Synapse
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A Responsible Electricity Future:

An Efficient, Cleaner and Balanced Scenario for the US Electricity System

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Prepared for
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June 11, 2004

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1. Introduction and Summary

1. 1 Introduction

The current electric power system in the US is heavily dependent upon central station plants, fossil and nuclear fuels, and an increasingly strained system of wires to deliver that generation to customers. "Business as usual" development of the system, as depicted for example in the US Energy Information Administration's latest *Annual Energy Outlook* (EIA's AEO 2004) shows consumption of electricity increasing by more than 50 percent by 2025 and massive investment in new coal and gas central station power generation to meet that demand.[1] The increasing demand and supply in this scenario place stresses upon the electricity transmission and distribution system which then requires its own massive investment in new equipment.

In this context, Synapse Energy Economics was asked to develop a reasonable and balanced scenario for the future evolution of the electric power system in the US. This "Balanced Case" includes stepped up investment in energy efficiency and in renewable and distributed generating technology. These clean additions to the system avoid the addition of new coal and gas plants in the reference case and also allow the retirement of a significant portion of the older existing nuclear and fossil generating plants. They also allow a much reduced level of investment in new transmission and distribution infrastructure.

Not surprisingly, the environmental impacts of the Balanced Case are far lower than those of the Reference Case. For example, the Reference Case carbon dioxide emissions increase from 2.2 billion metric tonnes in 2001 to 3.3 billion metric tonnes in 2025. In the Balanced Case, instead of this 50 percent increase carbon dioxide emissions decrease by 21 percent to 1.8 billion metric tonnes in 2025.

It may surprise some that costs are projected to be lower in the Balanced Case than in the Reference Case. How can we realize a diverse and clean electric system without paying substantially more for it? The Reference Case includes a tremendous investment in expensive new fossil fueled central station power generation and the investment in wires to bring that generation to consumers. The Balanced Case also requires substantial new investment, primarily in energy efficiency measures and in a mix of generating technologies that are renewable and/or distributed. The Balanced Case resource mix avoids the investment in new fossil fueled central station capacity, the costs of the fuel to operate that capacity, and much of the Reference Case transmission and distribution investment. Using EIA's numbers for the technology and fuel costs, we project that the

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[1] The AEO 2004 reference case has demand growth of 54% between 2001 and 2025. This growth is projected by EIA to be met almost entirely by new coal generating capacity (102 GW) and new gas generating capacity (254 GW). Of the reference case gas capacity additions (254 GW) about two-thirds is efficient combined-cycle technology (170 GW) and one-third is combustion turbine capacity for peaking (84 GW).

Balanced Case will begin saving money within a few years, and that by 2025 the annual savings will amount to about $36 billion.

1.2 The US Electricity Industry Today: Risky Business

Most of the electricity consumed in the US today is generated by a few types of power plants that pose significant risks to electricity customers and society in general. For example,

- Fifty percent of US electricity generation today comes from coal, which is responsible for some of the greatest environmental damages facing our society, including climate change, acid rain, fine particulate matter, mercury buildup, regional haze, and pollution from mining and waste.
- Twenty-one percent of US electricity generation today comes from nuclear power plants, which create risks regarding the cost of disposing nuclear waste, risks associated with power plant outages, and risks of routine and accidental radionuclide releases either from fuel mining, power plant operation, or spent fuel transport and disposal, in addition to the threat of a major accident.
- Eighteen percent of US electricity generation today comes from natural gas and oil power plants, which contribute to air pollution and other environmental problems and are prone to extreme price volatility.
- The majority of electric generation capacity is located at large central station power plants, which can impose increasing strains on the US transmission system, strains that translate into transmission constraints, compromising reliability and creating pressure to site and construct additional power lines.

Unfortunately, most of the new power plants and transmission projects being planned and built today are only increasing the risks posed to society from the electric industry. The vast majority of new power plants built in recent years and planned for the next several years are natural gas combined-cycle units, and the markets for that fuel are becoming increasingly volatile. In fact, the heavy demand for new gas power plants is a major contributing factor to that volatility which has strained the economics of other natural gas-dependent sectors of the economy.

In the past year, there has been a dramatic increase in plans to build new coal plants, which will only serve to increase the US reliance upon fossil-fuels with high environmental impacts. Figure 1.1 below presents the US government's forecast for CO_2 emissions from the electricity industry through 2025, and indicates how the increased reliance upon fossil fuels will lead to significant increases in this important greenhouse gas.

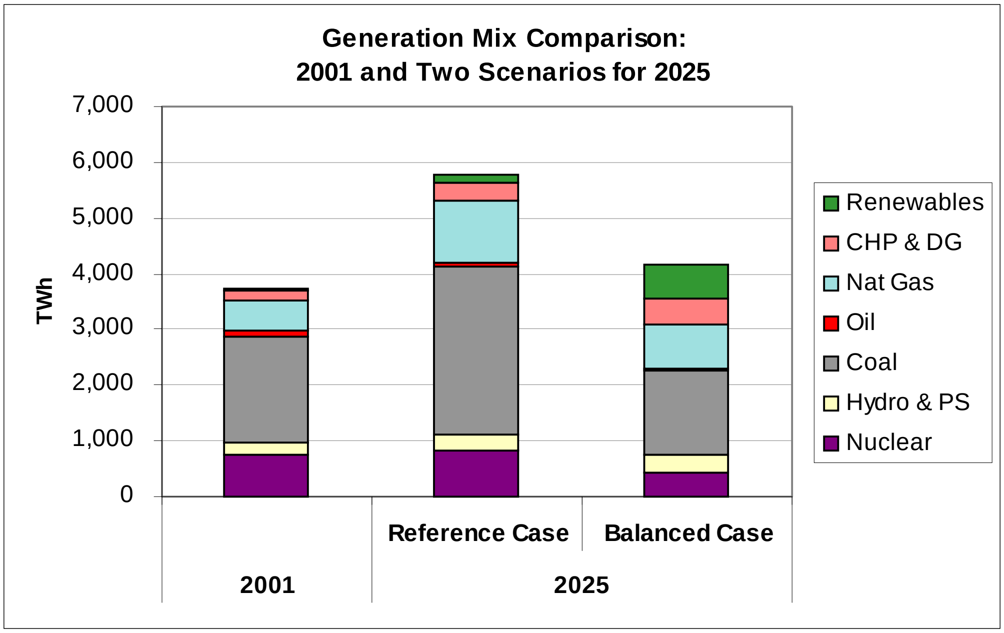
Increased air emissions from fossil-fired power plants will not only increase environmental damages, they will also increase the costs of complying with future environmental regulations, costs that are likely to be passed on to all customers. Power plants built today can generate electricity for as long as 60 years or more into the future. Therefore, it is essential that new power plants be chosen with a long-term perspective that considers not only today's construction and operating costs, but also considers the short and long term consequences for environmental quality and public health.

In recent years there has been dramatic progress in the development of less risky generation facilities, especially wind turbines, biomass facilities and distributed generation technologies. There also have been important advancements in the efficiency with which electricity is consumed by customers (i.e., in their homes and businesses) and much more such end-use efficiency remains to be tapped. However, despite this progress these less risky technologies still only represent a small portion of the total electricity resources in the US.

1.3 A Balanced Approach

The purpose of this study is to investigate the opportunities for creating a more balanced, less risky electricity industry. Instead of continuing to rely upon fossil-fueled power plants to meet new demand for electricity, we assess the potential for a more diverse mix of new electricity resources, including end-use energy efficiency, renewable resources, and combined heat and power. We also investigate the effects of retiring some of the older, more risky power plants sooner than might otherwise happen.

Figure 1.1: Generation Mix Comparison



We begin our analysis with a "Reference Case" that is based on the US Energy Information Administration's most recent forecast of the US electricity industry under "business-as-usual" conditions. We then construct a "Balanced Case" by modifying this forecast in several ways:

- Energy efficiency reduces US electricity demand by nearly 28% by 2025, relative to the electricity demand forecast in the Reference Case.
- Renewable resources, especially wind, provide roughly 15% of US generation by 2025, relative to the less than one percent forecast in the Reference Case.[2]
- Combined heat and power facilities provide roughly 10% of US generation by 2025, relative to the 5% forecast in the Reference Case.
- Oil and gas plants are assumed to be retired after about fifty years of operation. Coal plants are assumed to be retired after they operate for approximately fifty years and new generation has become available. Nuclear plants were assumed to retire at about forty five years of operation.

We find that these resources that make up the Balanced Case can be implemented at a *lower* cost than those in the Reference Case. By 2025 the total annual cost of meeting electricity demand in the Balanced Case is roughly $36 billion less than the Reference Case – which represents an annual savings of roughly 10%. Most of these savings come from the fact the energy efficiency resources cost significantly less than the cost of generating, transmitting and distributing electricity, and thus lower the total cost of providing electricity services to all customers.

The Balanced Case also reduces the demands and constraints on the US electricity transmission grid. First, by reducing future electricity demand through energy efficiency much less power needs to be transmitted through the grid, and there is much less need for new transmission capacity. Second, the renewable resources and CHP facilities installed in the Balanced Case tend to be smaller and constructed closer to load, relative to large nuclear and fossil-fired plants. Reduced transmission and distribution construction also lowers the total cost of the Balanced Case.

Furthermore, the Balanced Case results in a dramatic reduction in CO_2 emissions, as indicated in Figure 1.2. In the Reference Case CO_2 emissions are forecast to increase by 48% over today's levels, while in the Balanced Case the CO_2 emissions are expected to be *reduced* by roughly 21%. These reductions in emissions will not only assist in mitigating climate change, they will also result in lower costs associated with future climate change regulations. (The annual cost savings we estimate for the Balanced Case do *not* reflect any benefit from reducing the cost of complying with potential CO_2 emission reductions.)

