OVERVIEW OF BCSE'S ENERGY MARKETS ANALYSIS USING THE NATIONAL ENERGY MODELING SYSTEM (SAIC-NEMS)

SAIC ENERGY

One Source, Innovative Solutions

ENERGY INFORMATION SOLUTIONS DIVISION

McLean, Virginia

September 22, 2008

SAIC

From Science to Solutions™

PRESENTATION OVERVIEW

This presentation provides an overview of:

- Introduction and Basis for Study
- The National Energy Modeling System (SAIC-NEMS)
- Key BCSE Project Assumptions
- Project Results

PROJECT INTRODUCTION

In August 2008, SAIC assisted the Business Council for Sustainable Energy (BCSE) with an energy policy analysis using a modified version of the U.S. Department of Energy (DOE), Energy Information Administration's (EIA) National Energy Modeling System (BCSE-NEMS).

The purpose of the analysis was to model the impacts of accelerating the deployment of existing clean energy technology – such as renewable energy and energy efficiency – in the period between 2009 and 2020 (coverage to 2030 included).

The Council used EIA's Annual Energy Outlook 2008 as the reference case for the analysis.

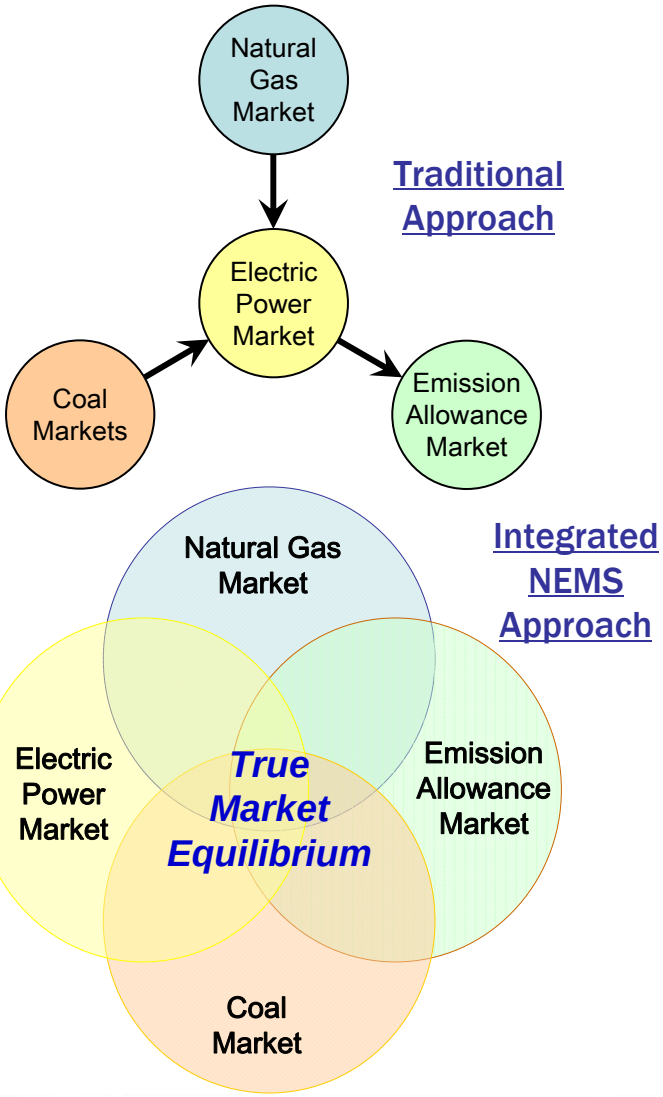
(Please note that EIA bears no responsibility for these model runs.)

NEMS INTRODUCTION

- NEMS is used by the Energy Information Administration (EIA) to provide U.S. energy market and infrastructure forecasts out to 2030
- EIA uses NEMS to provide its annual projections primarily through its *Annual Energy Outlook* publication
  - AEO projections are used by analysts and planners in other federal agencies and outside organizations
- EIA also uses NEMS and the *AEO* to respond to Congressional requests related to energy and environmental legislation (such as GHG) and other issues

NEMS BACKGROUND INFORMATION AND MODELING APPROACH

- NEMS - Comprehensive Long-Term Model of U.S. Energy Markets – Projections to 2030
  - US EIA's *Annual Energy Outlook*
- Achieves a supply/demand balance in end-use demand regions (defined as the 9 Census divisions) by solving for the prices of each energy product that will balance the quantities producers are willing to supply with the quantities consumers wish to consume.
- Reflects market economics, industry structure, supply and demand technologies, and existing energy policies and regulations that influence market behavior.
- This model that can comprehensively assess market impacts related to imposed CO_2 constraints.
  - Energy production, imports, conversion, consumption, prices, and emissions.
  - Long Term, **2030** (Not a short-term forecasting model)
  - **Regulated** and **deregulated** markets.
  - **Penetration** of conventional & advanced energy technologies.
  - Includes detailed simulations of fossil-fuel **supply, distribution, and conversion** technologies.
- The AEO2008 version of NEMS is the most current available from EIA – last updated in May 2008.

