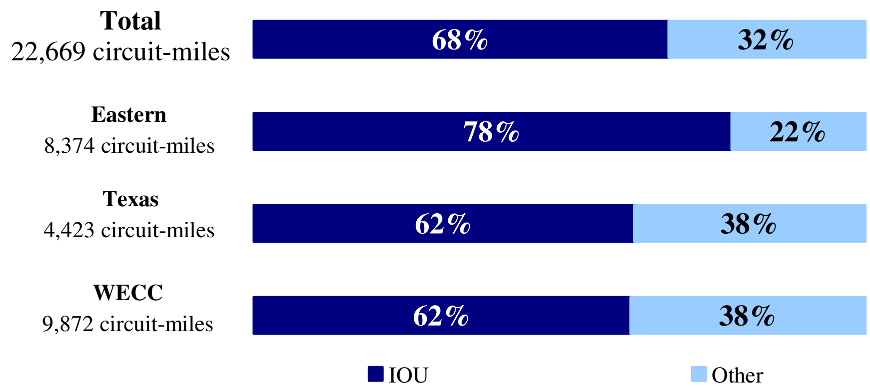
[53] EIA Form 411, "Table 6. Proposed High-voltage Transmission Line Additions Filed Covering Calendar Year 2009, by North American Electric Reliability Corporation, 2010 Through 2019," December 2010.

[54] Reporting on EIA Form 411 included projects approved by Independent System Operators and Regional Transmission Organizations. Further research was conducted to recategorize these projects into the categories mentioned above.

historical proportion of investor-owned transmission investments as discussed above. This allows us to "scale up" EEI's projected investor-owned transmission additions from 2009 through 2013 to project U.S.-wide additions as discussed further below.

Figure 10
Projected Circuit-Miles of Transmission Additions by Transmission Owner Type
(2011-2015 as reported voluntarily to NERC and in EIA Form 411 by IOUs, coop/munis, state/federal power agencies, ISOs/RTOs, and merchant developers)



Sources and Notes:
Based on categories as reported in EIA Form 411 with additional analysis and categorization by *The Brattle Group*.

Figure 10 also shows the proportion of projected circuit-mile investment by interconnection and type of transmission owner (*i.e.*, investor-owned and other entities). While the Texas and the Western Interconnections tend to have a slightly lower proportion of investor-owned transmission additions (62% of total), investor-owned entities account for 78% of all planned and proposed transmission additions in the Eastern Interconnection.

The NERC circuit-mile additions are also provided by voltage level as shown on Table 9 below for the 2011 through 2015 period. The table also shows that the reported additions peak in 2013. After 2015 the reported additions drop off even more quickly, reflecting the fact that many major, newly proposed conceptual transmission projects are not yet reported in these circuit-mile data. Despite the fact that the drop-off of reported circuit-mile additions will likely understate investment activity after 2013, we believe these circuit-mile data provide a reasonable reference point for projecting overall transmission investments.

Table 9
Projected Circuit-Miles of Transmission Additions by Voltage Level
(2011-2015 as reported voluntarily to NERC and in EIA Form 411 by IOUs, coop/munis, state/federal power agencies, ISOs/RTOs, and merchant developers)

Voltage (kV)	2011	2012	2013	2014	2015	**Total**
100-199	1,012	1,229	691	345	242	**3,519**
200-299	1,126	855	711	529	671	**3,892**
300-399	767	1,576	3,478	1,300	589	**7,710**
400-599	336	1,400	1,314	1,512	2,710	**7,273**
600+	0	0	0	275	0	**275**
Total	3,242	5,060	6,194	3,962	4,212	**22,669**

Voltage (kV)	2011	2012	2013	2014	2015	**Total**
100-199	31%	24%	11%	9%	6%	**16%**
200-299	35%	17%	11%	13%	16%	**17%**
300-399	24%	31%	56%	33%	14%	**34%**
400-599	10%	28%	21%	38%	64%	**32%**
600+	0%	0%	0%	7%	0%	**1%**
Total	100%	100%	100%	100%	100%	**100%**

Sources and Notes:
EIA Form 411, “Table 6. Proposed High-voltage Transmission Line Additions Filed Covering Calendar Year 2009, by North American Electric Reliability Corporation, 2010 Through 2019,” December 2010.

