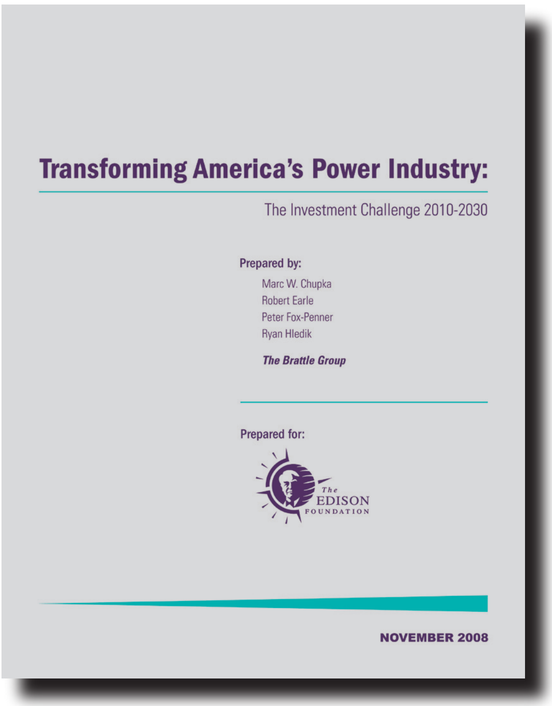
Transforming America's Power Industry:

The Investment Challenge 2010-2030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The Investment Challenge 2010-2030
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Executive Summary

The U.S. electric utility industry faces the greatest challenge in its history. The demand for electric services to meet the needs of our growing population and to power our increasingly digital and connected economy continues to rise. At the same time, high demand for commodities such as steel and cement is causing cost increases for building all electric infrastructure systems, including every type of new power plant, whether it's fueled by coal, nuclear power, natural gas, or renewable sources of energy. Concerns about global climate change and other environmental issues have created a new industry emphasis on more energy-efficient products and services and low-emission generation sources. New distribution end-use technologies, such as advanced automation and communications and plug-in hybrid electric vehicles (PHEVs), will dramatically change how utilities deliver electricity and how customers use it, allowing new efficiencies and greater customization of electric service.

To chart the magnitude of this challenge, The Edison Foundation asked *The Brattle Group* to examine the total investment that would be required to maintain today's high levels of reliable electric service across the United States through 2030, net of the investment that could be avoided through the implementation of more aggressive energy efficiency and demand response (EE/DR) programs.* In addition, the Foundation wanted *The Brattle Group* to determine the investment cost of one projected generation mix, known as the "Prism Analysis," which the Electric Power Research Institute (EPRI) developed to reduce the growth in carbon emissions.

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* For ease of exposition, we refer throughout this report to *The Brattle Group*; however, the analysis and views contained in this report are solely those of the authors and do not necessarily reflect the views of *The Brattle Group, Inc*. or its clients.

For our research, we developed four scenarios:

1) **Reference Scenario:** This is similar to the Annual Energy Outlook (AEO) forecast published by the U.S. Department of Energy's Energy Information Administration (EIA), but is adjusted for higher fuel and construction costs. The Reference Scenario is a modeling benchmark and the starting point for our analysis. It does not include the impact of any new federal policy to limit carbon emissions, nor does it include the possible impacts of new industry EE/DR program efforts. The Reference Scenario should not be viewed as our "base" or "most likely" scenario, but rather is a starting point for our analysis.

2) **RAP Efficiency Base Case Scenario**: This scenario adds the impact of realistically achievable potential (RAP) for EE/DR programs, but does not include any new federal carbon policy. This scenario includes a forecast of likely customer behavior and takes into account existing market, financial, political, and regulatory barriers that are likely to limit the amount of savings that might be achievable through EE/DR programs. It is important to note that the RAP Efficiency Base Case Scenario is our most likely case in the absence of a new federal carbon policy, while the Reference Scenario is simply a benchmark.

3) **MAP Efficiency Scenario:** This scenario captures the higher-end or maximum achievable potential (MAP) for EE/DR programs and assumes a more aggressive customer participation rate in EE/DR programs. It still does not include the effects of a new federal carbon policy.