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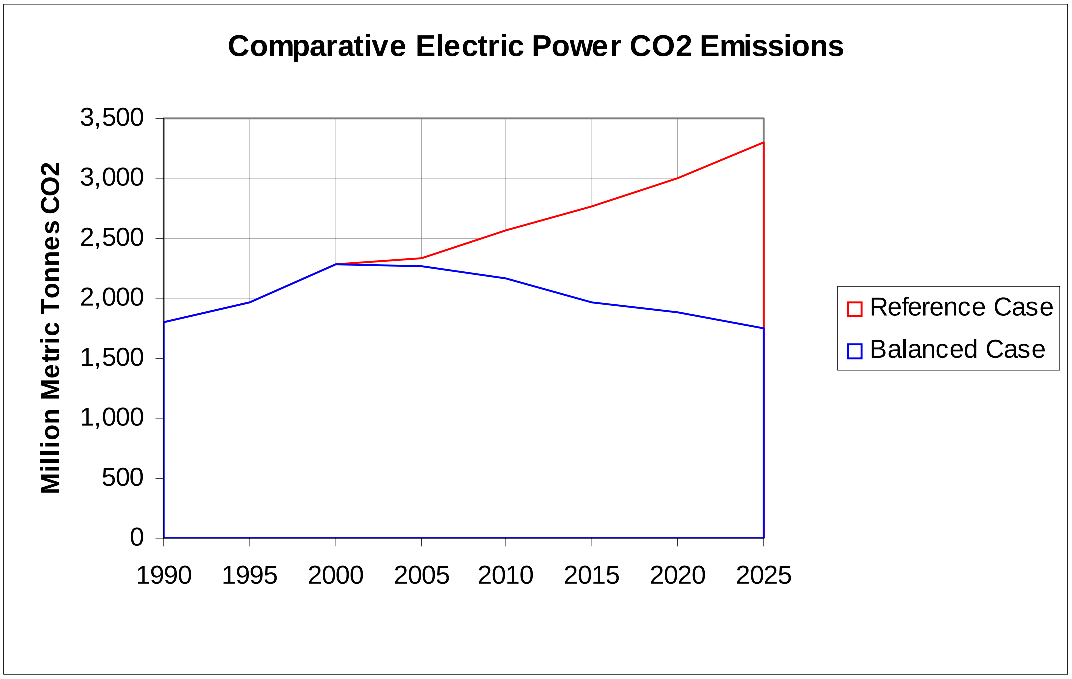
[2] The renewable generation included in this figure is "non-hydro renewables" only. Throughout this report we break out and report hydroelectric generation (of which there is considerable existing capacity) from "non-hydro renewables" (for which new policies are targeted to develop and promote capacity additions).

Figure 1.2 US Electric CO_2 Emissions: Reference Case versus Balanced Case



2. Study Methodology and Assumptions

2.1 The Reference Case

Our Reference Case is based entirely on the US Energy Information Administration's (EIA) most recent forecast of the electricity industry, as presented in the Annual Energy Outlook (AEO) 2004. We made use of the various public tables and reports to analyze the underlying modeling relationships and the components that went into producing the AEO results. We made no changes to the basic results, but disaggregated some categories (e.g. separating conventional hydro from renewables) to better present items of interest.

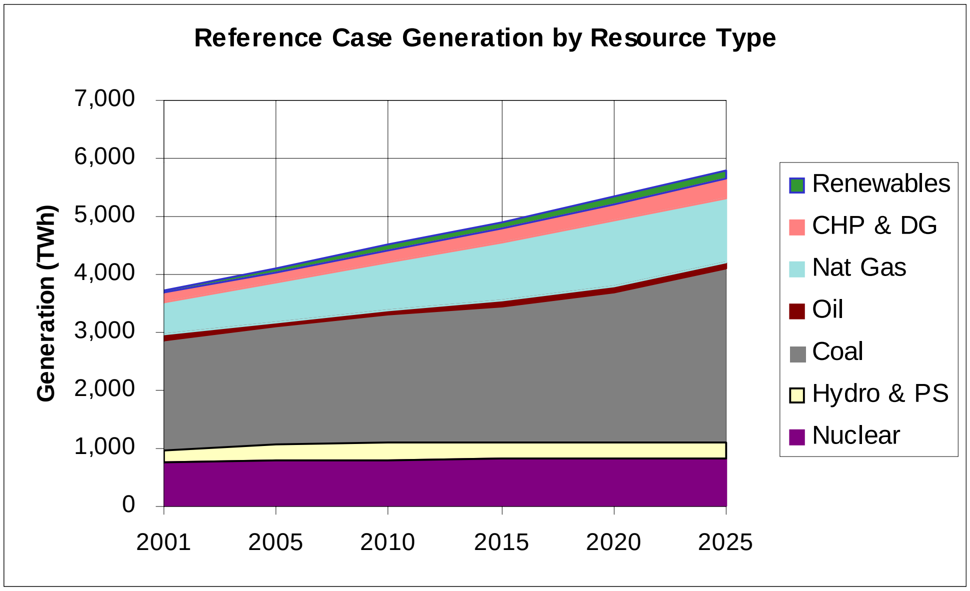
The AEO 2004 Reference Case has energy demand growing slightly under 2% per year for an overall increase of 53.8% in 2025 compared to 2001. The commercial sector has the highest rate of growth and exceeds the residential sector by 2010.

Table 2.1: Reference Case Electricity Demand

Reference Case	Demand (TWh)						% Increase
End-Use Sector	2001	2005	2010	2015	2020	2025	2001-25
Residential	1,203	1,319	1,428	1,531	1,641	1,747	45.3%
Commercial	1,197	1,296	1,480	1,653	1,828	2,003	67.3%
Industrial	964	1,030	1,120	1,216	1,310	1,422	47.4%
Transportation	22	24	26	29	32	35	63.5%
Total Demand	3,386	3,669	4,055	4,429	4,811	5,207	53.8%

The Reference Case very much represents a conventional technology "business-as-usual" future with increasing reliance on fossil fuels, and only a very modest increase in renewables. The following graph summarizes the key aspects of this case. Between the years 2001 and 2025 the amount of total generation increases by more than 50%. Generation from coal increases by 60% and that from natural gas more than doubles. By 2025 non-hydro renewables account for only 3% of the total generation.

Figure 2.1: Reference Case Generation by Resource Type



In this Reference Case total customer electricity costs increase from $255 billion in 2001 to $367 billion by 2025, for a percentage increase of 44%, which is a little less than the percentage increase in total demand growth.[3] Generation accounts for about 65% of the customer costs.

Table 2.2: Reference Case Electricity Costs

Reference Case	Costs (Million Y2003$)						% Increase
Service Category	2001	2005	2010	2015	2020	2025	2001-25
Generation	166,223	161,127	170,297	196,752	218,368	240,372	44.6%
Transmission	18,997	20,658	25,030	29,593	32,757	36,263	90.9%
Distribution	69,616	74,411	79,596	82,006	85,750	90,857	30.5%
Total Costs	254,836	256,196	274,923	308,351	336,875	367,492	44.2%

Fossil fuel consumption increases by 48% overall in the Reference Case. Petroleum use declines by 35%, while natural gas and coal use increase by approximately 50%. Note that fossil fuel costs account for about one third of the generation costs paid by the users. The remainder of the generation charges represent capital costs, O&M, and administrative expenses.

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[3] Costs throughout this report are presented in constant year 2003 dollars. To express future costs in "nominal dollars" a forecast of general price inflation should be applied. To express future costs in "present value" or "discounted dollars" a discount rate should be applied.

Table 2.3: Reference Case Fuel Consumption & Costs

Reference Case	Fuel Consumption (QBtu)						% Increase
Fuel Type	2001	2005	2010	2015	2020	2025	2001-25
Petroleum	1.25	0.66	0.66	1.04	0.85	0.81	-35.1%
Nat Gas	5.48	5.81	6.79	7.78	8.78	8.55	55.9%
Coal	19.68	20.96	23.05	24.20	26.22	29.67	50.8%
Fossil Fuel Consumption	26.41	27.43	30.51	33.02	35.85	39.03	47.8%

Reference Case	Fuel Costs (Million Y2003$)						% Increase
Fuel Type	2001	2005	2010	2015	2020	2025	2001-25
Petroleum	6,339	2,833	2,842	4,795	4,052	4,014	-36.7%
Nat Gas	29,552	24,676	27,910	37,831	43,286	42,760	44.7%
Coal	25,031	26,233	28,545	29,466	31,235	35,547	42.0%
Fossil Fuel Costs	60,922	53,741	59,297	72,092	78,573	82,321	35.1%

A full description of the AEO 2004 study can be found on the EIA website at: http://www.eia.doe.gov/oiaf/aeo/index.html

2.2 The Balanced Case

The Balanced Case was developed by making several key modifications to the Reference Case, as summarized below.

1. Plant Retirements – We took the Reference Case retirements as the base-line level. Then we added the retirement of existing oil and natural gas plants after about fifty years of operating life. For nuclear plants we assumed a retirement after about 45 years of operating life. Coal plants were retired incrementally as new generation became available after approximately fifty years of operation.

2. Energy Efficiency – We reviewed several recent studies of energy efficiency potential as the basis for developing an aggressive but feasible amount of energy efficiency resources. The details of the energy efficiency analysis are provided in Section 3.

3. Additions of Conventional Power Plants – We included the capacity additions projected through 2005 in AEO, but assumed that AEO additions after 2005 would not be installed in the Balanced Case. We also applied AEO's estimates for the upratings of all existing nuclear plants. Where necessary in the later years natural gas peaking capacity was added to meet reserve margin requirements.