To estimate projected transmission investments based on the reported circuit-mile additions, we estimated average investment levels per circuit-mile and voltage level based on a sample of almost 100 transmission projects currently under construction and proposed.[55] These project-specific data include total line miles of addition, voltage level, and overall costs, including the costs of substations, transformers, and upgrades to existing facilities,[56] which allowed us to estimate typical “transmission costs per circuit-mile” as reported in the second column of Table 10. By applying these transmission costs per mile to the circuit-mile data reported in Table 9, we were able to project the transmission investment requirement associated with the reported circuit-mile additions as shown in Table 10.

55 Edison Electric Institute, *Transmission Projects: At A Glance*, February 2010.
56 We excluded projects that involve underground lines and significantly mixed voltage levels. No attempt was made to adjust the dollar amounts for inflation.

Table 10
Projected Total Transmission Additions Based on EEI and NERC Data
(2011-2015 based on cost information derived from projects reported by EEI and circuit-miles as reported voluntarily to NERC and in EIA Form 411)

		$ Billion					
Voltage (kV)	$ Million / Mile	2011	2012	2013	2014	2015	Total
100-199	$1.8	$1.8	$2.2	$1.3	$0.6	$0.4	$6.4
200-299	$2.3	$2.6	$2.0	$1.6	$1.2	$1.5	$8.9
300-399	$2.2	$1.7	$3.5	$7.7	$2.9	$1.3	$17
400-599	$3.0	$1.0	$4.2	$4.0	$4.6	$8	$22
600+	$4.1	$0.0	$0.0	$0.0	$1.1	$0.0	$1.1
Total		$7.1	$12	$15	$10	$11	$55

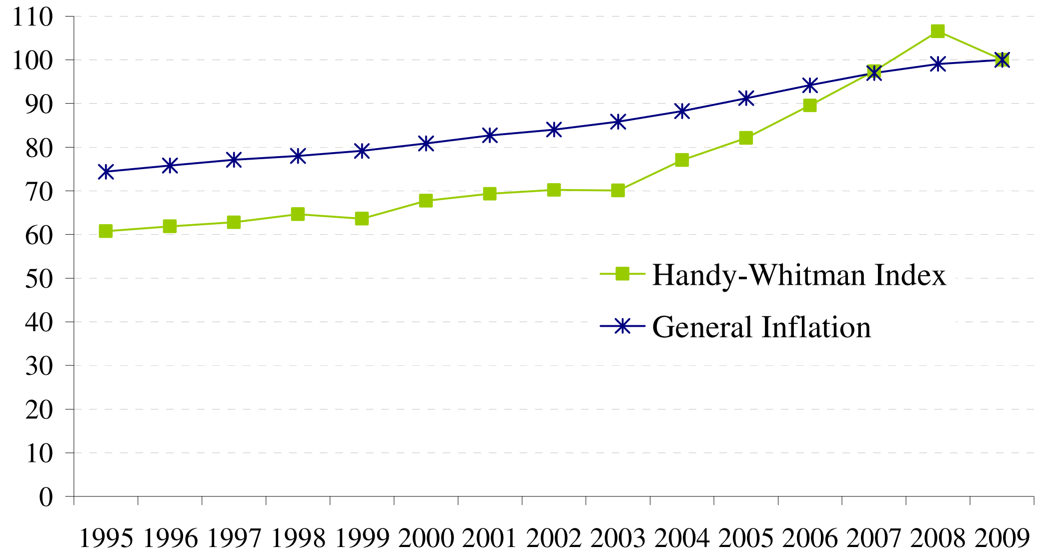
	Percent					
Voltage (kV)	2011	2012	2013	2014	2015	Total
100-199	26%	19%	9%	6%	4%	12%
200-299	36%	17%	11%	12%	13%	16%
300-399	24%	29%	53%	28%	11%	31%
400-599	14%	36%	27%	44%	71%	40%
600+	0%	0%	0%	11%	0%	2%
Total	100%	100%	100%	100%	100%	100%

Sources and Notes:
EIA Form 411, "Table 6. Proposed High-voltage Transmission Line Additions Filed Covering Calendar Year 2009, by North American Electric Reliability Corporation, 2010 Through 2019," December 2010 and Edison Electric Institute, Transmission Projects: At A Glance, February 2010.