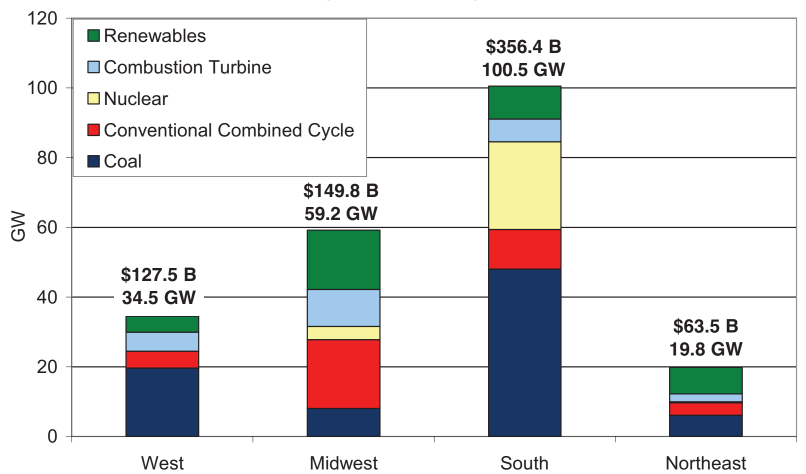
4) **Prism RAP Scenario:** The final scenario assumes there is a new federal policy to constrain carbon emissions, and captures the cost of EPRI's Prism Analysis projections for generation investments (nuclear, advanced coal, renewables, etc.) that will reduce the growth in carbon emissions. This scenario further assumes the implementation of RAP EE/DR programs.

Study Findings

- **By 2030, the electric utility industry will need to make a total infrastructure investment of $1.5 trillion to $2.0 trillion.**[i] The entire U.S. electric utility industry will require investment on the order of $1.5 trillion under the RAP Efficiency Base Case Scenario. The cost could increase to $2.0 trillion under the Prism RAP Scenario.

- **Under the Reference Scenario, 214 gigawatts (GW) of new generation capacity would be required by 2030, at an investment cost of $697 billion.**[ii] For the Reference Scenario, we determined that the entire U.S. electric utility industry would require an investment of $697 billion to build 214 GW of new generation capacity under existing EE/DR programs and state-level renewable programs and carbon policies. Figure 1 shows the breakdown of required new generation capacity by geographic region and generation capacity type.

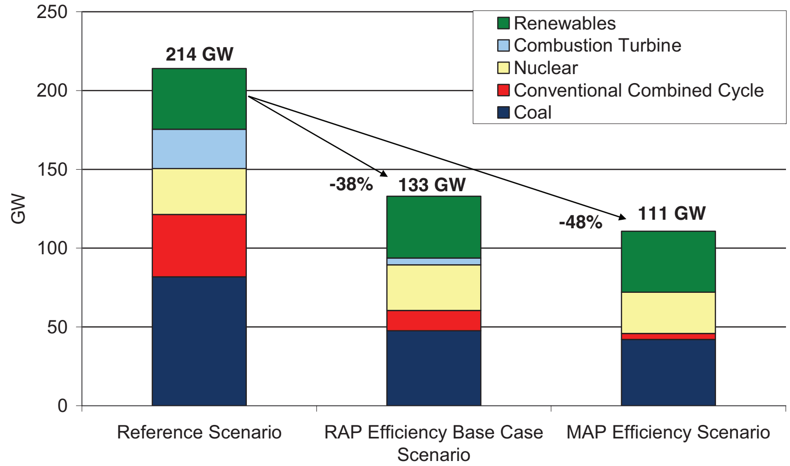
Figure 1: Required New Regional Generation Capacity Reference Scenario - No Carbon Policy (2010-2030)



- **EE/DR programs could significantly reduce, but not eliminate, the need for new generation capacity.** As shown in Figure 2, the implementation of realistically achievable EE/DR programs by electric utilities would reduce the need for new generation capacity significantly; dropping the Reference Scenario's forecast from 214 GW to an estimated 133 GW, or by 38 percent.

  In Figure 2, we also calculated the potential results for the MAP Efficiency Scenario, which represents the higher-end of the range of potential impacts of EE/DR programs. Under the MAP Efficiency Scenario, the need for new generation capacity would be reduced from 214 GW to 111 GW, or by 48 percent.