4. Additions of Renewable Generators and Combined Heat and Power (CHP) – The Balanced Case is designed to include enough renewables to generate three percent

of electricity in 2010 and six percent by 2020, relative to the Reference Case generation levels.[4] The details of the renewables analysis are provided in Section 4. The Balanced Case also includes additional CHP beyond the Reference Case CHP additions.[5]

5. Transmission and Distribution Costs – We used AEO costs for the short term, but then phased in savings from reduced load growth over ten years. We reduced T&D costs to account for distributed resources, but we added additional interconnection costs for remote wind generation.
6. Power Plant Capacity Factors – We used the AEO Base Case capacity factors for the base load units (coal and nuclear) as well as for renewable resources. Where necessary, we made proportional adjustments in the capacity factors for oil and natural gas units to bring generation into balance with the load.
7. Emission Rates – For conventional generation we used the average annual emission rates as derived from the AEO results.
8. Fuel Usage – For conventional generation we used average heat rates based on generation technology and fuel type to derive fuel usage.

Power Plant Costs

The figure below, based on AEO 2004 data,[6] shows the comparative levelized costs of energy (including transmission) from new technologies in 2010 and 2025. While the individual cost components (capital and fuel) differ, the total costs are quite similar across the technologies. In 2010, wind is cheaper than coal and only marginally more expensive than natural gas. Even by 2025, when wind costs are assumed to rise because of the need to use less desirable sites, the differences are still fairly small. The higher transmission costs for wind are because the energy needs to travel longer distances from the wind resources to the areas of need. Note too the relative importance of fuel costs for conventional resources. The production tax credit (PTC) for wind is not included in the numbers presented here (nor is it accounted for in the total cost results presented elsewhere in this report). The PTC, if extended out into this time period, would make wind look substantially better relative to the conventional generating technologies.

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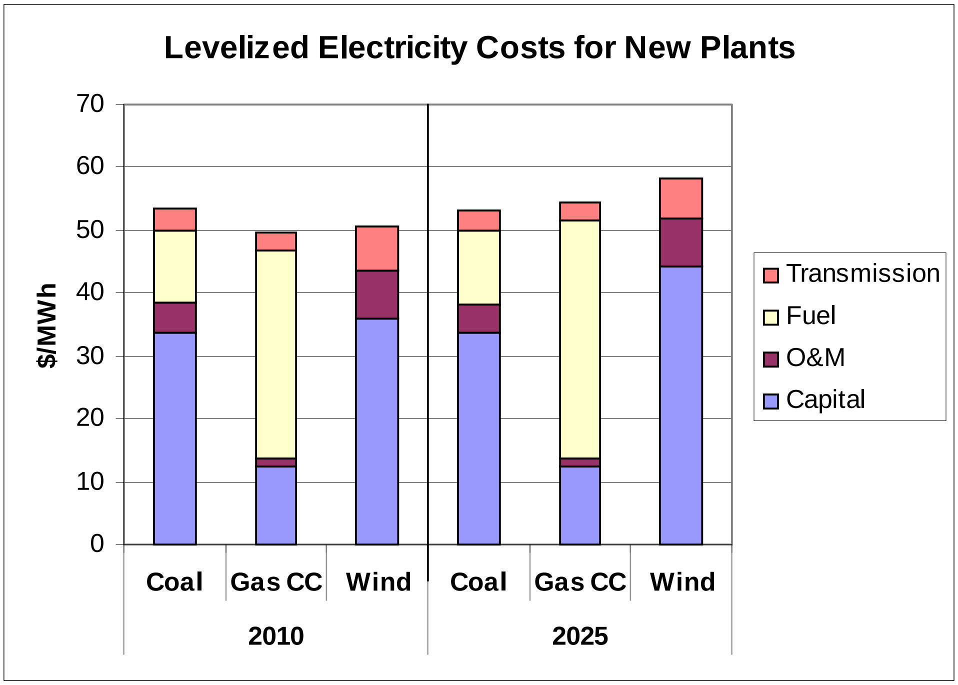
[4] The Balanced Case total generation levels are significantly lower than the Reference Case total generation levels, so the percentages would be higher expressed relative to the Balanced Case totals. For example, the 6% new renewables figure relative to the Reference Case total generation would be about 8 percent of the Balanced Case total generation.

[5] In the Reference Case CHP electricity generation roughly doubles between 2001 and 2025. In the Balanced Case CHP electricity generation roughly triples between 2001 and 2025.

[6] This data corresponds to that of Figure 72 in the AEO 2004 report.

Figure 2.2: Comparative Levelized Electricity Costs from AEO



Source: EIA 2004a, page 82.

3. Energy Efficiency in the Balanced Case

3.1 Energy Efficiency Opportunities

Throughout the United States there is a vast potential to improve the efficiency with which electricity is used. All types of electricity customers have numerous opportunities to replace aging electric equipment with newer, more efficient models, or to upgrade their homes, businesses and industries with more efficient designs and systems.

Energy efficiency as used in this report is defined as technologies, measures, activities and programs designed to reduce the amount of energy needed to provide a given electricity service (e.g., lighting, heating, air conditioning, refrigeration, motor power). Energy efficiency allows customers to maintain or improve their electricity services, while reducing their electricity consumption and their electricity bills.

There is a long and ever-expanding list of technologies and measures available to improve the efficiency with which electricity is consumed. Most of these efficiency measures have been commercially available for many years, and are continually improved over time, while some have been developed recently in response to public policies and customer demand. Some of the more common measures include:

- For residential customers the key electric efficiency measures include: efficient light bulbs; efficient light fixtures; refrigerators; clotheswashers; dishwashers; hot water heating measures; heating ventilation and air conditioning measures; weatherization, insulation and other building shell measures; and building design measures, such as daylighting and shade trees.
- For commercial customers the key electric efficiency measures include: efficient lamps and ballasts; daylighting; efficient exit lamps, street lights and traffic lights; heating ventilation and air conditioning measures; refrigeration measures; office equipment measures; and energy management systems.
- For industrial customers the key electric efficiency measures include: efficient motors and motor drives; industrial process improvements; heating ventilation and air conditioning measures; efficient lamps and ballasts; and energy management systems.

3.2 Energy Efficiency Benefits

The primary benefit of energy efficiency is that it reduces costs for the electric utility and all of its customers. Many efficiency measures cost significantly less than generating, transmitting and distributing electricity. Most of the efficiency measures listed above can be installed for a cost of 1 ¢/kWh to 4 ¢/kWh, while electricity generation, transmission and distribution can cost in the range of 5 ¢/kWh to 10 ¢/kWh, and even more depending upon the location and time of day. Thus, energy efficiency programs offer a huge potential for both lowering system-wide electricity costs and reducing customers' electricity bills.

In addition to its economic benefits, energy efficiency offers a variety of benefits to utilities, their customers, and society in general.

- Energy efficiency can help reduce the demand for new (or upgraded) transmission and distribution facilities. The demand for transmission and distribution investments is primarily driven by increased customer demand for electricity, and energy efficiency is most cost-effective and has the greatest potential when targeted at new customer demand. In addition, efficiency can have a substantial impact on peak demand, and thereby help reduce the stress on local transmission and distribution systems.
- Energy efficiency can help reduce the risks associated with fossil fuels and their inherently unstable price and supply characteristics.
- Energy efficiency can improve the overall reliability of the electricity system. First, efficiency programs can have a substantial impact on peak demand, during those times when reliability is most at risk. Second, by slowing the rate of growth of electricity peak and energy demands, energy efficiency can provide utilities and generation companies more time and flexibility to respond to changing market conditions.
- Energy efficiency can result in significant benefits to the environment. Every kWh saved through efficiency results in less electricity generation, and thus less pollution.[7]
- Energy efficiency can also promote local economic development and job creation by increasing the disposable income of citizens and making businesses and industries more competitive.
- Energy efficiency can help a utility, state and region increase its energy independence, by reducing the amount of fuels (coal, gas, oil, nuclear) and electricity that are imported from other regions or even from other countries.

3.3 Energy Efficiency in the Balanced Case

Over the past two decades there have been many studies that assess the potential for energy efficiency across the US, in various regions, in various states, and for various electric utilities. While there are some important differences across the studies, there is also a consistent theme across them all: there is a large amount of untapped, cost-effective energy efficiency available in all parts of the country and from all types of customers.

We have reviewed some of the most recent, leading studies of energy efficiency potential to determine the amount of efficiency to include in our Balanced Case. In particular, we

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[7] Unlike other pollution control measures – such as scrubbers or selective catalytic reduction– energy efficiency measures can reduce air emissions with a *net reduction* in costs. Thus, energy efficiency programs should be considered as one of the top priorities when investigating options for reducing air emissions from power plants.

reviewed four nation-wide studies (Five Labs 2000, WWF and EF 1999, ACEEE 1999, UCS 2001), and four regional studies (ELPC 2001, REPP 2002, Tellus 2002, SWEEP 2003).

These studies include forecasts of the amount and cost of energy efficiency available through 2010 and, in most cases, 2020. They find that there is enough cost-effective efficiency available to reduce electric demand in 2010 by as much as 11% to 23%, and in 2020 by as much as 21% to 35%. The primary difference between these studies, and thus their findings, is the amount of public policy support they rely upon to achieve the future efficiency savings. Those studies that assume, and promote, more aggressive public policies predict greater amounts of efficiency savings. In other words, the key barrier to achieving the efficiency savings is not in the technical or economic availability of the measures, but in the ability of governments, institutions, and customers to take the necessary actions to adopt those measures.