By applying these transmission costs per mile to the circuit-mile data reported from the NERC data, the resultant transmission investments range from $7 billion to $15 billion annually for the years 2011 through 2015, with a cumulative total of $55 billion. This will understate total transmission investments because the NERC data exclude any projects that the transmission owners have not reported (due to the voluntary nature of the data submissions) and do not cover transmission investments at voltage levels below 100 kV. We estimate that the investment requirements derived from these NERC reported data will likely understate 2011 through 2015 transmission investments by approximately $10 billion.

The last several years have been marked by volatile commodity prices for inputs commonly used in the electric utility industry such as concrete, steel, and aluminum. This has increased the cost of transmission infrastructure significantly faster than general price inflation. Figure 11 shows the Handy-Whitman index for the cost trend in electric utility construction compared to general inflation for the period from 1995 through 2009, with 2009 costs normalized to equal to 100.

Figure 11
1995-2009 Handy-Whitman Index for Electric Utility Construction Compared to General Inflation Based on Year 2009
(2009 Index Year = 100)



Sources and Notes:
Derived from Edison Electric Institute estimates of nominal and 2009$ real expenditures from 1995 through 2008 using The Handy-Whitman Index of Public Utility Construction Costs.

This cost trend shows that $60 spent on transmission investments in 1995 (or $107 dollars spent in 2008) is equivalent to $100 spent in 2009. These cost trend data show that, after a period of relative stability from 1995-2003, utility construction costs increased quickly from 2003 through 2008, before decreasing slightly since 2008. In comparison, general inflation has increased more modestly and more steadily throughout this 1995-2009 period. We are using the Handy-Whitman index for utility construction costs to adjust transmission investment data to 2009 dollar values and then apply general inflation to adjust to 2011 dollar values in the projections of U.S. transmission investments shown below.

3. Drivers and Type of Projected Transmission Investments

Historically, the large majority of transmission projects was driven by reliability requirements and involved lower voltages. For example, 72% of historical transmission revenue requirements of Midwest ISO members, almost all of which were driven by reliability requirements, consist of facilities rated at less than 345 kV. In contrast, only 28% of the Midwest ISO's projected transmission investment involves facilities at 345 kV and above.[57]

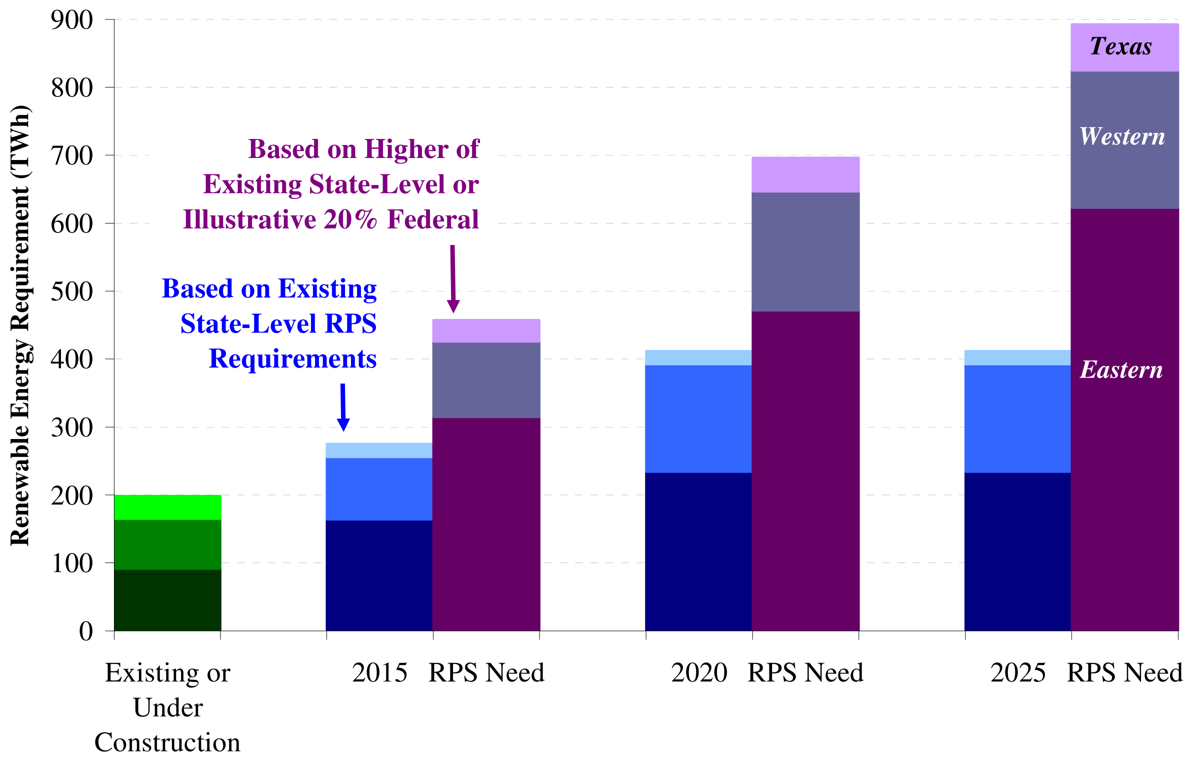
[57] Affidavit of Alan C. Heintz on Behalf of the Midwest ISO Transmission Owners, FERC Docket Nos. ER07-1233-000 and ER07-1261-000, Exhibit 6, page 9-11, August 1, 2007.