Figure 2: Impact of RAP and MAP EE/DR Programs on Reference Scenario Required Generation Capacity No Carbon Policy (2010-2030)



  Our projected demand and sales reductions from utility EE/DR programs used in this study are based on a study of energy efficiency potentials conducted by EPRI.[iii] The EPRI study incorporates extensive analysis of demand response and dynamic pricing programs, as well as energy-saving technologies.

- **Reductions in generation capacity requirements do not mean an equal reduction in total investment, due in part to offsetting the cost of utility EE/DR programs.** As shown in Figure 3, the implementation of the RAP Efficiency Base Case Scenario would reduce required generation investment by $192 billion (28 percent), from $697 billion to $505 billion. Generation investment costs are not reduced in proportion to the GW reduction. This is because the bulk of capacity avoided due to the RAP Efficiency Base Case Scenario programs is comprised of lower capital cost natural gas technologies. This generation investment reduction notwithstanding, the implementation of the RAP Efficiency Base Case Scenario would require an additional investment of at least $85 billion through 2030 in both advanced metering infrastructure (AMI) and EE/DR programs. Thus, the net reduction in total investment needs between the Reference Scenario and the RAP Efficiency Base Case Scenario is $107 billion, or 15 percent.

Figure 3: Potential Avoided Investment from RAP and MAP EE/DR and AMI Programs No Carbon Policy (2010-2030)

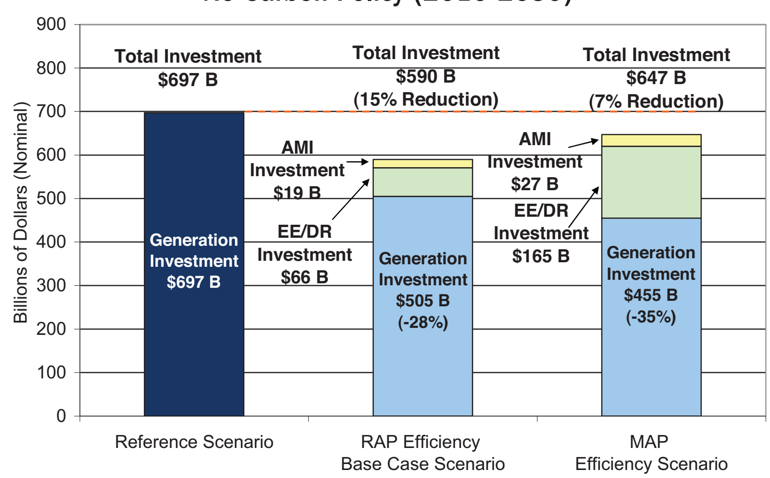
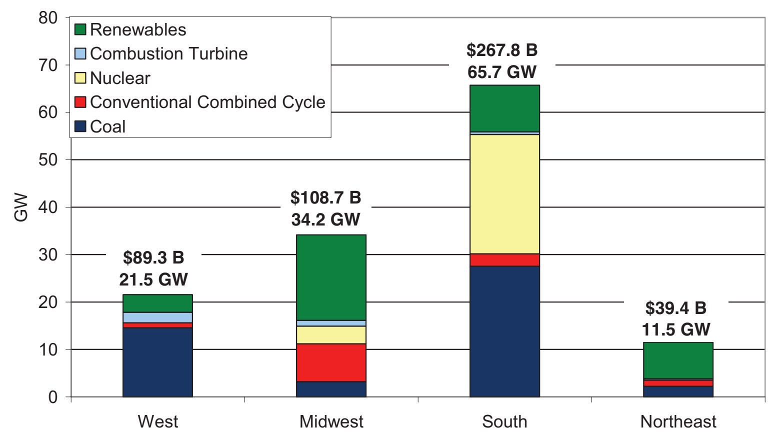


Figure 3 also shows that the more aggressive MAP Efficiency Scenario would lead to a $242-billion (35-percent) drop in the generation investment requirement, from $697 billion to $455 billion. However, this would require AMI and EE/DR program outlays of about $192 billion and, therefore, would decrease total investment needs by only $50 billion to $647 billion, which is a savings of 7 percent.