For the purposes of our Balanced Case, we used the average results of these eight efficiency studies. In general, these studies found that future electricity demand could be reduced by roughly 1.6% per year, averaged across all sectors. This represents a very aggressive but very feasible level of energy efficiency savings. It is based on the assumption that there will be several concerted, long-term, aggressive, and successful public policy initiatives to transform the markets for efficiency measures, and change the way that customers purchase and use electricity products.

We then determined the energy efficiency savings of the Balanced Case by applying this average annual reduction in electricity demand to the load forecast of the AEO 2004 reference case. The results are shown in Table 3.1.

Table 3.1 US Electricity Sales and Growth Rates: Reference and Balanced Cases

	Reference Case			Balanced Case	
	Electricity Sales 2004 (TWh)	Electricity Sales 2020 (TWh)	Growth Rates 2004-2020 (%)	Electricity Sales 2020 (TWh)	Growth Rates 2004-2020 (%)
Residential	1,302	1,641	1.4%	1,306	0.0%
Commercial	1,254	1,828	2.3%	1,367	0.5%
Industrial	1,003	1,310	1.7%	1,038	0.2%
Total	3,582	4,811	1.8%	3,731	0.2%

In the Reference Case, total electricity demand is expected to grow by roughly 1.8% per year, resulting in a total of 4,811 TWh of annual electricity sales by 2020. In the Balanced Case the electricity sales growth rates are reduced dramatically. The residential sales are reduced to the point where there is essentially no new load growth in this sector. The commercial sector continues to grow at roughly 0.5% per year, because this sector has the highest amount of load growth in the reference case. The electricity demand for all sectors combined increases only slightly, at an average rate of 0.2% per year.

The results are presented graphically in Figure 3.1. As indicated, the 2025 electricity sales in the Balanced Case are only slightly higher than the 2004 electricity sales, with most of the increase coming from the commercial sector.

Figure 3.1 US Electricity Sales: Reference Case and Balanced Case

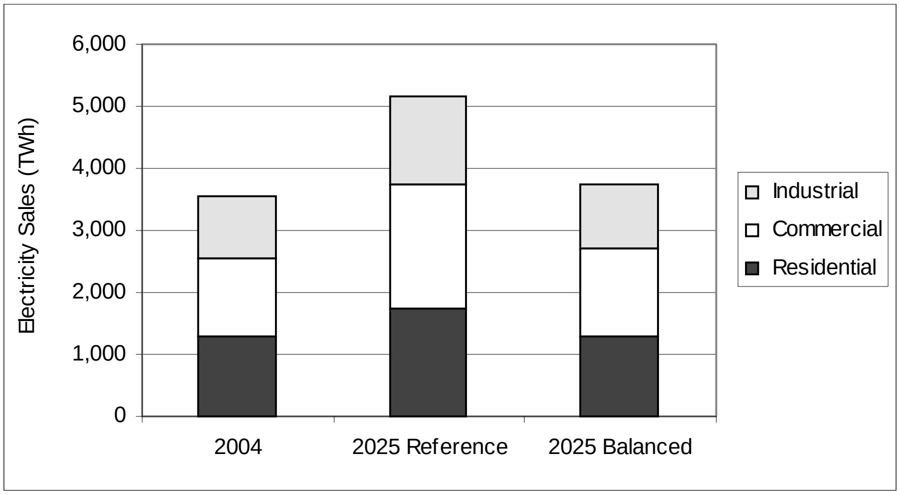

Table 3.2 presents the amount of electricity saved in 2025 relative to the Reference Case. The total amount of savings across all sectors is expected to be 1,080 TWh, which is a reduction of 22% of the electricity sales in the reference case. This amount of electricity savings is roughly equivalent to the amount of generation from over 600 typical new power plants.[8]

Table 3.2 Efficiency Savings in 2025

	Reference Case Sales 2025 (TWh)	Balanced Case Sales 2025 (TWh)	Electricity Saved 2025 (TWh)	Percent Reduction (%)
Residential	1,747	1,303	444	25%
Commercial	2,003	1,391	612	31%
Industrial	1,422	1,051	371	26%
Total	5,171	3,745	1,427	28%

As noted above, these savings will not be achieved without aggressive, concerted, successful public policy initiatives. There are many policies to help achieve these savings, the key ones being: national efficiency standards for a variety of new appliances; national efficiency standards for the construction of new buildings; energy efficiency

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[8] We assume that transmission line losses equal seven percent, so that power plants would need to generate 1,156 TWh in the absence of these efficiency savings. We also assume that a typical power plant is a 300 MW natural gas combined cycle unit operating at 70% capacity factor, generating 1,840 GWh of electricity per year.

programs administered by electric utilities or other agencies, funded through state and national system benefits charges; pricing mechanisms to encourage wiser customer electric consumption patterns;[9] and government purchasing practices to help increase the demand for energy efficiency products and services. On the other hand, energy efficiency and renewable generation can significantly moderate price volatility due to fuel price fluctuations and supply/demand imbalances, suggesting that there are consumer benefits that could make these programs palatable to the public. (Synapse 2003)

We also rely upon recent energy efficiency studies to estimate the costs of these efficiency savings. The cost of achieving these savings will depend upon the policy mechanism that is used to implement the efficiency measures. Appliance and building standards only require an incremental cost associated with the production of the more efficiency equipment. Utility energy efficiency programs also require additional costs in order to administer the programs, and market and deliver the efficiency measures.

We assume that the average cost of achieving the efficiency savings in the Balanced Case will be $30/MWh (in constant 2003 dollars) for all years of the analysis. This represents electricity savings achieved through a combination of efficiency standards and utility programs with associated administration costs. This cost assumption is consistent with several recent regional efficiency studies that also assume a mix of aggressive efficiency standards and utility efficiency programs (ELPC 2001, REPP 2002, SWEEP 2003). It is also consistent with recent experience with utility energy efficiency programs.[10]

We multiply this cost of saved energy by the annual efficiency savings to determine the annual cost of efficiency investments. In 2020 the total annual efficiency savings are estimated to be 1,080 TWh, which implies an outlay for that year of roughly $32 billion. These costs will be more than offset by the avoided generation, transmission and distribution costs, as described in the following chapters.

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[9] For example, loading costs into fixed customer charges and rate structures with “declining blocks” can encourage wasteful behavior.

[10] For example, the energy efficiency programs implemented by California utilities from 1990 through 1998 cost roughly $25/MWh on average (NRDC 2001). The programs offered by Efficiency Vermont in 2000 cost roughly $26/MWh (Efficiency Vermont). In Massachusetts the utility energy efficiency programs for 1998 through 2002 range in cost from $19/MWh to $30/MWh (MECO 2003, WMECO 2003, NSTAR 2003). The energy efficiency programs offered by the two Connecticut utilities in 2000 cost roughly $23/MWh (CT ECMB 2002).

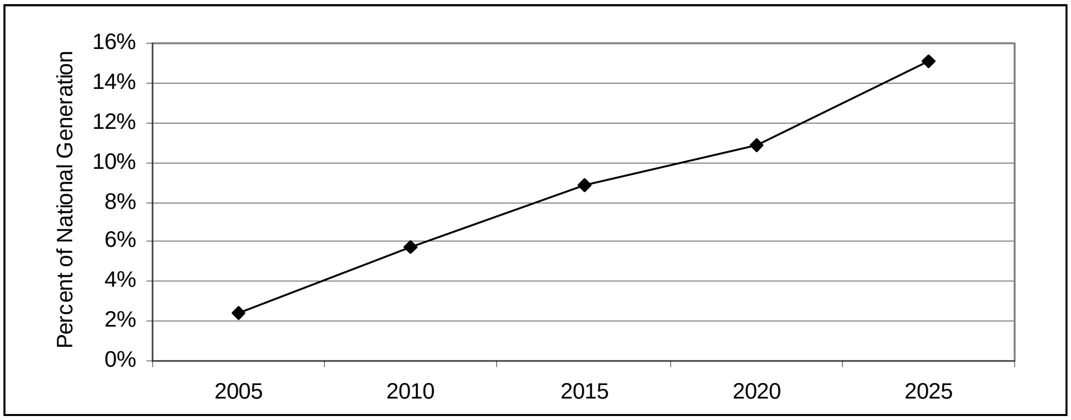
4. Renewables and CHP in the Balanced Case

4.1 Renewable Generation Targets

The growth of renewable electricity generation in the Balanced Case is based on target percentages of total electricity generation in 2010 and 2020. We set out to achieve three percent of total Reference Case electricity generation in 2010 from new renewable resources beginning in 2003, ramping up to six percent in 2020 and continuing to grow thereafter. Note that these are percentages of Reference Case generation. The expanded efficiency investment in the Balanced Case reduces total electricity use relative to the Reference Case, making new renewable generation an even larger percentage of total generation in the Balanced Case. (See Figure 4.1.) These figures are consistent with many of the renewable portfolio standards in the U.S. and more conservative than some of them.

Starting with the percentage targets cited above, we reviewed existing data on the technical and economic potential for each renewable generating technology in each region of the U.S. We reviewed a large number of documents assessing regional potentials, and had discussions with several experts.[11] Based on this research, we developed annual capacity addition assumptions for each technology within each NERC region. In some regions we did not achieve the target percentages of total generation. In other regions we did achieve the percentages, and in some regions we exceeded the targets. As shown in Table 4.1, the contribution of new non-hydro renewable energy grows from just over two percent in 2005 to roughly 15 percent in 2025.