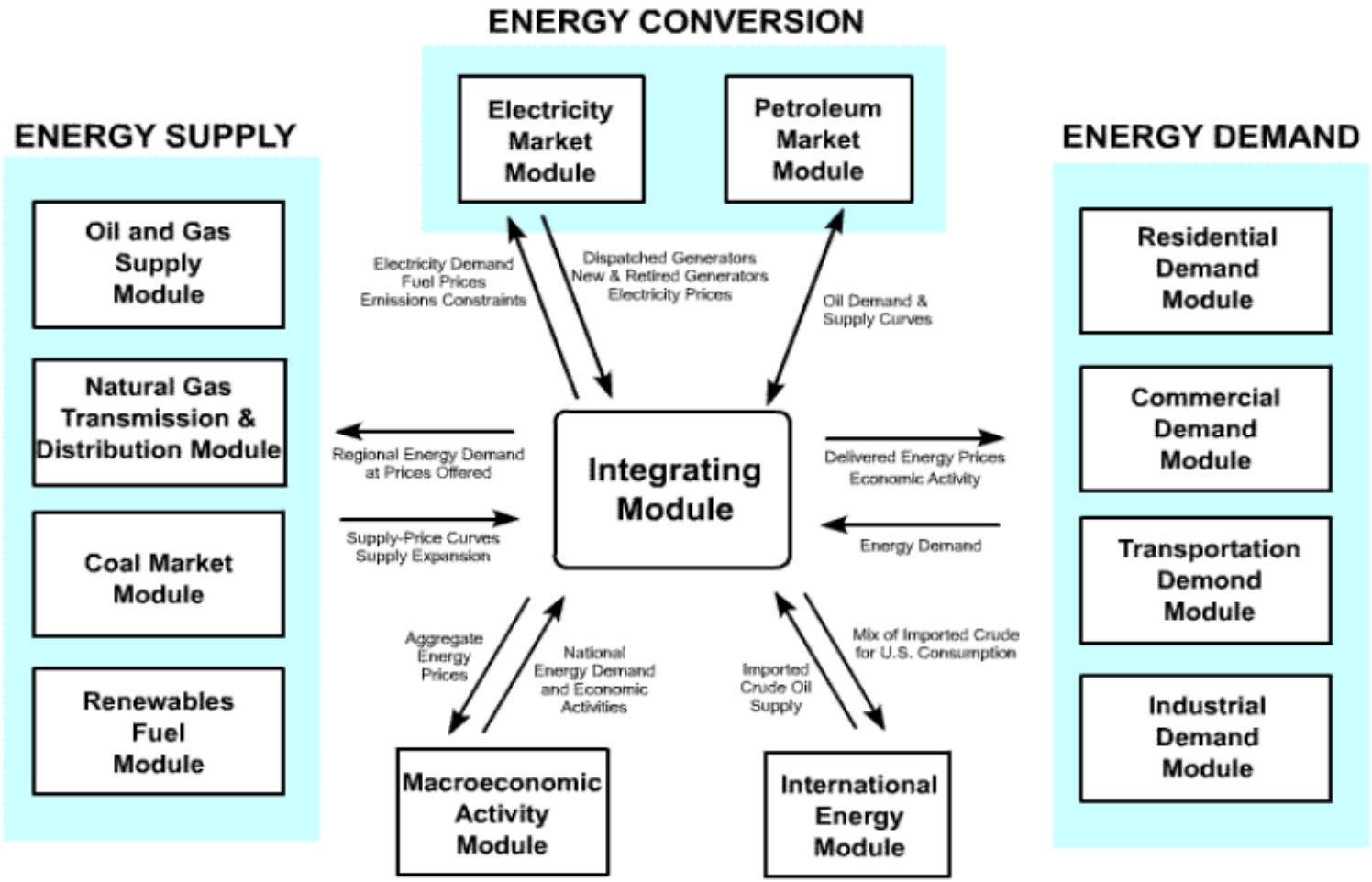


Legislated Polices included in NEMS

- This project was executed using the most up-to-date 2008 version of NEMS as well as the version of the model that EIA modified for the S.2191 assessment
- Standards and Policies Accounted For (among others):
  - Energy Independence and Security Act of 2007 (HR6)
  - Emissions limits (e.g., NOx, SO_2, mercury), are based on Federal and State laws and regulations in effect on or before October 31, 2007.
  - Energy Policy Acts of 1992 (EPACT92) and 2005 (EPACT05) tax credits, among other provisions, are also accounted for in the version of NEMS used for this project, including *an investment tax credit for the construction and development of new or repowered coal-fired generating projects and nuclear projects*.
  - Clean Air Act Amendments of 1990 (CAAA90)
  - The Clean Air Interstate Rule[1] (CAIR) and Clean Air Mercury Rule (CAMR) — promulgated by the EPA in March 2005 and published in the *Federal Register* as final rules in May 2005 — limit emissions SO_2, NOx, and mercury from power plants in the United States.

[1] CAIR will permanently cap emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx) in the eastern United States. CAIR achieves large reductions of SO2 and/or NOx emissions across 28 eastern states and the District of Columbia. When fully implemented, CAIR will reduce SO2 emissions in these states by over 70 percent and NOx emissions by over 60 percent from 2003 levels.