- **All types of generation capacity are needed.** As Figure 4 illustrates, in projections through 2030, new generation investment will vary significantly in different regions of the United States, with the highest investment and load growth occurring in the South.

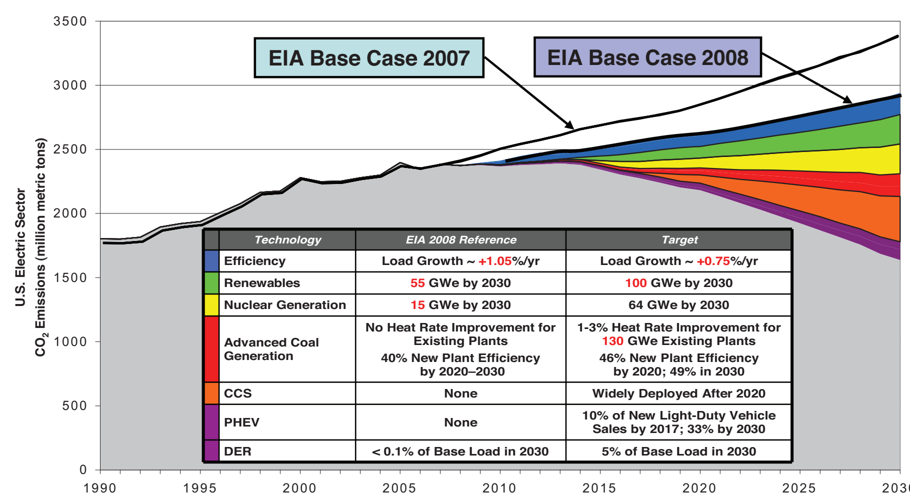
  For the country as a whole, every type of power plant, including those fueled by natural gas, coal, nuclear, and renewable sources will play a significant role in the projected expansion plan. Of the total new 133 GW built under the RAP Efficiency Base Case Scenario, natural gas would fuel 17 GW (13 percent), of which about 13 GW represents combined cycle and 4 GW represents combustion turbines. Coal would comprise an additional 48 GW (36 percent); nuclear would provide 29 GW (22 percent); and renewable sources (primarily wind and biomass) would provide 39 GW (29 percent). This level of renewable investment assumes the full implementation of state-level requirements in place as of August 2008.

Figure 4: Required New Regional Generation Capacity For RAP Efficiency Base Case Scenario No Carbon Policy (2010-2030)



- **Implementation of a new federal carbon policy would significantly increase the cost and change the mix of new generation capacity.** For this study, we created a simplified model of one scenario for industry adjustment to a new carbon policy. It is based on EPRI's Prism Analysis, shown in Figure 5, which incorporates both

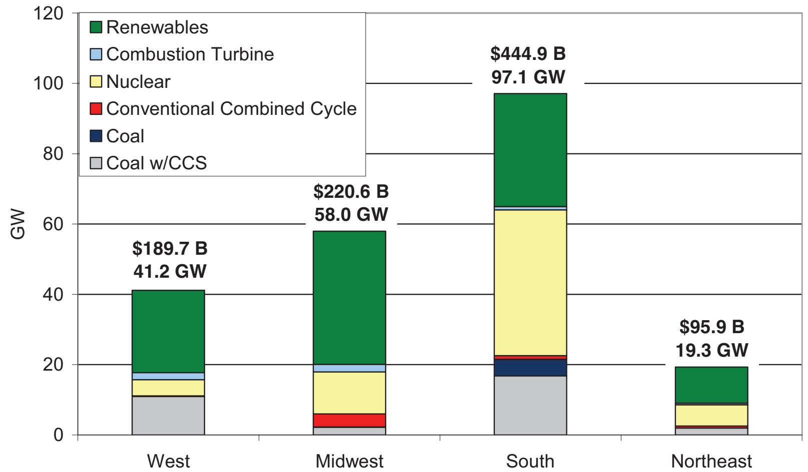
Figure 5: EPRI Prism Analysis for U.S. Carbon Policy Outcomes