More recently, renewable integration has become a major driver of transmission investments. As previously shown in Figure 3 (in Section II of our report), 26% of the planned and proposed new transmission projects have been reported to NERC as renewables-driven investments. This likely understates the extent to which renewable integration has already affected transmission investment because, for example, projects such as the Competitive Renewable Energy Zone ("CREZ") buildout in Texas are categorized under "reliability" rather than "renewables."[58]

4. PROJECTED LONG-TERM INVESTMENT: 2016-2030

Figure 12 below summarizes the phase in of existing state-level (blue bars) and a hypothetical 20% federal (purple bars) renewable energy standards for 2015, 2020, and 2025 compared to the level of renewable generation from existing plants or plants currently under construction (green bar).

Figure 12
Cumulative Renewable Energy Need (TWh)



Sources and Notes:
Assumes federal RPS is 10% in 2015, 15% in 2020, and 20% in 2025.

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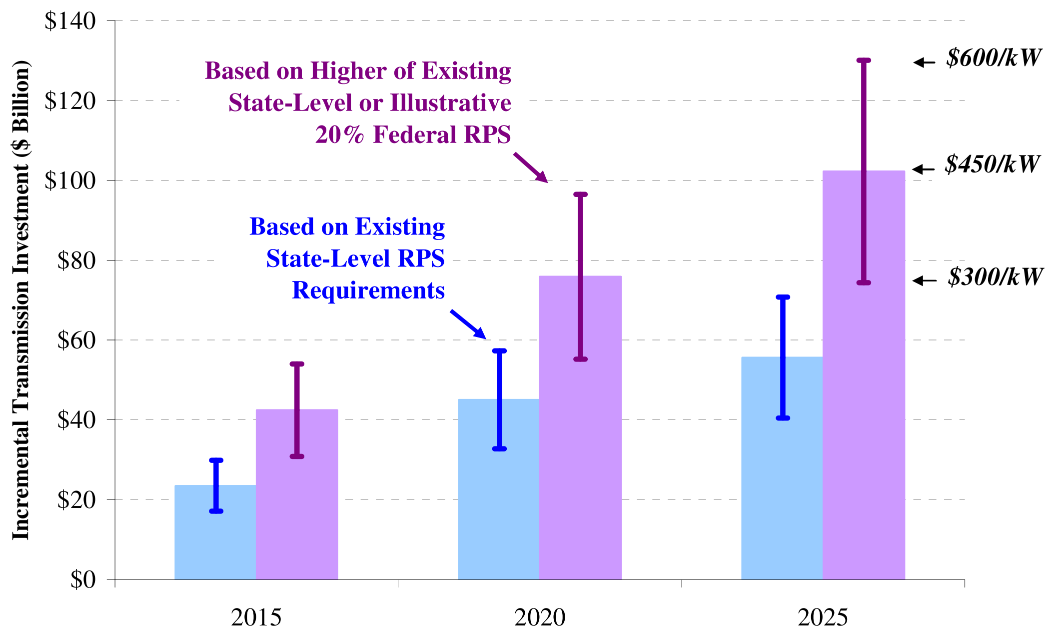
58 CREZ is a $5 billion series of 345 kV and 138 kV upgrades in the Electric Reliability Council of Texas to integrate a total of 18,000 MW of wind generation. CREZ is considered an overlay project and cost estimates do not include lower voltage upgrades or collector systems for wind generation that may be needed.