NEMS MODELING APPROACH: MODEL STRUCTURE



BCSE PROJECT ASSUMPTIONS

The BCSE Scenario incorporates the following assumptions into BCSE-NEMS:

- Residential, Commercial and Industrial demand sectors incorporate *high technology* assumptions developed by EIA that specify earlier availability, lower costs, and/or higher efficiencies for more advanced equipment
- National Renewable Portfolio Standard (NRPS) is implemented, which requires electricity providers to meet specified renewable resource targets -- based on the 2007 EIA study "Impacts of a 15-Percent Renewable Portfolio Standard" as requested by Senator Jeff Bingaman
- Updated cost and performance values for all power generation technologies – Capital and operating costs, capacity factors, efficiencies, construction lead times, and commercialization years based on a 2008 Lazard assessment
- Updated world oil price estimate based on NYMEX WTI futures pricing through 2016 while maintaining the 2016 price for through 2030 with adjustment for the projected inflation rate.

BCSE PROJECT ASSUMPTIONS

DEMAND-SIDE HIGH TECHNOLOGY ASSUMPTIONS:

- **Residential:** All new construction is assumed to meet Energy Star specifications after 2016.
- **Commercial:** Building shell efficiencies are assumed to improve 25 percent more than in the reference case after 2008. Existing building shells, therefore, increase by 6.25 percent relative to 2003 levels and new building shells by 8.75 percent relative to their efficiency in 2003 by 2030.
- **Industrial:** The rate at which biomass byproducts will be recovered from industrial processes increases from 0.1 percent per year to 0.7 percent per year. The availability of additional biomass leads to an increase in biomass-based cogeneration. Changes in aggregate energy intensity result both from changing equipment and production efficiency and from changes in the composition of industrial output.

BCSE POWER SECTOR ASSUMPTIONS

NATIONAL RENEWABLE PORTFOLIO STANDARDS

- The AEO2008 Reference Case represents various state-level policies generally referred to as Renewable Portfolio Standards (RPS). These policies vary significantly among states, and because of the complexity of the various requirements, the regional target aggregation, and nature of some of the limitations, measurement of compliance is assumed to be approximate.
- In lieu of the above, the BCSE Scenario models the implementation of a National RPS, which would require electricity providers to gradually increase the amount of renewable energy sources such as wind, solar, bioenergy, and geothermal in their power supplies. This scenario uses the modeling assumptions for EIA's Assessment of a National RPS as Requested by Senator Jeff Bingaman in May 2007: "Impacts Of A 15-Percent Renewable Portfolio Standard" as Completed by EIA In June 2007.
- The report designated as "**BCSE Energy Analysis – Preliminary Summary Report**" contains the complete BCSE National RPS assumptions (See Tables 1 and 2)

BCSE PROJECT ASSUMPTIONS

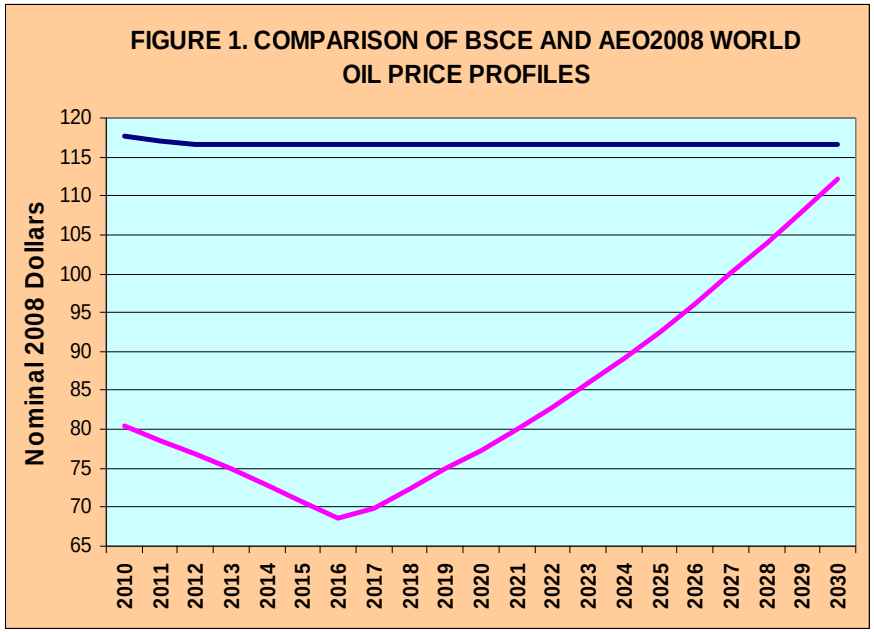
BCSE POWER SECTOR ASSUMPTIONS:

- Under BCSE guidance, SAIC specified the calendar year of first commercial operation for the following generating technologies:
  - Nuclear Power: 2021
  - IGCC with Carbon Capture and Sequestration (CCS): 2021
  - NGCC with Carbon Capture and Sequestration (CCS): 2021
- BCSE provided alternate data inputs to replace the following technology characterizations used by NEMS in the AEO2008 Reference Case:
  - Overnight Capital Costs
  - Fixed Operating and Maintenance (O&M) Costs
  - Variable Operating and Maintenance (O&M) Costs
  - Technology Heat Rates
  - Capacity Factors
  - Construction Lead times
- The report designated as "**BCSE Energy Analysis – Preliminary Summary Report**" contains the complete BCSE power sector assumptions (See Attachments 1 – 3)

BCSE PROJECT ASSUMPTIONS

UPDATED WORLD OIL PRICE ESTIMATE :

- SAIC used the NYMEX WTI futures pricing through 2016 with adjustment for the inflation rate implied in government inflation-protected securities
- For NYMEX pricing, BCSE recommended using the last trade date before the run, adjusted to real $/barrel. The NYMEX curve for crude goes out to 2016 and appears to be about flat in nominal terms the last few years. BCSE recommended using the 2016 price for the rest of the forecast, and adjusting it downward for inflation, using the rate implied in inflation-protected securities.
- The implied inflation rate was based on data provided by BCSE in a spreadsheet called "implied inflation from TIPS."



BCSE PROJECT ASSUMPTIONS

AEO2008 AND BCSE ANALYSIS ACCOUNTING OF LNG AND SHALE RESOURCES

- LNG: Import of LNG is handled by NEMS
  - Liquefied natural gas (LNG) imports into North America are represented for the four existing facilities as of 2004, seven potentially new generic liquefied natural gas import regions directly into the United States (2004 and beyond), a potential import point in the Bahamas, potential import points in eastern and western Canada, and in western Mexico (if destined for the United States).
  - Any new LNG facilities built since 2004 or under construction are forced in the model as planned expansions.
  - LNG exports from Alaska are included, as well as three import/export border crossings at the Mexican border. The decision to add LNG regasification capacity is set at the beginning of each forecast year based on a net present value (NPV) calculation using expected future domestic gas prices, current cost estimates, future world gas price estimates, and estimates of risks associated with the siting of a terminal. The primary output of this decision is the current regasification capacity level that is used to set the LNG import levels in a current forecast year.
- Shale: Gas and Oil recovery from shale is handled by NEMS
  - NEMS' Oil and Gas Supply Module (OGSM) encompasses domestic crude oil and both conventional and unconventional natural gas supply. Unconventional gas recovery (UGR) includes recovery from low permeability sandstone and shale formations, and coalbeds. Unconventional oil includes production of synthetic crude from oil shale (syncrude).

BCSE PROJECT ASSUMPTIONS: Total Energy Consumption Relative to Reference Case

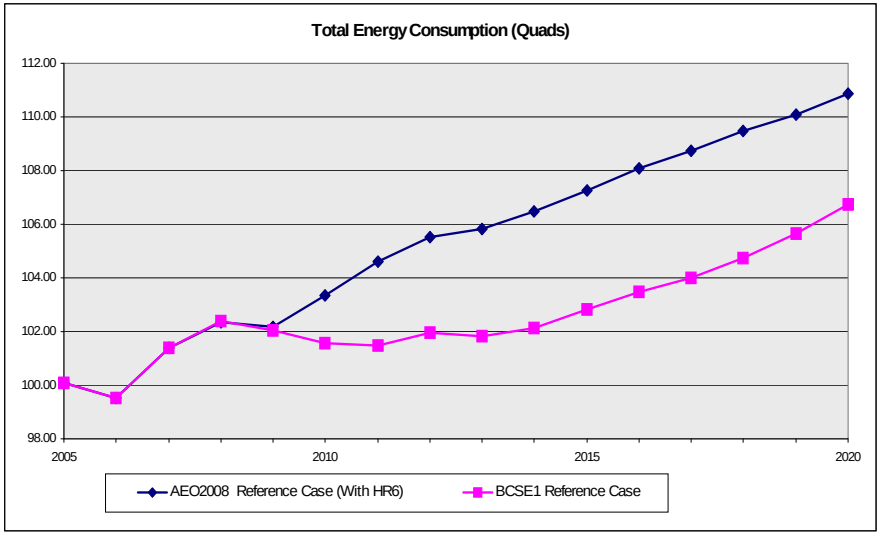
- Total domestic energy consumption decreases annually under the BCSE Scenario relative to the Reference Case by approximately 3.7 percent in 2020, and 4.7 percent in 2030. Energy demand reductions for each sector are as follows:

ENERGY DEMAND REDUCTION BY SECTOR COMPARED WITH REFERENCE CASE

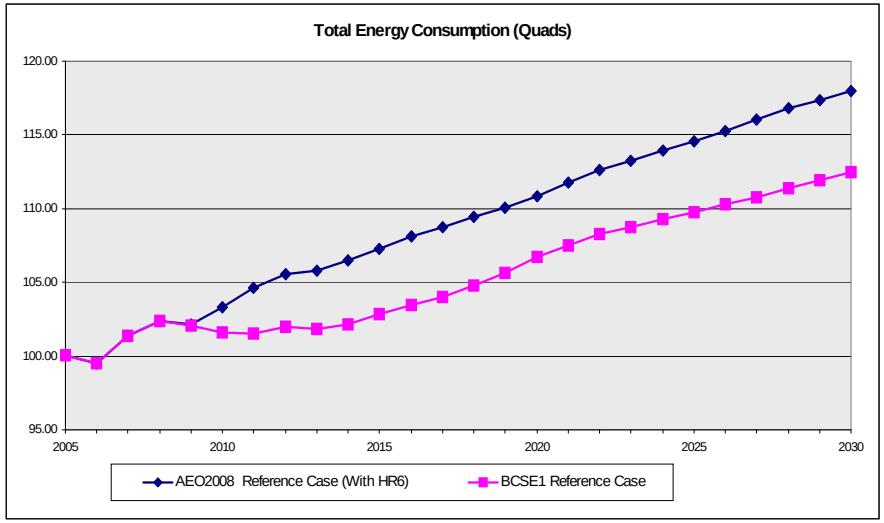
DEMAND SECTOR	YEAR	
	2020	2030
Residential Sector	3.2	6.1
Commercial Sector	5.2	8.7
Industrial Sector	3.5	5.2
Power Sector	5.2	8.6
Transportation Sector	3.2	0

BCSE PROJECT ASSUMPTIONS: Total Energy Consumption Relative to Reference Case

2009 TO 2020

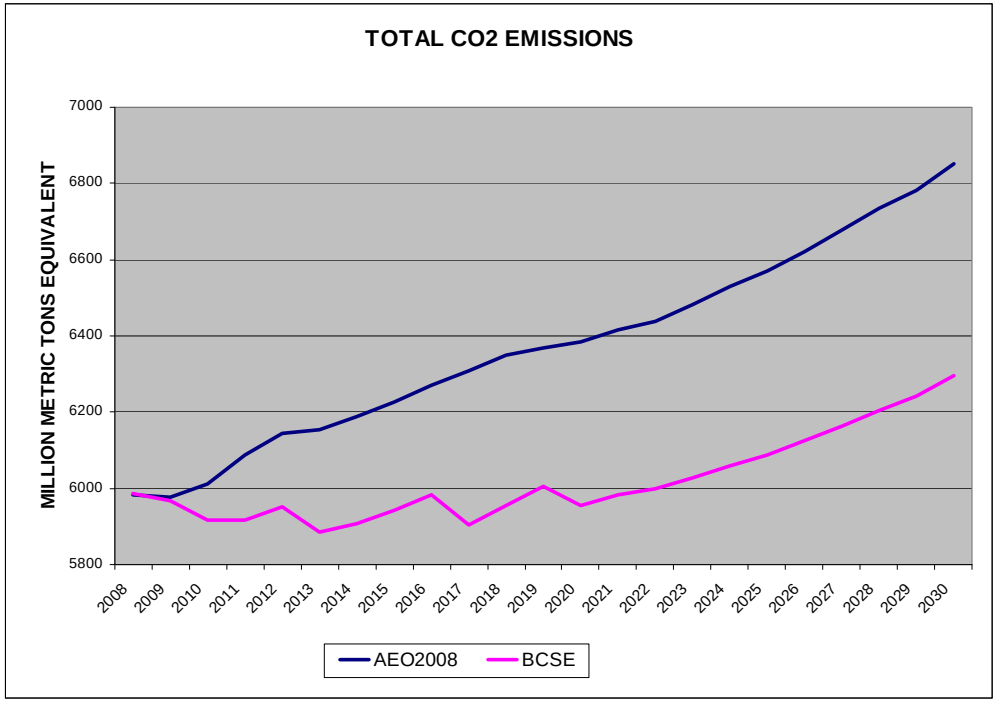


2009 TO 2030



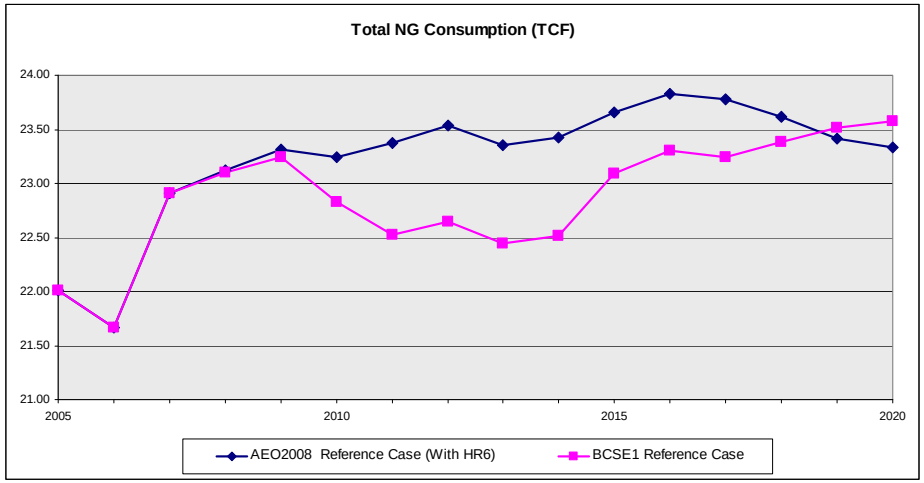
BCSE PROJECT RESULTS: Total Carbon Dioxide Emissions Relative to Reference Case