Figure 4.1 Percentage of New Renewable Generation in the Balanced Case



Overall, we were conservative in our assumed capacity additions, and the rates of addition in the various regions are eminently achievable. Renewable capacity additions by year in the Balanced Case are shown in Table 4.1. The vast majority of the renewable

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[11] The major sources consulted on regional renewable generating potential's are: ELPC 2001, REPP 2002, Tellus Institute 2002, UCS 2001, and US DOE 1997.

capacity added over the study period is fueled by wind and biomass, and this is consistent with most studies of US renewable generation potential.

Table 4.1 Renewable Generating Capacity Additions in the Balanced Case

Renewable Capacity (GW)	2001*	2005	2010	2015	2020	2025
Geothermal	2.88	3.09	4.18	5.35	6.53	8.88
MSW – Landfill Gas[12]	3.38	3.65	3.89	4.03	4.17	4.44
Wood and Other Biomass	1.79	3.38	12.04	19.02	26.01	39.97
Solar Thermal	0.33	0.36	0.50	0.58	0.66	0.82
Solar Photovoltaic	0.02	0.12	0.58	1.48	2.38	4.18
Wind	4.15	8.68	21.03	34.08	47.14	73.25
Total (non-hydro)	12.54	19.28	42.22	64.55	86.88	131.54

**2001 figures show capacity existing in 2001.*

4.2 Renewable Generation Costs

For the costs of new renewable generation, we use the input data from EIA's *Annual Energy Outlook, 2004*, shown in Table 4.2. These data are for facilities built in 2003.

Table 4.2 Renewables Cost Inputs in AEO 2004

	Size (MW)	Base Overnight Costs in 2003	Total Overnight Cost in 2003*	Variable O&M	Fixed O&M
Biomass	80	1,615	1,760	3.02	47.40
Landfill Gas	30	1,404	1,502	0.01	101.56
Geothermal	50	2,135	2,240	0.00	80.87
Wind	50	965	1,032	0.00	26.94
Solar Thermal	100	2,520	2,966	0.00	50.47
Photovoltaic	5	3,875	4,476	0.00	10.28

**Total overnight costs include contingency factors.*
Source: Assumptions for AEO 2004, Table 38. All costs are in 2003 dollars.

To generate a trajectory for the capital costs of each renewable technology over the study period, we use a simplified version of the technology learning function in the NEMS model. In this function, a technology's capital costs are primarily a function of the amount of the technology installed over time. This reflects the idea that, as more capacity is installed, manufacturer's and developer's costs are reduced by experience and economies of scale.

In addition to this learning effect, for wind capacity we also include EIA's cost adjustments to reflect wind sites of differing quality. The best wind sites (i.e., most economic) are those with a strong wind resource, located close to transmission lines in

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[12] Most Municipal Solid Waste generating capacity in 2001 is incineration, but new generation after 2005 is considered to be from landfill gas.

flat, accessible terrain. As wind turbines are installed on these sites, developers will have to turn to less desirable sites, and their costs will increase. To reflect this dynamic, EIA has placed the total wind resource in each region into categories and applied factors to increase capital costs in certain categories. In the Balanced Case, all of the most attractive U.S. wind sites are developed by about 2019. Therefore, in 2020 and after, we apply EIA's cost factor for the next most attractive wind sites – a 20-percent cost increase.

Table 4.3 shows the capital cost trajectories for selected renewable technologies over the study period. The cost trajectories of the other renewable technologies are virtually the same in the two cases, because they are mature technologies and/or we do not add much more capacity than is added in EIA's reference case.

Table 4.3. Capital Costs of Renewables in the Reference and Balanced Cases

	2003		2020		2025	
Technology	Reference	Balanced	Reference	Balanced	Reference	Balanced
Biomass	$1,760	$1,760	$1,692	$1,690	$1,672	$1,669
Wind	$1,032	$1,032	$1,022	$1,218	$1,019	$1,218
Photovoltaic	$4,476	$4,476	$2,797	$2,567	$2,555	$2,264

All costs are in 2003 dollars/kw. Note that these costs correspond to the "total overnight costs" including contingency factors.

Note that, in both cases, the cost of biomass capacity falls much more slowly than the cost of photovoltaic capacity. This is because the NEMS learning function treats mature technologies differently from immature technologies. The capital costs of more mature technologies decrease slowly as capacity is installed, because additional improvements in technology and economies of scale are harder to achieve. The costs of less well developed technologies, like photovoltaics, fall faster with capacity additions and time. The cost of new wind capacity falls slightly throughout the reference case, due to learning, but it increases in 2020 in the Balanced Case as developers turn to less attractive wind sites.

We assume that the operating and maintenance costs of renewable technologies remain the same throughout the study period in both cases.

We also use the NEMS input assumptions for the cost of biomass fuel over the study period. For biomass fuel costs, NEMS uses thirteen regional biomass supply curves developed by the EIA. These curves take into account a number of sources of biomass, from dedicated feedstocks to wood wastes, and indicate the regional, market-clearing price of biomass at different levels of demand. We have aggregated these supply curves into a national curve, and priced biomass fuel in our scenarios based on this curve. The result is that biomass fuel becomes more expensive in the Balanced Case, because more biomass is demanded in the power generation sector. In the Reference Case, the cost of biomass fuel rises from $1.09/MMBtu in 2003 to $1.27/MMBtu in 2025 (in constant 2003 dollars). In the Balanced Case, it rises from $1.09/MMBtu to $1.60/MMBtu in 2025.

5. The Balanced Case Results

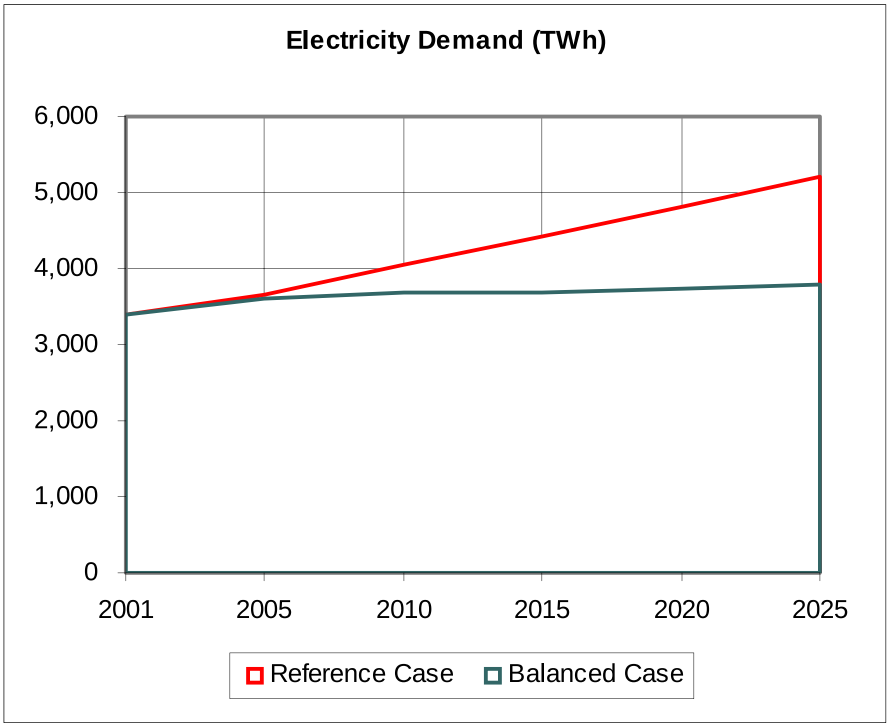
5.1 Electricity Demand and Generation

The AEO 2004 Reference Case has electricity demand growing at an average annual rate of 1.75% between 2005 and 2025, for an overall increase of 41.9%. The proposed balanced plan with an emphasis on energy efficiency results in an average annual rate of growth of 0.23%, with a resulting overall increase of 4.7% over 20 years.

Table 5.1: Electricity Energy Demand Summary Comparison

Electricity Demand (TWh)	2001	2005	2010	2015	2020	2025	From 2005 to 2025 Change	 Percent Change	 Avg. Ann. Growth Rate
Reference Case	3,386	3,669	4,055	4,429	4,811	5,207	1,537	41.9%	1.75%
Balanced Case	3,386	3,610	3,673	3,692	3,743	3,780	170	4.7%	0.23%

Figure 5.1: Electricity Energy Demand Summary Comparison

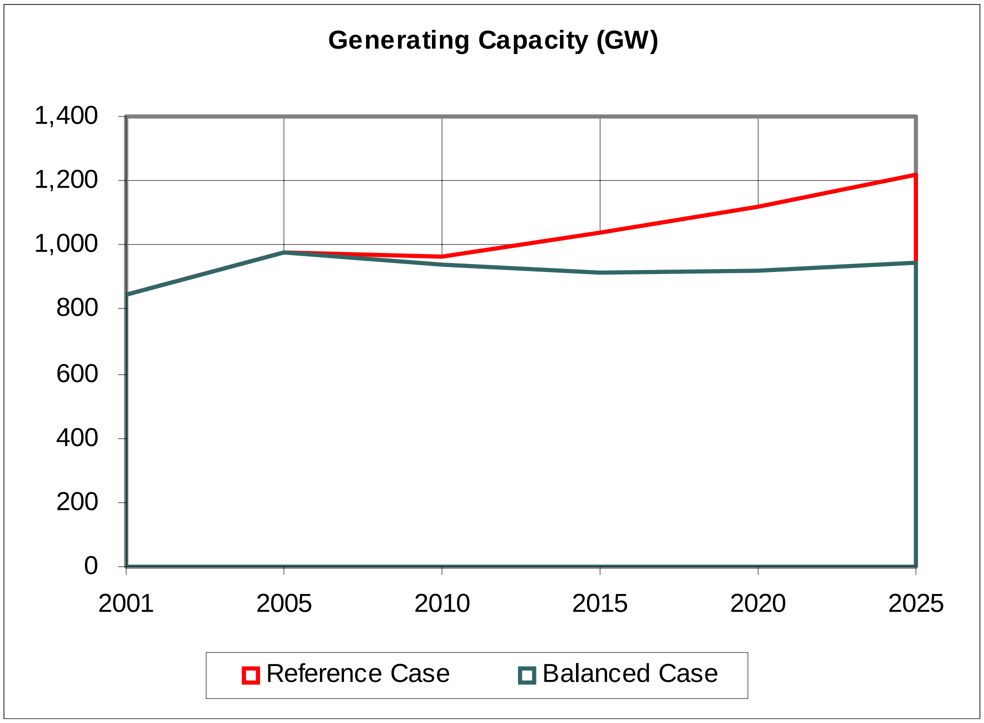


Since the electricity demand increases significantly in the Reference Case, so also do electricity generation and capacity. Because of current excess generating capacity, the overall net increase in capacity is limited to 24.9%. For the Balanced Case, this current surplus means that there is actually a slight decline in total capacity of 2.8% by 2025.