Source: Based on data compiled by Electric Power Research Institute (EPRI), found at: http://www.iea.org/Textbase/work/2008/roadmap/2a_Tyran_EPRI%20Roadmaps.pdf.

energy efficiency and generation-related technologies to reduce the growth in carbon emissions.[iv] In the scenario that we developed based on EPRI's Prism Analysis (i.e., the Prism RAP Scenario), plants with advanced coal technology and full carbon capture and storage (CCS) would be the only coal-based plants deployed after 2020; some fossil-based plants would be retired prematurely; and the electric industry would increase investments in renewable energy and nuclear plants. The results of this scenario should be viewed as an illustrative example of a possible outcome rather than a definitive picture of the impacts of a U.S. carbon policy (Figure 6).

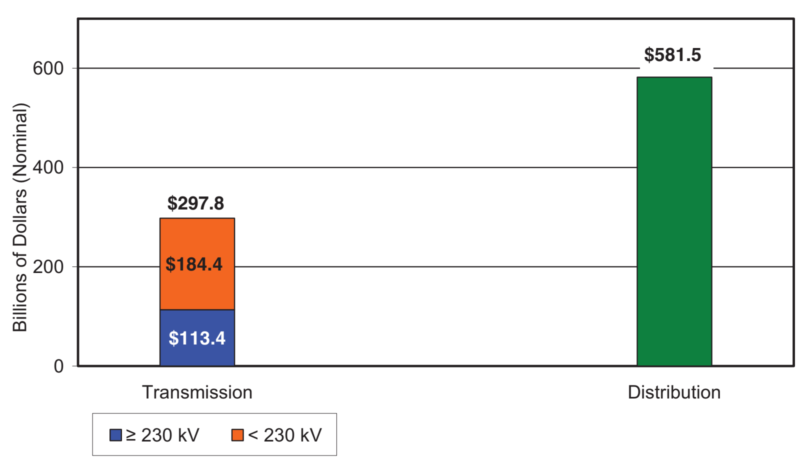
Figure 6: Regional Capacity Additions and Generation Capital Costs in Prism RAP Scenario With Carbon Policy (2010-2030)



In the EPRI Prism Analysis, energy efficiency programs produce approximately the same reduction in demand growth as under our RAP Efficiency Base Case Scenario. However, in our Prism RAP Scenario, the generation capacity requirements will increase to 216 GW from 133 GW, which will increase the total investment cost to $951 billion from $505 billion. This capacity increase is due to several factors: the greater use of renewables; 21 GW of premature retirements of carbon-intensive generation; and a larger nuclear construction program of 64 GW.

- **Required transmission and distribution (T&D) investment could be as large as, or larger than, generation investment.** The combined investment in new T&D during this period will total about $880 billion, including $298 billion for transmission and $582 billion for distribution (Figure 7).[v] In comparison, generation investment will cost $505 billion for the RAP Efficiency Base Case Scenario. These investments will enable the industry to integrate the approximately 39 GW of renewable energy already mandated under state renewable portfolio standards (RPS) and continue the installation of a "Smart Grid."[vi] These investments also will bring new efficiencies and service options to electricity customers and accommodate new end-use technologies, such as PHEVs.

Figure 7: Transmission and Distribution Investment Including Smart Grid (2010-2030)



Study Methodology

This study's findings are based on EIA's AEO 2008. We modified EIA's data to reflect more recent, higher prices for electric fuels and the costs of new power plants. This resulted in an average price increase of 53 percent for natural gas (Figure 8) and 18 percent for coal (Figure 9) over the 2010 to 2020 period. The cost of constructing new power plants was based on EPRI's Technical Assessment Guide (TAG), published in July 2008 (Figure 10).

We inserted these updated cost figures into a generation expansion planning model that *The Brattle Group* developed, the Regional Capacity Model (RECAP). This allowed us to estimate regional least-cost build-out plans through 2030.[vii] RECAP uses traditional least-cost planning criteria to choose the mix of generation additions that can most economically supply the energy needs of each region that remain after energy efficiency programs reduce peak demand and energy sales. Using the re-adjusted EIA data in RECAP, we developed the four scenarios outlined on page 2.