To estimate the incremental transmission buildout associated with the additional projected renewable needs, we assumed 80% of additional renewable energy need (net of existing or under construction capacity) would require incremental regional transmission investments. The bars and ranges shown in Figure 13 below reflect the estimated magnitude of the additional transmission investments needed to integrate this level of renewable energy resources based on low, mid-point, and high cost estimates of our study summarized in item 2 of Table 1 (Section II of our report).[59]

Figure 13
Estimated Renewable-Related Transmission Investment Need ($ Billion)
(Based on $300, $450, and $600/kW-wind transmission network costs and $100/kW-wind interconnection cost)



Sources and Notes:
Assumes approximately 80% of cumulative renewable energy need (net of existing or under construction capacity) is fulfilled by wind generation which will incur incremental transmission investment. Wind capacity factors are based on state-level onshore averages. All transmission investment costs include an additional $100/kW of wind interconnection cost.

Over the entire study period of approximately 2013 to 2025, the annualized investment amount to meet state-level RPS is $3.1 billion to $5.5 billion per year and increases to $6.3 billion to $10 billion per year to meet a hypothetical federal RPS.

59 It is assumed that a federal RPS would be phased-in starting with 10% in 2015, 15% in 2020, and reaching the maximum of 20% in 2025, broadly in-line with existing state-level mandates. It is also assumed that approximately 80% of the *incremental* renewable energy need would be met with remotely located in-state, onshore wind generation, which would require regional transmission investments of approximately $300/kW to $600/kW of renewable generation capacity. In addition to these *regional* transmission costs estimates, we have added $100/kW of additional *local* interconnection costs.

Appendix B
Bibliography

"Comments of Johannes Pfeifenberger, Peter Fox-Penner and Delphine Hou," in response to FERC's Notice of Proposed Rulemaking on Transmission Planning and Cost Allocation (Docket RM10-23), September 29, 2010.

"Comments of Peter Fox-Penner, Johannes Pfeifenberger, and Delphine Hou," in response to FERC's Notice of Request for Comments on Transmission Planning and Cost Allocation (Docket AD09-8).

Affidavit of Alan C. Heintz on Behalf of the Midwest ISO Transmission Owners, FERC Docket Nos. ER07-1233-000 and ER07-1261-000, Exhibit 6, page 9-11, August 1, 2007.

Alberta Electric System Operator, "Fact Sheet: Cost of Transmission Upgrades," November 2009.

Alberta Electric System Operator, *AESO Long-term Transmission System Plan 2009*, June 2009.

American Transmission Company LLC, *Arrowhead-Weston Transmission Line: Benefits Report*, February 2009, p. 7.

American Transmission Company LLC, *Planning Analysis of the Paddock-Rockdale Project*, April 2007.

Angevine Economic Consulting Ltd., *The Economic Impacts of AltaLink Capital Spending and Operations 2010-2015*, prepared for AltaLink, September 30, 2010.

Before the Arizona Power Plant and Transmission Line Siting Committee, Docket No. L-00000A-06-0295-00130, Case No. 130, Oral Testimony on behalf of Southern California Edison Company re: economic impacts of the proposed Devers-Palo Verde No. 2 transmission line, September and October, 2006.

The Brattle Group, "Transmission Investment and Cost Allocation: What are the Options?" presented at the ELCON Fall Workshop by Johannes Pfeifenberger, October 26, 2010.

The Brattle Group, *Jobs and Economic Benefits of Transmission and Wind Generation Investments in the SPP Region*, prepared for SPP, March 2010.