Table 5.2: Electrical Generating Capacity Summary Comparison

							From 2005 to 2025		
Generating Capacity (GW)	2001	2005	2010	2015	2020	2025	Change	Percent Change	Ann. Avg. Growth Rate
Reference Case	975	965	1,037	1,120	1,217	242	975	24.9%	1.11%
Balanced Case	976	941	916	921	949	(27)	976	-2.8%	-0.14%

Figure 5.2: Electrical Generating Capacity Summary Comparison



Although the total generating capacity needed declines, new capacity is added in the Balanced Case as older capacity is retired. The new capacity is primarily renewable resources replacing coal and other fossil plants. The table below shows that the major differences are the reductions in coal capacity along with a significant increase in renewables. For example, the Reference Case adds 103 GW of new coal capacity, whereas the Balanced Case retires 99 GW of existing coal plants. There is also a small increase in natural gas peaking capacity to complement the intermittent nature of some renewables.

Table 5.3: Generating Capacity Type Comparison

Generating Capacity Changes (GW) 2005 to 2025			
	Reference Case	Balanced Case	Difference
Coal Steam	103.4	-99.0	-202.4
Oil Steam	-9.1	-17.2	-8.0
Nat Gas Steam	-23.2	-65.2	-42.0
Nat Gas Comb Cycle	80.7	-4.2	-84.9
Oil CT	-5.4	-9.0	-3.5
Nat Gas CT	46.2	51.7	5.5
Nuclear Power	2.8	-43.8	-46.7
Pumped Storage/Other	0.0	0.0	0.0
Fuel Cells	0.1	0.1	0.0
Hydro	0.1	0.7	0.6
Renewables (non-hydro)	15.8	111.7	95.9
Distributed Generation[13]	12.3	12.3	0.0
Non-Utility CH&P	18.7	34.8	16.1
Total Capacity Change	242.4	-27.0	-269.4

The figure below shows the generation mix in 2001 and for the two cases in 2025. Note that the generation in the Balanced Case is slightly above 2001 levels but represents a more varied mix of resources both than in either 2001 or in the Reference Case.

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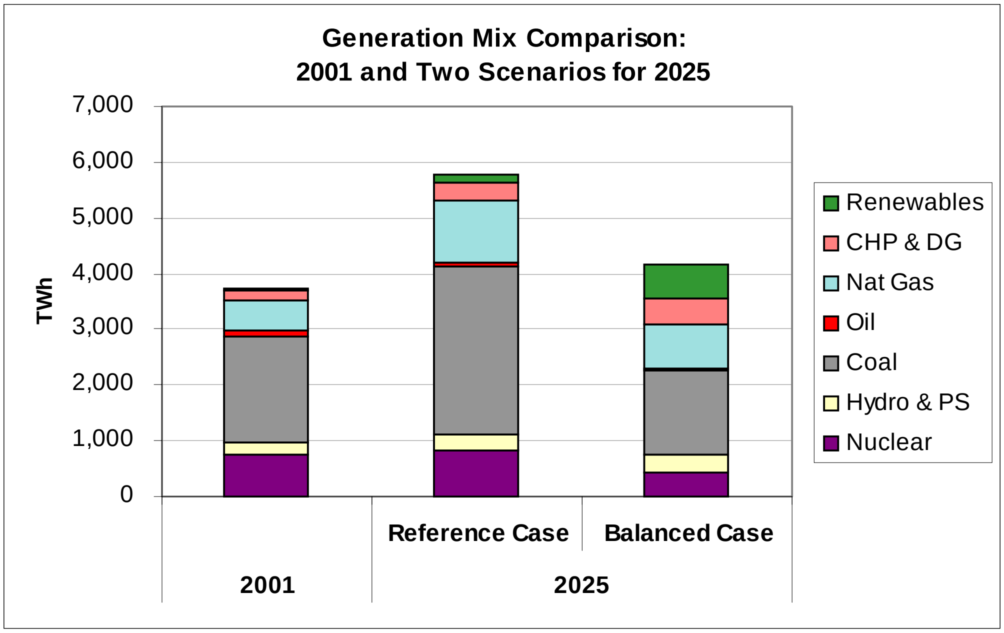
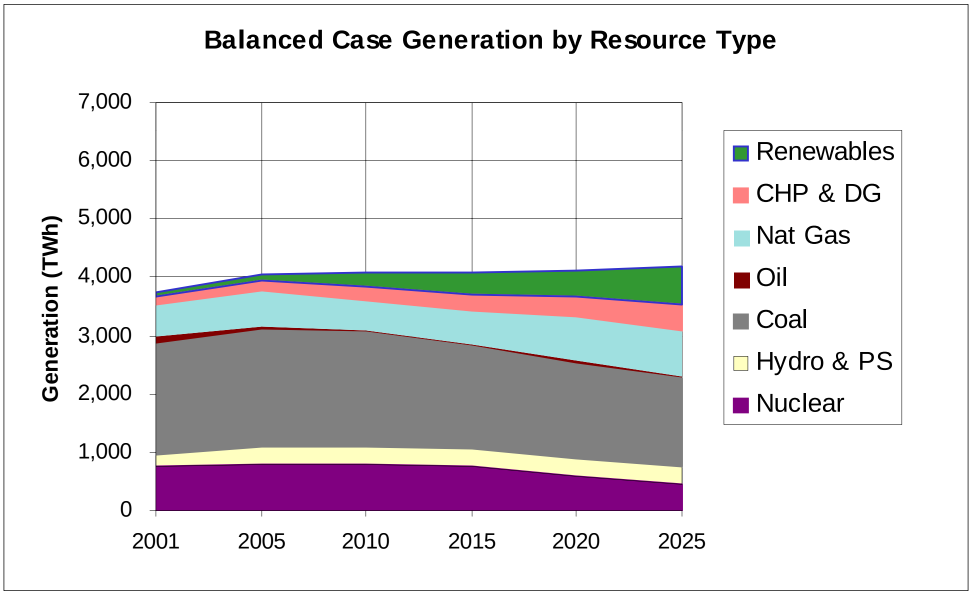
[13] The Balanced Case has additional distributed generation capacity not included in the Reference Case, but that capacity is included in the renewable and CHP categories.

Figure 5.3: Generation Mix Comparison



The figure below shows the generation by resource type in the Balanced Case. Nuclear generation is moderately reduced after 2010. There are substantial reductions in coal generation as renewable and CHP resources come on-line. Natural gas generation, primarily from existing combined-cycle plants, increases slightly. The big increase is for non-hydro renewables, which by 2025 account for 15% of the electricity generation. For a side-by-side comparison with the Reference Case, see Figure 2.1 in Section 2.

Figure 5.4: Balanced Case Generation by Resource Type

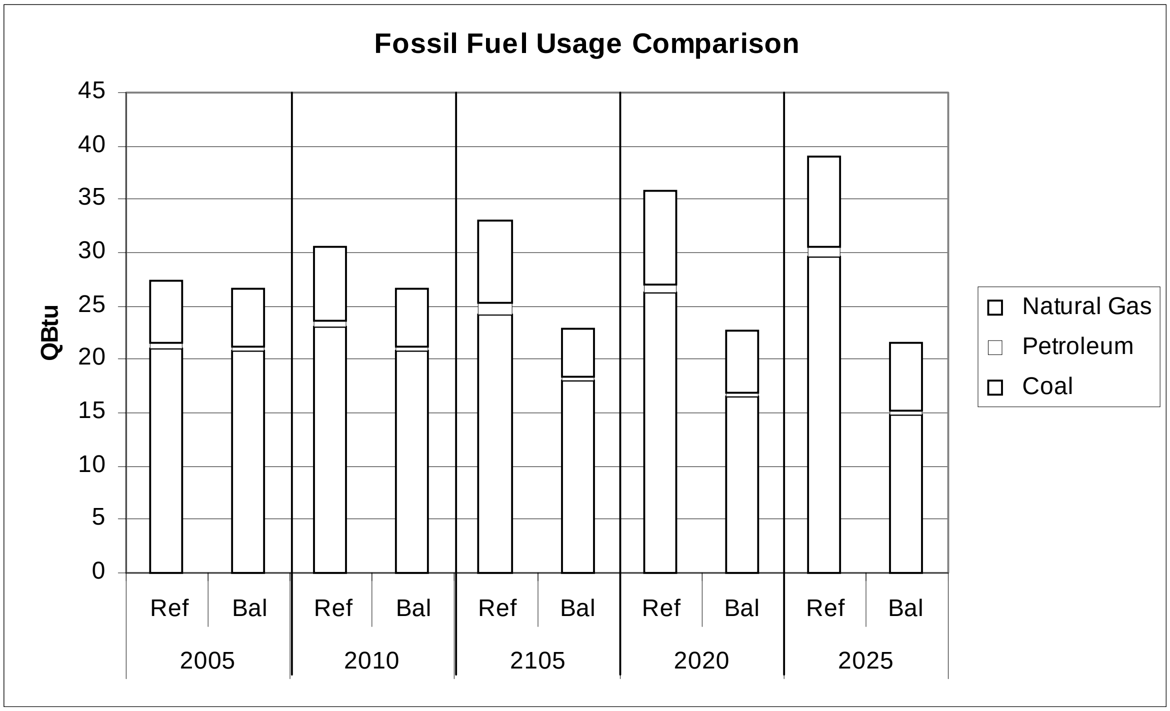


The Balanced Case has a modest increase in natural gas usage compared to current consumption, but a substantial decrease in coal. (Table 5.4 corresponds to Table 2.3 for the Reference case). But there are substantial reductions in consumption of natural gas compared to the Reference Case as shown in the figure below.

