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Beyond Business as Usual

Investigating a Future without Coal and Nuclear Power in the U.S.

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Executive Summary

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The electric power industry in the U.S. is at a crossroads. The nation is struggling to develop an effective mechanism to combat climate change. At the same time we are poised to spend hundreds of billions on new pollution controls at coal-fired power plants, and these controls will do nothing to reduce CO_2 emissions. Carbon capture and sequestration at coal plants is still in the demonstration stage and cost estimates are escalating. The nation is also running headlong toward a new generation of nuclear plants. However, cost estimates for these plants are skyrocketing – again – and we still have not established a central repository for radioactive waste. This waste remains stored at nuclear plants across the country. The risk, cost and complexity of a future based on coal and nuclear power look increasingly daunting.

This study investigates a long-term, national strategy to transition away from coal and nuclear electricity and toward increased efficiency and renewable energy. The focus of the study is on what resources would be likely to replace coal-fired and nuclear generation, where they are located, and what this resource mix would cost relative to a "business as usual" energy future.

The study finds that a future built on more efficient use of electricity and development of the nation's renewable resources would pose modest near-term costs but would cost less than business as usual over the long term. Specifically, we find that by 2050:

- Aggressive investments in more efficient technologies in every sector could reduce electricity use by 15% from today's requirements, or over 40% from a "business as usual" scenario. Utilities in several states are already achieving savings at this level.
- The U.S. could feasibly retire the entire fleet of coal-fired plants and build no new coal-fired generation, rather than burning more coal. At the same time, we could retire over a quarter of the nation's nuclear capacity.
- Tens of billions could be saved in avoided pollution control costs at the coal-fired plants retired between 2010 and 2020.
- Electric sector emissions of carbon dioxide would fall by 82% relative to predicted 2010 levels and by 83% relative to 2005 levels.
- Renewable energy, including wind, solar, geothermal and biomass, could increase throughout the nation, eventually providing half of the nation's electricity requirements.
- Natural gas use in the electric sector would grow more slowly than under business as usual, leaving more gas for clean cars and other uses.
- There would be modest near-term costs of the scenario, but over the long term it would cost less than a business as usual energy future.

Business as Usual

The Business as Usual scenario, or Reference Case, looks like today's electric grid, just larger. We base our Reference Case on the U.S. Energy Information Administration's 2010 Annual Energy Outlook (AEO), a forecast extending out 25 years. We extend the same assumptions out to 2050 for our Reference Case. Based on AEO 2010, the U.S. will be consuming nearly 50% more electricity in 2050 than it consumes today. To meet this demand, the U.S. coal fleet will expand by 10% (22,000 MW, atop today's 320,000 MW) and increase generation markedly, providing 37% more energy than today. Gas, nuclear, and biomass generation would increase significantly as well.

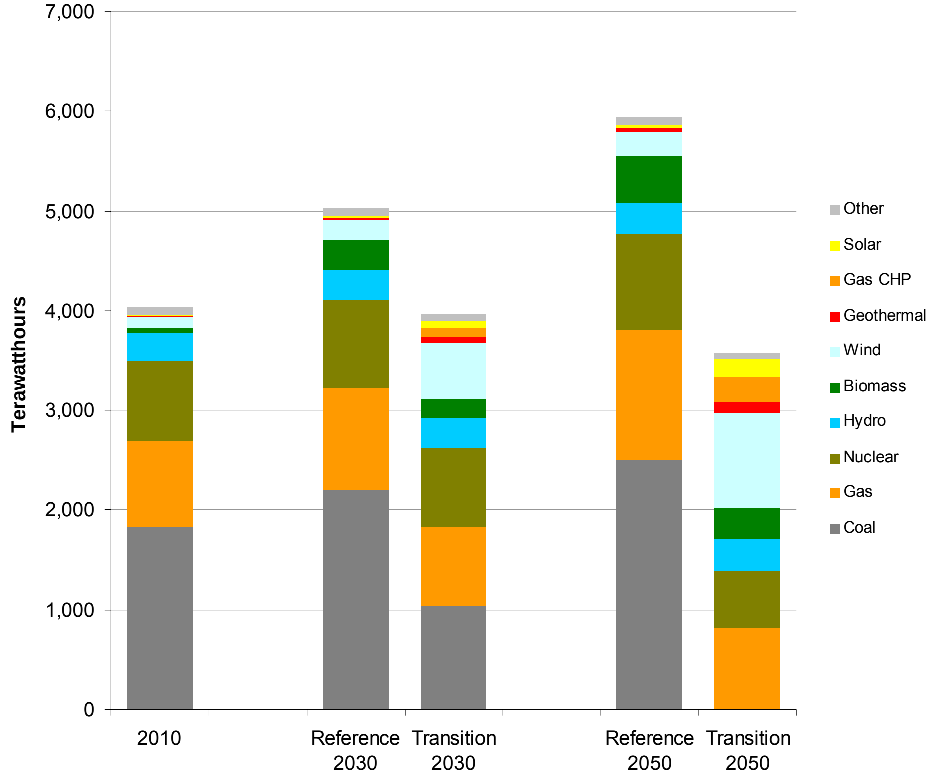
Beyond Business as Usual - The Transition Scenario