Figure 8: Comparison of U.S. Average Delivered Natural Gas Price Projections (2006 Dollars)

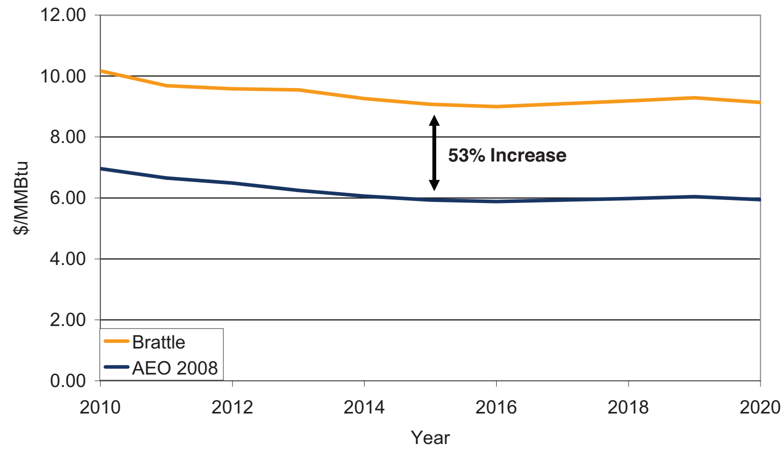


Figure 9: Comparison of U.S. Average Delivered Coal Price Projections (2006 Dollars)

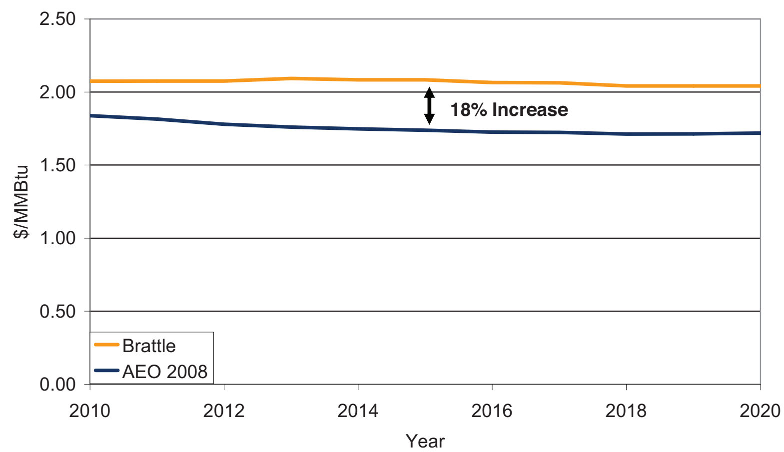
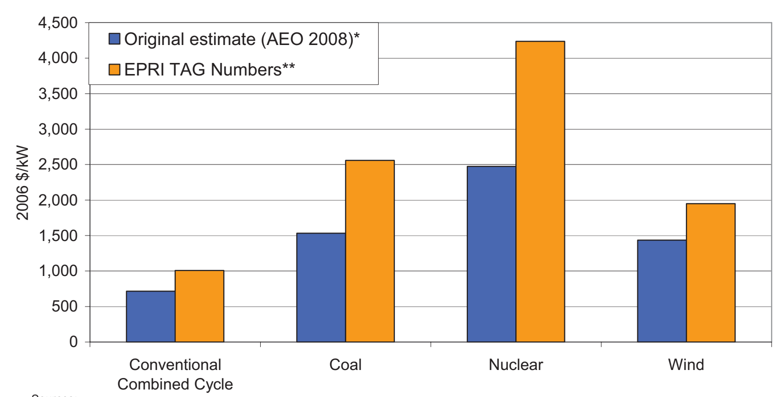


Figure 10: Updated Plant Construction Cost Estimates (Including Construction Interest)



Sources:
* Annual Energy Outlook 2008, U.S. Department of Energy, Energy Information Administration, June 2008.
** Program on Technology Innovation: Power Generation (Central Station) Technology Options - Executive Summary, Electric Power Research Institute, July 2008.

Summary of Results and Conclusion

The results of our study, in terms of capacity and investment costs, are summarized in Table 1.