Table 5.4: Balanced Case Fossil Fuel Consumption

	Fuel Consumption (QBtu)						% Change
Fuel Type	2001	2005	2010	2015	2020	2025	2001-25
Petroleum	1.25	0.50	0.36	0.35	0.43	0.40	-68.2%
Natural Gas	5.45	5.38	4.26	4.54	5.87	6.21	13.9%
Coal	19.68	20.75	20.35	18.05	16.45	14.88	-24.4%
Total	26.37	26.63	24.96	22.94	22.75	21.49	-18.5%

Figure 5.5: Fossil Fuel Usage Comparison



5.2 Electricity Costs

The economic benefits of the Balanced Case are significant, with reductions in generation and T&D costs that more than offset the costs of the efficiency and renewable programs. By 2025 the Balanced Case is expected to result in $35.8 billion savings for that year, relative to the Reference Case. To give a rough perspective to these numbers, customer electricity costs are approximately $250 billion in 2004 and projected to increase to $367 billion by 2025 (in constant 2003 dollars). Thus the Balanced Case represents a 10% overall direct economic savings in 2025 compared to the Reference Case.

Table 5.5: Cost Impact Summary of the Balanced Case

Annualized Cost Impacts (Billion $)	**2005**	**2010**	**2015**	**2020**	**2025**
Variable Generation Costs	-2.7	-13.5	-24.8	-27.1	-31.2
Fixed Generation Costs	1.0	3.2	-0.8	-7.3	-14.2
Transmission & Distribution	0.2	-4.1	-17.9	-25.6	-33.2
Efficiency Programs	1.8	11.5	22.1	32.0	42.8
Annual Net Cost Difference	0.4	-2.9	-21.3	-28.0	-35.8

Notes: Variable Generation Costs include Fuel and Variable O&M; Fixed Generation Costs include the capital cost of new plants and the associated Fixed O&M.

The big reduction compared to the Balanced Case are variable generation costs, which are primarily fuel. There are immediate savings in natural gas and oil generation, which are followed in later years with coal savings as coal capacity (and generation) are reduced. The variable costs for renewables increase slightly as generation increases.

Table 5.6: Variable Generation Cost Differences

Variable Generation Cost (Fuel & VOM) Differences (M$/Year)					
Resource Category	**2005**	**2010**	**2015**	**2020**	**2025**
Coal	-290	-3,727	-8,379	-13,296	-20,709
Natural Gas & Oil	-2,708	-11,915	-19,882	-17,002	-14,364
Nuclear	0	-38	-533	-2,201	-3,713
Renewables	176	1,291	2,313	2,745	3,705
CH&P	171	925	1,726	2,623	3,834
Total	-2,650	-13,464	-24,755	-27,132	-31,247

There is a net reduction in the Balanced Case in generation investments with new coal and natural gas capacity additions being greatly reduced after 2010. Renewable capacity investments more than match coal and gas investment savings in the first decade until a balance point is reached about 2015.

Table 5.7: Investment Differences

Cumulative Generation Investment Differences (B$)					
Resource Category	**2005**	**2010**	**2015**	**2020**	**2025**
Coal	0.0	-9.1	-26.3	-74.1	-159.3
Natural Gas & Oil	0.0	-7.2	-37.8	-46.8	-49.7
Nuclear	0.0	0.0	0.0	0.0	0.0
Renewables	5.1	32.6	58.3	82.7	141.2
CH&P	0.6	3.4	6.4	10.0	14.5
Total	5.7	19.6	0.7	-28.1	-53.2

Fixed costs represent primarily the financial costs of the investment capital with a smaller portion (~10%) representing the annual fixed costs of plant operation. Again the avoidance of new coal and natural gas generation after 2010 more than offset the costs associated with the renewable technologies.

Table 5.8: Fixed Generation Costs Differences

Fixed Generation Cost (Capital & FOM) Differences (M$/Year)					
Resource Category	2005	2010	2015	2020	2025
Coal	0	-1,866	-5,393	-15,231	-32,760
Natural Gas & Oil	0	-1,296	-6,765	-8,371	-8,877
Nuclear	0	0	0	0	0
Renewables	907	5,735	10,249	14,539	24,874
CH&P	110	600	1,143	1,782	2,586
Total	1,017	3,173	-767	-7,281	-14,177

Transmission and Distribution (T&D) costs are approximately $95 billion per year presently and are predicted to rise to $127 billion by 2025 in the Reference Case. Much of this increase can be avoided if load growth is reduced. Thus the primary T&D impact of the Balanced Case comes from the fact that load only grows by 4.7% from 2005 to 2025, instead of by 41.9%. Further transmission savings result from CHP and DG resources placed closer to loads. There is also a reduction in interconnection costs since less capacity is added in the later years. To account for the fact that additional transmission lines will be needed for remote wind resources we have also included an additional cost for wind generation.

Table 5.9: T&D Cost Differences

Transmission & Distribution Cost Differences (M$/Year)					
Component	2005	2010	2015	2020	2025
Load Change Impacts	0	-4,928	-17,632	-24,996	-33,089
Plant Interconnect Costs	127	163	-1,489	-2,377	-3,053
Wind Transmission	110	704	1,261	1,790	2,985
Total T&D Differences	236	-4,060	-17,860	-25,583	-33,158

There are several reasons why the cost benefits presented for the Balanced Case are conservative. The Balanced Case does not count any of the following benefits or cost savings:

1. Avoided carbon emission costs.
2. Avoided additional costs for more stringent NOx, mercury and particulate emissions.
3. Fuel price reductions associated with reduced use of fossil fuels (e.g. natural gas).
4. Benefits of reduced price volatility associated with lesser use of fossil fuels.

5. Environmental and health benefits from reduced emissions, land use for generation and transmission, or water use for generation.
6. Environmental benefits associated with less fossil fuel extraction.
7. Jobs and competitive industry benefits associated with the promotion of new renewable technologies.

5.3 Environmental Impacts

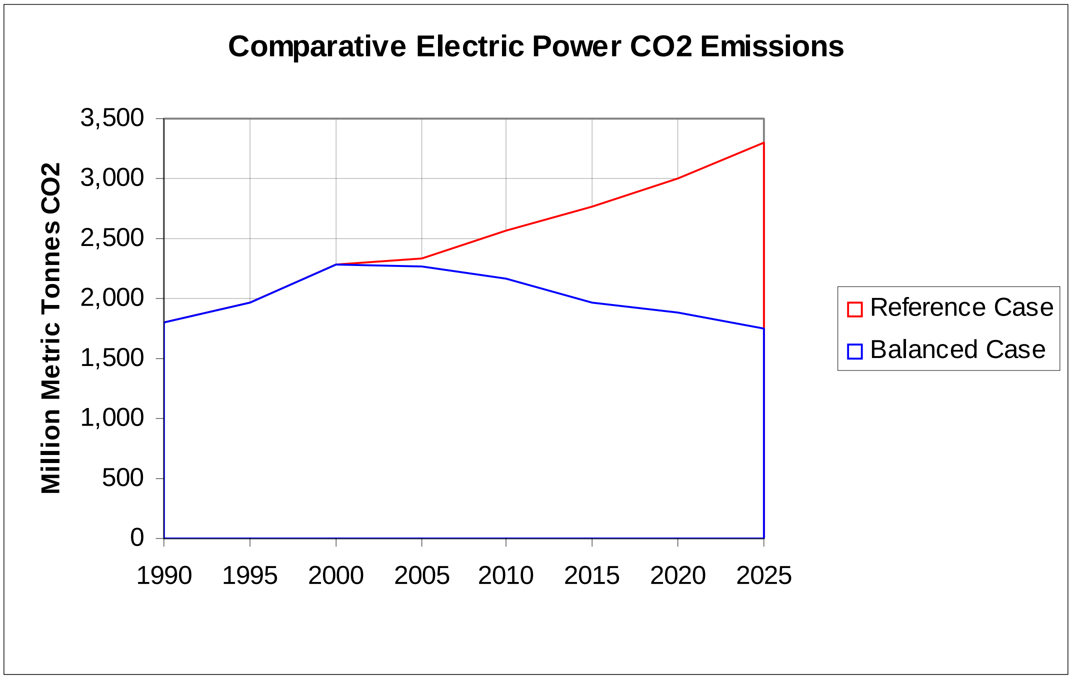
The major environmental impacts of the Balanced Case are the reduction in fossil fuel use along with the associated emissions and their related health impacts. Overall, the Balanced Case reduces CO_2 emissions by over 40% in 2025 compared to the Reference Case. The primary cause of these differences is the nearly equivalent percentage reduction in coal-fired generation, along with a similar reduction in natural gas generation.