In the Transition Scenario we retire all coal-fired capacity in the country and 28% of the nuclear capacity by 2050. The country's massive Midwestern wind resource is tapped, and that energy is used primarily in the Midwest. The South Central wind resource is developed and used there and in the Southeast. The Northeast and California import less from other regions than they do today, and the Northwest continues to export electricity from its low-cost renewable resources. Solar energy is developed across the country and especially in the Southwest. The country's biomass and geothermal resources are also developed. All of these new resources have a cost, and we include these costs in this analysis.

The key to achieving this clean energy future is aggressive and sustained investment in energy efficiency. We assume that a concerted, nation-wide efficiency effort brings energy savings levels across the nation to the level that the most aggressive states are achieving now. Technologies emerging from the lab today would allow us to continue pushing electricity use down throughout the study period, even in the face of strong economic growth.

Peak loads are met easily in the Transition Scenario, aided in the near term by the current capacity surplus. Power system operators are able to manage large amounts of variable generation (like wind and solar), because regional power systems have become much more flexible. Much of today's most inflexible capacity – coal and nuclear units – is gone. Gas-fired plants follow wind generation, filling in during periods of low wind (although the use of gas is significantly lower than in the Reference Case). Robust demand response programs allow customers to shift demand easily to off-peak periods, and larger electricity balancing areas and upgraded transmission systems also aid in managing variable generation.

At a national scale, the Transition Scenario looks something like the figure below (ES-1). Through 2030, total demand stays fairly flat, and increasing use of renewable energy picks up where coal plant retirements leave off. In contrast, electricity use in the Reference Case grows significantly. As renewable energy becomes more cost effective in later decades, more is added, including wind, solar, biomass and geothermal. All of these technologies are already commercial – the Transition Scenario is not dependent on technologies still under development. An increasing number of boilers and combustion turbines generate both heat and electricity in Combined Heat and Power (CHP) plants. All of these incremental improvements allow the U.S. gradually to retire all of its coal plants and over a quarter of its nuclear plants.



ES-1. CO2 Resource and Fuel Mix in the Reference and Transition Scenarios

Social Benefits and the Cost of the Transition

The Transition Scenario provides very large emission reductions. Figure ES-2 shows CO_2 emissions from the electric power sector in the Reference and Transition Cases (in million short tons). In the Reference Case, annual electric sector CO_2 emissions *increase* by nearly 770 million tons (32%) between 2010 and 2050. In the Transition Scenario they *fall* by 2 billion tons or 82%. (They fall by 83% relative to 2005 levels.) In total, the Transition Scenario prevents 55 billion tons of CO_2 from entering the atmosphere relative to the Reference Case. Note that there is no carbon policy in our Reference Case. This is consistent with the Energy Information Administration's AEO 2010 Reference Case. The Administration assesses electric sector policy proposals, including carbon reduction policies, by comparing them to a future with no carbon policy.