- The BCSE scenario results in a significant reduction in CO2 emissions relative to the Reference Case due to reduced energy demand, increased use of renewable resources, and greater consumption of natural gas versus coal for electricity generation.
- Total cumulative emissions reduction from 2008 through 2020 is projected to be 3.2 billion metric tons of CO2 or about 4% less than projected for the Reference Case.
- Cumulative emissions reduction from 2008 through 2030 is projected to be 8.1 billion metric tons of CO2 or about 5.5% less than projected for the Reference Case.
- The annual CO2 emissions reduction in 2020 is projected to be 7.2% and 8.8% in 2030.

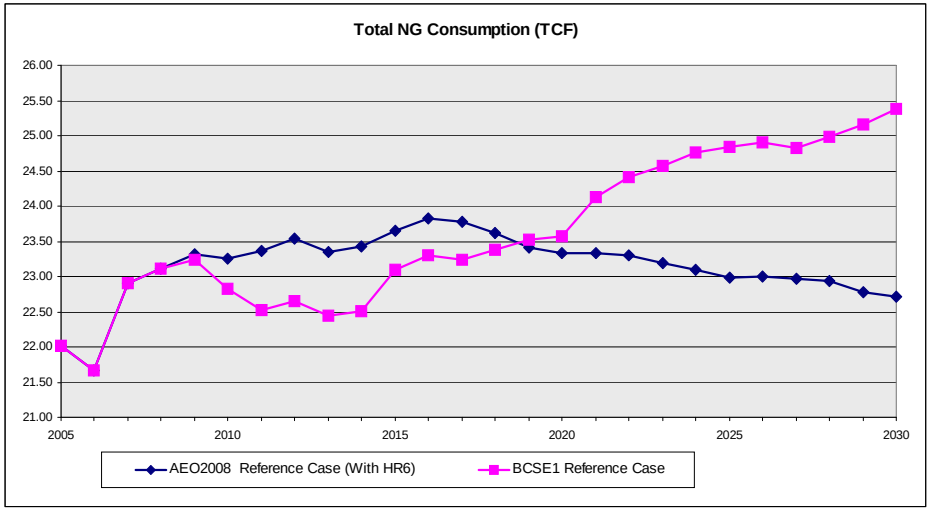


BCSE PROJECT RESULTS: Natural Gas Demand and Prices Relative to Reference Case

- Total cumulative natural gas consumption decreases by 6 trillion cubic feet relative to the Reference Case for the period from 2008 to 2019;
  - This represents 2% of the projected total natural gas consumed over this time frame for the reference case.
  - Average annual reduction in gas consumption is also 2%. This reduction is primarily due to reduced demand in the residential, commercial, industrial and power sectors because of energy efficiency gains and secondarily due to increased cost of natural gas resulting from a higher crude oil price profile relative to EIA's reference case pricing.

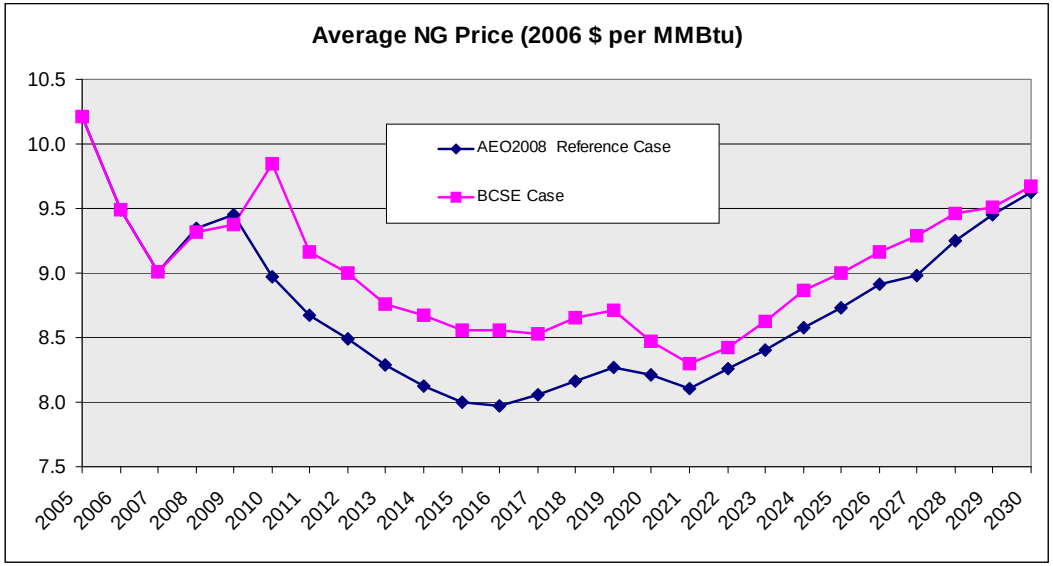


- From 2020 to 2030, this trend is reversed due to projected increased natural gas demand in the power sector, which increases over the Reference Case by 1% in 2020 and by 59% in 2030.
  - In contrast, gas consumption in the Commercial, Residential, and Industrial sectors drops over the same period, limiting the total increase in gas consumption in 2030 to just 11.7%.
  - The increased power sector natural gas demand is primarily due to the BCSE assumptions for cost, performance, and commercial availability of competing power sector technologies, which yields lower levelized cost-of-electricity for natural gas generation versus coal-based generation during the 2020 to 2030 time frame.