The Brattle Group, *Transforming America's Power Industry: The Investment Challenge 2010-2030*, prepared for The Edison Foundation, November 2008.

British Columbia Transmission Corporation, *F2010 and F2011 Transmission System Capital Plan*, November 2008.

Build Energy America!, *Quarter Million Backbone Jobs*, February 24, 2011.

Burns and McDonnell, *Wind Energy Transmission Economics*, prepared for WPPI Energy, March 2010.

California ISO, *Economic Evaluation of the Palo Verde-Devers Line No. 2 (PVD2)*, February 24, 2005.

California ISO, *Transmission Economic Assessment Methodology ("TEAM")*, June 2004.

Celebi, Graves, Bathla and Bressan, *Potential Coal Plant Retirements Under Emerging Environmental Regulations, The Brattle Group*, December 8, 2010.

Center on Globalization, Governance & Competitiveness, Duke University, *U.S. Smart Grid: Finding New Ways to Cut Carbon and Create Jobs*, April 19, 2011.

Conference Board of Canada, *Canada's Electricity Infrastructure: Building a Case for Investment*, April 2011.

Development Strategies, *An Economic Impact Study of the Proposed Grain Belt Express Clean Line*, September 17, 2010.

Edison Electric Institute, "Actual and Planned Transmission Investment By Shareholder-Owned Utilities (2004-2013)", 2010.

Edison Electric Institute, "Table 9.1: Construction Expenditures for Transmission and Distribution Years 1980 through 2008," *EEI Web Preview of the Statistical Yearbook/2009 Data*, 2010.

Edison Electric Institute, *Transmission Projects: At A Glance*, February 2010.

Edison Electric Institute, *Transmission Projects: At A Glance*, March 2011.

Energy Information Administration, EIA Form 411, "Table 6. Proposed High-voltage Transmission Line Additions Filed Covering Calendar Year 2009, by North American Electric Reliability Corporation, 2010 Through 2019," December 2010.

Energy Information Administration, EIA Form 412: Annual Electric Industry Financial Report (discontinued in 2003).

Federal Energy Regulatory Commission, *2011 Performance Metrics for Independent System Operators and Regional Transmission Organizations*, April 7, 2011,

Federal Energy Regulatory Commission, *Notice of Proposed Rulemaking on Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Docket RM10 23 (131 FERC ¶ 61,253), issued June 17, 2010.

Federal Energy Regulatory Commission, *Order Accepting Tariff Revisions, Docket No. ER10-1069-000*, June 17, 2010 for SPP's "Highway/Byway" cost allocation methodology (Highway/Byway Methodology).

Fox-Penner, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*, Island Press, 2010.

Fox-Penner, Pfeifenberger, "The Anchor-Tenant Model – And Some of the Chickens and Eggs," The Electricity Journal Guest Editorial, Volume 22, Issue 6, July 2009.

Fox-Penner, Pfeifenberger, Hou, "For Grid Expansion, Think 'Subregionally'," *The Energy Daily*, June 8, 2010.

Hydro-Québec, *Hydro-Québec Strategic Plan: 2009-2013*, 2009.

Idaho National Laboratory, *The Cost of Not Building Transmission: Economic Impact of Proposed Transmission Line Projects for the Pacific NorthWest Economic Region*, July 2008.

Manitoba Hydro, *2010/11 & 2011/12 General Rate Application*, November 30, 2009.

Montana Department of Labor and Industry, Wagner, B., *Employment and Economic Impacts of Transmission Line Construction in Montana*, July 30, 2010.

The National Electrical Manufacturers Association, "Siting Transmission Corridors—A Real Life Game of Chutes and Ladders," October 2010.

National Renewable Energy Laboratory, *Eastern Wind Integration and Transmission Study ("EWITS")*, January 2010.

National Renewable Energy Laboratory, *Economic Development from New Transmission and Generation in Wyoming*, prepared for the Wyoming Infrastructure Authority, February 1, 2011.

New Brunswick System Operator, *10-Year Outlook: An Assessment of the Adequacy of Generation and Transmission Facilities in New Brunswick 2010-2020*, July 2010.