Table 5.10: Emission Comparison Summary

Electricity Industry CO_2 Emissions (million metric tonnes)						
	2001	2005	2010	2015	2020	2025
Reference Case	2,227	2,322	2,571	2,760	2,989	3,299
Balanced Case	2,227	2,268	2,160	1,960	1,887	1,756
Difference	0	-54	-411	-800	-1,102	-1,543
Percent Difference	0%	-2.3%	-16.0%	-29.0%	-36.9%	-46.8%

The table and graph below show the long-term trend in CO_2 emissions from electrical generation. The Reference Case emissions are 82% above 1990 CO_2 levels by 2025, whereas the Balanced Case emissions in 2025 are 3% below 1990 emissions, and 23% below 2000 emissions.

Figure 5.6: Comparative CO_2 Emissions



Note: Combined Heat and Power (CHP) emissions are not included in either case.

There are several pending legislative efforts to further reduce mercury and NOx emissions. We were not able to incorporate those calculations within this study. Because of the reduced level of fossil fuel use in the Balanced Case the costs of such controls would be less than for the Reference Case, but we have not calculated nor credited those benefits in this report.

6. Further Research and Analysis

There are a numbers of aspects of this analysis that could be refined and extended. Some of the topics that would be appropriate for further research include the following:

- Analysis on a detailed regional basis.
- Incorporation of innovation and technological change.
- Detailed costing including emission controls and avoided emission control costs in the Balanced Case.
- Detailed simulation of the dispatching of generating resources to meet loads.
- Analysis of the impact of the Balanced Case upon fuel markets and prices.
- Assessment of risks including exposure of the two cases to price volatility, long-term price uncertainty, fuel supply disruptions, and environmental risks.

The results of the broad brush analysis presented here are sufficient, however, to indicate that the business-as-usual course should be changed immediately, and that further research and analysis of "Balanced Cases" would be worthwhile.

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Appendix A – Reference Case Tables

Reference Case **Demand by Sector (TWh)**	2001	2005	2010	2015	2020	2025
Residential	1,203	1,319	1,428	1,531	1,641	1,747
Commercial/Other	1,197	1,296	1,480	1,653	1,828	2,003
Industrial	964	1,030	1,120	1,216	1,310	1,422
Transportation	22	24	26	29	32	35
Total Sales	3,386	3,669	4,055	4,429	4,811	5,207
Required Generation (TWh)	3,745	4,072	4,483	4,877	5,296	5,733
Required Capacity (GW)	851.7	975.7	965.6	1,038.3	1,120.7	1,218.4

Reference Case **Capacity (GW)**	2001	2005	2010	2015	2020	2025
Coal Steam	310.6	308.9	310.3	321.5	353.5	412.3
Oil Steam	38.2	36.4	30.0	29.0	28.6	27.3
Nat Gas Steam	96.8	92.4	76.1	73.6	72.5	69.2
Nat Gas Comb Cycle	65.5	154.5	160.0	191.7	217.3	235.2
Oil CT	38.8	38.6	34.9	34.6	33.9	33.1
NG CT	63.2	101.1	101.6	123.4	135.4	147.3
Nuclear Power	98.2	99.8	100.6	102.1	102.6	102.6
Pumped Storage/Other	19.9	20.3	20.3	20.3	20.3	20.3
Fuel Cells	0.0	0.0	0.1	0.1	0.1	0.1
Hydro	78.1	78.6	78.7	78.7	78.7	78.7
Renewables (non-hydro)	12.5	15.6	18.7	22.5	27.2	31.4
Distributed Generation	0.0	0.0	0.5	2.4	7.6	12.4
Non-Utility CH&P	25.9	28.7	33.1	37.3	42.1	47.4
Installed Capacity	847.7	974.9	964.7	1037.4	1119.7	1217.3
Effective Capacity	847.7	974.9	964.7	1037.4	1119.7	1217.3

Reference Case

Generation (TWh)	2001	2005	2010	2015	2020	2025
Coal Steam	1,883	2,033	2,235	2,352	2,593	3,008
Oil Steam	102	45	48	93	70	65
Nat Gas Steam	129	57	61	117	88	83
Nat Gas Comb Cycle	398	563	711	808	984	970
Oil CT	17	17	15	15	15	15
NG CT	28	44	44	54	59	65
Nuclear Power	769	791	794	812	816	816
Pumped Storage/Other	(8)	(9)	(9)	(9)	(9)	(9)
Fuel Cells	0	0	0	0	0	0
Hydro	214	303	304	304	305	305
Renewables (non-hydro)	45	76	96	116	138	156
Distributed Generation	0	0	0	1	3	5
Non-Utility CH&P	154	176	207	236	270	305
Total Generation	3,730	4,096	4,507	4,900	5,331	5,784

Reference Case

Renewable Capacity (GW)	2001	2005	2010	2015	2020	2025
Geothermal	2.88	2.90	4.01	5.11	6.06	6.84
Municipal Solid Waste	3.38	3.66	3.92	3.92	3.95	3.95
Wood and Other Biomass	1.79	1.89	2.20	2.31	3.04	3.74
Solar Thermal	0.33	0.42	0.43	0.47	0.49	0.52
Solar Photovoltaic	0.02	0.06	0.15	0.24	0.32	0.41
Wind	4.15	6.68	8.01	10.48	13.39	15.99
Renewable (non-hydro)	12.54	15.62	18.73	22.53	27.25	31.44

Reference Case

Fossil Generation Emissions	2001	2005	2010	2015	2020	2025
CO2 (million metric tonnes)	2,227	2,322	2,571	2,760	2,989	3,299
Mercury (tons) *	49.1	50.1	52.2	52.6	53.6	54.4

* Mercury emissions do not incorporate current proposals for more stringent controls.

Appendix B – Balanced Case Tables

Balanced Case **Demand by Sector (TWh)**	2001	2005	2010	2015	2020	2025
Residential	1,203	1,299	1,306	1,300	1,306	1,303
Commercial/Other	1,197	1,271	1,315	1,331	1,367	1,391
Industrial	964	1,015	1,025	1,032	1,038	1,051
Transportation	22	24	26	29	32	35
Total Sales	3,386	3,610	3,673	3,692	3,743	3,780
Required Generation (TWh)	3,752	4,035	4,081	4,078	4,133	4,175
Required Capacity (GW)	808.1	861.6	876.6	881.2	893.3	902.3

Balanced Case **Capacity (GW)**	2001	2005	2010	2015	2020	2025
Coal Steam	310.6	305.8	273.8	239.8	221.8	206.8
Oil Steam	38.2	36.4	29.8	27.0	23.3	19.3
Nat Gas Steam	96.8	92.2	74.6	62.4	46.5	27.0
Nat Gas Comb Cycle	65.5	154.5	153.9	151.3	150.8	150.3
Oil CT	38.8	38.6	34.9	34.5	33.2	29.6
NG CT	63.2	101.1	95.1	94.7	122.4	152.8
Nuclear Power	98.2	99.8	100.1	95.4	74.9	55.9
Pumped Storage/Other	19.9	20.3	20.3	20.3	20.3	20.3
Fuel Cells	0.0	0.0	0.1	0.1	0.1	0.1
Hydro	78.1	78.4	78.9	79.0	79.0	79.2
Renewables (non-hydro)	12.5	19.3	42.2	64.6	86.9	130.9
Distributed Generation *	0.0	0.0	0.5	2.4	7.6	12.4
Non-Utility CH&P	25.9	29.4	36.9	44.7	53.6	64.2
Installed Capacity	847.7	975.8	941.1	916.2	920.5	948.8
Effective Capacity	847.7	970.0	927.4	894.3	890.7	903.0

* Note that a portion of the CH&P capacity as well as some renewables such as photovoltaics can be considered as distributed generation.

Balanced Case

Generation (TWh)	2001	2005	2010	2015	2020	2025
Coal Steam	1,883	2,012	1,972	1,754	1,627	1,509
Oil Steam	102	32	22	23	26	23
Nat Gas Steam	129	40	27	26	26	16
Nat Gas Comb Cycle	398	535	452	508	667	711
Oil CT	17	16	12	14	17	16
NG CT	28	41	33	37	63	85
Nuclear Power	769	791	791	759	596	445
Pumped Storage/Other	(8)	(9)	(9)	(9)	(9)	(9)
Fuel Cells	0	0	0	0	0	0
Hydro	214	303	305	306	306	307
Renewables (non-hydro)	45	96	233	362	451	631
Distributed Generation	0	0	0	1	3	5
Non-Utility CH&P	154	182	238	295	359	435
Total Generation	3,730	4,038	4,077	4,076	4,133	4,174

Balanced Case

Renewable Capacity (GW)	2001	2005	2010	2015	2020	2025
Geothermal	2.88	3.09	4.18	5.35	6.53	8.88
Municipal Solid Waste	3.38	3.65	3.89	4.03	4.17	4.44
Wood and Other Biomass	1.79	3.38	12.04	19.02	26.01	39.31
Solar Thermal	0.33	0.36	0.49	0.59	0.68	0.87
Solar Photovoltaic	0.02	0.12	0.58	1.48	2.38	4.18
Wind	4.15	8.68	21.03	34.08	47.14	73.25
Renewable (non-hydro)	12.54	19.27	42.21	64.56	86.90	130.93

Balanced Case

Fossil Generation Emissions	2001	2005	2010	2015	2020	2025
CO2 (million metric tonnes)	2,227	2,268	2,160	1,960	1,887	1,756
Mercury (tons) *	49.1	49.6	46.1	39.3	33.6	27.3

* Mercury emissions do not incorporate current proposals for more stringent controls.