BCSE PROJECT RESULTS: Natural Gas Demand and Prices Relative to Reference Case

- Relative to the Reference Case, delivered natural gas prices are somewhat higher in each demand sector for the 2008 to 2019 time frame.
  - Since, as discussed above, natural gas consumption decreases in all sectors during this time frame, the price increase can be fully attributed to the direct correlation of gas and crude oil prices.
  - Gas prices would have been even higher if not for the assumptions related to demand-side efficiency improvements and the national RPS.
  - Average natural gas price is approximately 3.7 percent higher in 2020 than in the Reference Case, but only about 0.5 percent higher in 2030. This latter result is due to the shift in demand created by the power sector, which sees lower delivered natural gas prices than do the other demand sectors because of long-term purchase contracts.



BCSE PROJECT RESULTS: Electricity Demand and Prices Relative to Reference Case

- Demand for electricity is projected to decrease for all sectors from 2008 through 2030 relative to the Reference Case.
  - Total annual electricity consumption is projected to drop 3.8% in 2020 and 5.4% in 2030.
- The lower demand projection is primarily due to the BCSE assumptions for earlier availability, lower costs, and/or higher efficiencies for more advanced appliances and equipment than used in the Reference Case.
- While seemingly contrary to reduced electricity demand, average end-use electricity prices are projected to be higher for all sectors compared with the Reference Case. The average end-use price is 5.8% higher in 2020 and 7.3% higher in 2030. Higher relative electricity costs are due to:
  1) Higher natural gas price projection as discussed above,
  2) Higher power generation technology capital cost and operating cost assumptions,
  3) Updated power generation technology commercial introduction assumptions; and
  4) RPS requirements for increased use of renewable power generation

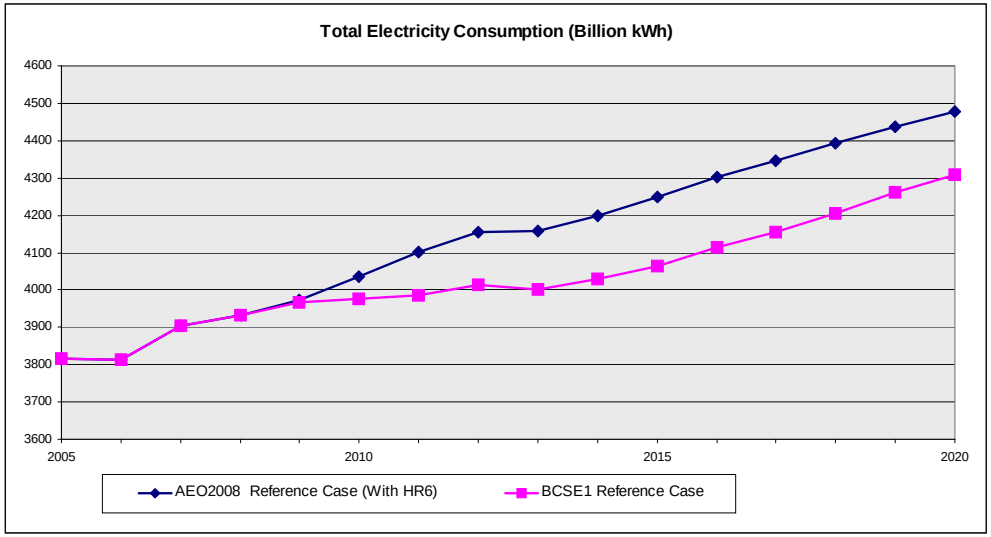
ELECTRICITY DEMAND REDUCTION BY SECTOR COMPARED WITH REFERENCE CASE

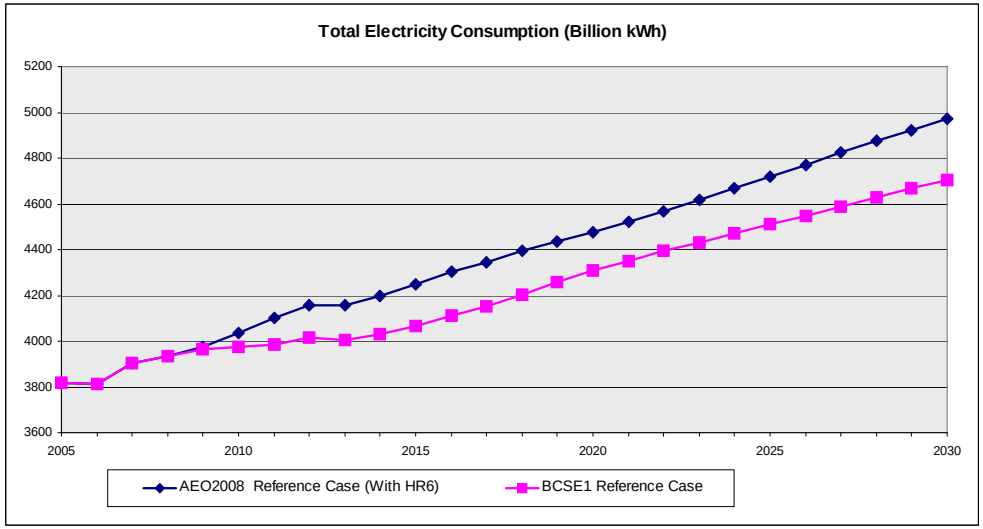
DEMAND SECTOR	YEAR	
	2020	2030
Residential Sector	3.2	6
Commercial Sector	5.8	10
Industrial Sector	7.3	7.8