As our starting point under the Reference Scenario, we determined that the electric industry would have to build 214 GW of new generation capacity and make a total infrastructure investment of $1.577 trillion by 2030. In the RAP Efficiency Base Case Scenario, which depicts the most likely impact of EE/DR programs under existing real-world constraints (and is therefore highlighted in Table 1), the industry still would have to build 133 GW of new generation capacity and make a total infrastructure investment of $1.470 trillion. In the MAP Efficiency Scenario, which depicts the impact of more aggressive EE/DR programs, the required new generation build still would be 111 GW, with a total infrastructure investment cost of $1.527 trillion. Finally, in the Prism RAP Scenario, which depicts the impact of a new carbon policy, the industry would have to build 216 GW of new generation capacity and make a total infrastructure investment of $2.023 trillion.

No matter which scenario is implemented, total utility industry investment needs will range from approximately $1.5 trillion to $2.0 trillion by 2030.

Table 1: Model Results Overview

	Reference Scenario No Carbon Policy	RAP Efficiency Base Case Scenario No Carbon Policy	MAP Efficiency Scenario No Carbon Policy	Prism RAP Scenario Carbon Policy
Average Peak Load Growth Rate		0.70%	0.30%	0.70%
New Capacity Through 2030 (in GW)				
Renewables	38.6	39.2	38.8	103.7
Combustion Turbine	25.0	4.3	0.0	5.5
Nuclear	29.1	28.9	26.2	64.0
Conventional Combined Cycle	39.5	12.9	3.8	5.4
Coal	81.8	47.6	42.1	36.9*
Total New Capacity (GW)	**214.0**	**132.9**	**110.9**	**215.5**
Capital Investment Through 2030 (rounded to nearest billion)				
Generation	$697	$505	$455	$951
Transmission	$298	$298	$298	$298
AMI and EE/DR	$0	$85	$192	$192
Distribution	$582	$582	$582	$582
Total Capital Investment ($ Billions)	**$1,577**	**$1,470**	**$1,527**	**$2,023**

*32 GW of EPRI Prism coal generation incorporates carbon capture and storage.

It is important to recognize that total investment amounts are not the same as revenue requirements, rate levels, or societal costs. As a result, one cannot directly link higher investment costs with specific rate changes until fuel costs and other operating expenses are considered. For example, the implementation of RAP and MAP EE/DR programs could lead to reduced fuel expenditures or the Prism RAP Scenario could reduce the costs of complying with carbon policy mandates.

Affordable, reliable electricity is as essential to the global economy of the 21st century as it was to the American economy of the 20th century. The U.S. electric utility industry is capable of rising to this enormous investment challenge, but implementation of appropriate policies will be an essential ingredient for success.

Endnotes

[i.] Dollar amounts have been rounded to the nearest billion or trillion dollars, and generation capacity has been rounded to the nearest gigawatt (GW) throughout the text of this report for readability.

[ii.] Our estimates of generation cost apply to the entire U.S. electric utility industry, including shareholder-owned electric utilities, electric cooperatives, and government-owned utilities. We assume that all segments of the industry have approximately the same capital costs and plan their systems to supply at the lowest regional cost.

[iii.] A report on the results of the study, entitled *Assessment of Achievable Potential for Energy Efficiency and Demand Response in the U.S. (2010-2030)*, by the Electric Power Research Institute will be published soon.

[iv.] Figure 5 uses "GWe" as an acronym for Gigawatt-electric. GWe is equivalent to GW.

[v.] These estimates are derived primarily from shareholder-owned electric utility expenditure data. To the extent that the data excludes T&D expenditures undertaken by electric cooperatives or government-owned utilities, these estimates are conservative.

[vi.] There is currently no standard definition of "Smart Grid" within the electric utility industry. It commonly refers to an array of advanced technologies for the telecommunication network and electric grid that possess two-way communication and monitoring to link all functional areas of the electric power system, including customers. The "Smart Grid" vision is that the technologies will: 1) provide customers with information and tools that allow them to be responsive to system conditions; 2) ensure more efficient use of the electric grid; and 3) enhance system reliability.

[vii.] It is important to note that we did not model customer response to the increased retail rates that would accompany the higher fuel and construction costs used in RECAP. Depending on the price elasticity of demand, the reductions in future load growth could be significant.

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