NorthStar Economics, Inc., *The Economic Impact of Electric Power Transmission Line Construction in the Midwest*, prepared for American Transmission Company, LLC, March 2009.

Nova Scotia Power, Inc., *2011 Annual Capital Expenditure Plan*, December 23, 2010.

The Perryman Group, *The Potential Impact of the Proposed Plains & Eastern Clean Line Transmission Project on Business Activity in the US and Affected States*, June 2010.

The Perryman Group, *Winds of Prosperity*, May 2010.

Pfeifenberger, "Barriers to Transmission Investments and Implications for Competition in Wholesale Power Markets," The American Antitrust Institute, April 12, 2011.

Pfeifenberger, "Easier Said Than Done: The Continuing Saga of Transmission Cost Allocation," presented to Harvard Electricity Policy Group, February 24, 2011.

Pfeifenberger, "Transmission Investments and Cost Allocation: What are the Options?" ELCON Fall Workshop, October 26, 2010.

Pfeifenberger, "Transmission Planning: Economic vs. Reliability Projects," EUCI Conference, Chicago, October 13, 2010.

Pfeifenberger, Chang, Hou, Madjarov, "Job and Economic Benefits of Transmission and Wind Generation Investments in the SPP Region," *The Brattle Group,* March 2010.

Pfeifenberger, *"Assessing the Benefits of Transmission Investments,"* presented at the Working Group for Investment in Reliable and Economic Electric Systems (WIRES) meeting, Washington, DC, February 14, 2008.

Pfeifenberger, Direct Testimony on behalf of American Transmission Company re: Transmission Cost-Benefit Analysis Before the Public Service Commission of Wisconsin, Docket 137-CE-149, January 17, 2008.

Pfeifenberger, Testimony on behalf of Southern California Edison Company re: economic impacts of the proposed Devers-Palo Verde No. 2 transmission line, before the Arizona Power Plant and Transmission Line Siting Committee, Docket No. L-00000A-06-0295-00130, Case No. 130, September and October, 2006.

Pfeifenberger, Fox-Penner, Hou, "Transmission Investment Needs and Cost Allocation: New Challenges and Models," The Brattle Group, presented to FERC Staff, Washington, DC, December 1, 2009.

Pfeifenberger, Hou "Transmission Planning and Cost Benefit Analysis," EUCI Web Conference, September 22, 2010

Pfeifenberger, Newell, "Evaluating the Economic Benefits of Transmission Investments," EUCI's Cost-Effective Transmission Technology Conference, Nashville, TN, May 3, 2007.

Pfeifenberger, Newell, *Direct testimony on behalf of The AWC Companies re: the Public Policy, Reliability, Congestion Relief, and Economic Benefits of the Atlantic Wind Connection Project*, filed December 20, 2010 in FERC Docket No. EL11-13.

Province of Newfoundland & Labrador, "Backgrounder - Quick Facts - Muskrat Falls Development Generation and Transmission." Available at: http://www.gov.nl.ca/lowerchurchillproject/backgrounder_7.htm (accessed February 28, 2011).

Province of Ontario, *Ontario's Long-Term Energy Plan*, 2010.

Public Service Commission of Wisconsin order in Docket 5-EI-141, filed October 10, 2008.
Rural Utilities Service, RUS Form 12: Operating Report – Financial.

SaskPower, "Power Infrastructure Projects: Transmission & Distribution." Available at: http://www.saskpower.com/sustainable_growth/projects/ (accessed February 28, 2011).

Southwest Power Pool, *SPP Priority Projects Phase II Report, Rev. 1, Summary of Economic Result*, April 2010.

Southwest Power Pool, *SPP Priority Projects Phase II Report, Rev. 1, Summary of Economic Result*, April 2010.

Stuefen Research, LLC, *The South Dakota Wind Blueprint-Envisioning One Thousand Megawatts of New Capacity: An Economic Impact Analysis*, prepared for South Dakota Wind Energy Association, September 2010.

UMD Labovitz School, Skurla, J.A., et al., *The Economic Impact of Constructing Five Electric Power Lines in Minnesota, North Dakota, South Dakota and Wisconsin, 2010-2015*, prepared for CapX2020, November 2010.