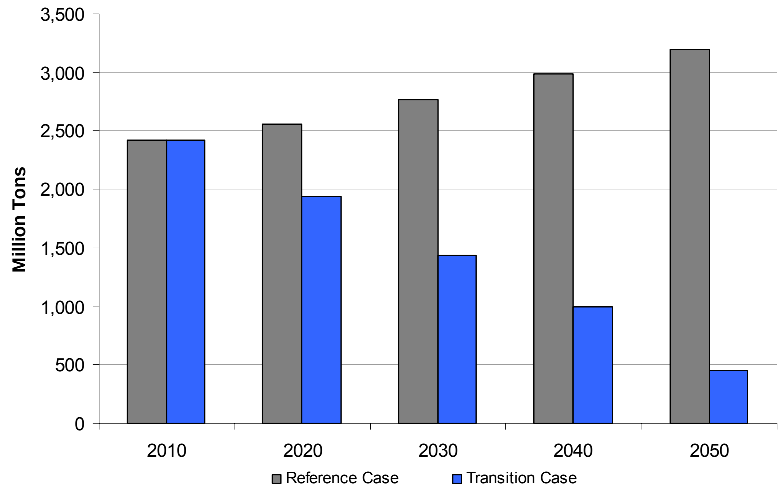


Figure ES-2. CO2 Emissions in the Reference and Transition Scenario

Emissions of SO_2, NO_x, and mercury fall in the Reference Case, as new emission controls are installed at coal-fired plants, but they fall much more in the Transition Scenario. Emissions of NO_x fall by 60% over the study period and emissions of SO_2 fall by 97%. Electric sector mercury emissions fall by nearly 100%. Water consumption at coal-fired and nuclear power plants would *grow* by an estimated 440 billion gallons in the Reference Case, and it would *fall* by over 710 billion gallons in the Transition Scenario.

To assess the net costs of the Transition Scenario, we developed cost and performance assumptions for each resource type, based on an extensive review of the current literature. We used the AEO 2010 costs for very few technologies, primarily because these data do not appear to account for recent escalations in construction and materials costs. We then compared the cost of the Transition Scenario to that of the Reference Case to determine the incremental cost of the transition.

Table ES-3 below shows the net annual costs of the Transition Scenario in selected years of the study period. Costs are shown in millions of 2009 dollars. Negative numbers, in parentheses, indicate that the Transition Scenario provides savings relative to the Reference Case. "Incremental transmission" represents the annual cost of increasing transfer capabilities between regions to accommodate the increased power exchange in the Transition Scenario. "Avoided emission control" represents the cost of emission controls avoided by retiring coal-fired plants rather than installing new emission controls during the period 2010 through 2020.

The cost of the Transition Scenario is modest in the near term, and it falls over time such that the scenario saves money relative to the Reference Case in later years. Savings are achieved over the long term for three main reasons. First, over time energy efficiency reduces generation levels relative to the Reference Case by larger and larger amounts, and efficiency costs less than supply-side resources. Second, technology improvements and market maturation reduce the cost of renewable technologies over time. There is less room for cost reductions in coal, gas and nuclear plants, because these are mature technologies. And finally, natural gas becomes very expensive in the later years of the study, and much less gas is burned in the Transition Scenario than in the Reference Case.

The total cost of about $10 billion in the year 2020 is quite small relative to total electric sector costs. The incremental cost of 0.25 cents/kWh in 2020 (2.5 $/MWh) is about 2.5% of the current average retail price of electricity of 10 cents/kWh. For a typical residential consumer, purchasing about 900 kWh per month, this cost increase would amount to about $2.20 per month. By 2040, the same customer would be *saving* about $1.50 per month and by 2050, saving nearly $3.90 per month.

Table 1. Net Cost of the Transition Scenario, Relative to Reference Case (million 2009$)

	2020	2030	2040	2050
Cost of Generation	($1,000)	($35,000)	($85,000)	($130,000)
Wind Integration Costs	$330	$1,600	$2,900	$3,900
Energy Efficiency	$14,000	$48,000	$79,000	$110,000
Incremental Transmission	$800	$1,600	$2,300	$3,100
Avoided Emission Control	($4,500)	($4,500)	($4,500)	$0
Total Net Cost	$9,630	$11,700	($5,300)	($13,000)
Total Net Cost (¢/kWh)	0.25	0.34	(0.17)	(0.43)

We would characterize the costs of the Transition Scenario as modest, particularly in the context of uncertainties in this sort of long-term analysis, and relative to the benefits of the Transition Scenario. We have not included, for example, the benefits of reducing significant climate change risks and damages or the public health benefits associated with decreased pollution from power plants. For example, a recent National Academies study estimated the *annual* health impacts of power generation in the U.S. at $62 billion in 2005.

In considering the scenario laid out here relative to other proposals for the electric power sector, it is important to include all of the benefits the scenario provides.

- Electric sector CO_2 is reduced by 82% relative to the 2010 levels predicted in AEO 2010.
- Emissions of other pollutants fall dramatically, with near 100% reductions in SO_2 and mercury.
- The environmental impacts and safety risks of coal mining are eliminated.
- The amount of radioactive waste produced in the U.S. each year falls rather than rises, as does the risk of nuclear accidents.
- The power sector uses less natural gas, leaving more for clean cars and other uses.

Our hope is that this report contributes to very careful consideration of the different paths the U.S. power sector could take.