ELECTRICITY PRICE INCREASE BY SECTOR COMPARED WITH REFERENCE CASE

DEMAND SECTOR	YEAR	
	2020	2030
Residential Sector	4.5	5.8
Commercial Sector	6.2	7.5
Industrial Sector	6.1	10.4

BCSE PROJECT RESULTS: Electricity Demand and Prices Relative to Reference Case





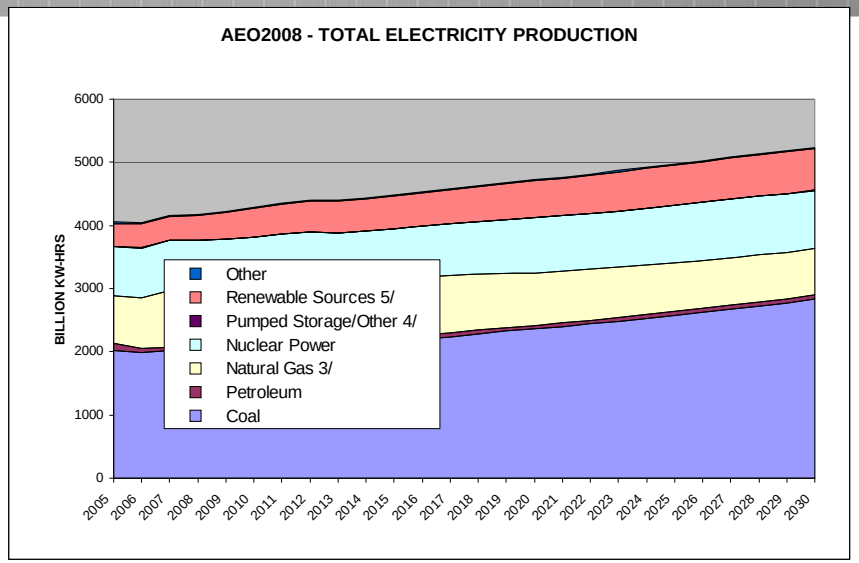
BCSE PROJECT RESULTS: Electricity Generation Relative to Reference Case

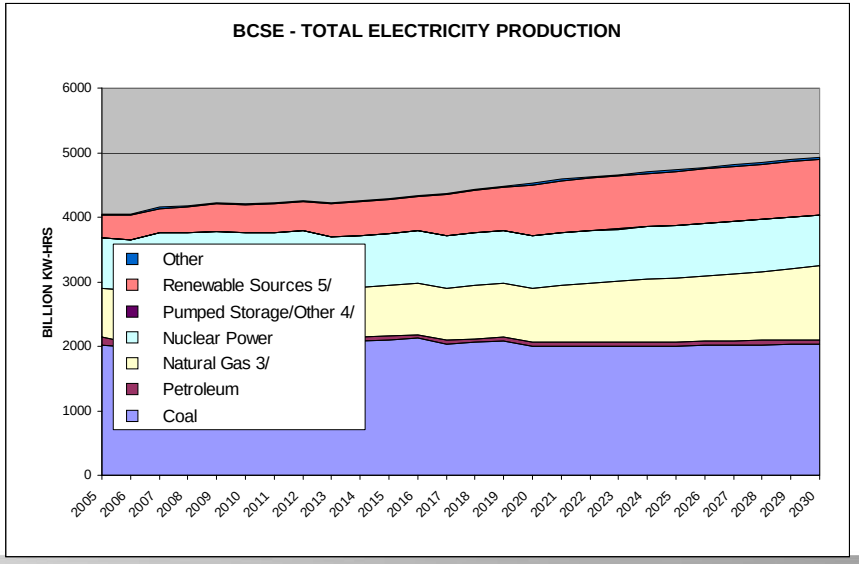
- The BCSE scenario yields a significant change to the mix of power generation technologies and related resource consumption relative to the Reference Case.
  - Table 4 draws a comparison between the two cases in 2020 and 2030 with respect to the market share of total power generated in those years.
  - For 2020, the model projects a large shift from coal to renewables generation, with a smaller increase projected for natural gas-based generation.
  - Nuclear also sees a slight decline in production. This shift in resources in 2020 is primarily due to the implementation of the national RPS specifications and secondarily the modification of power generation capital and operating costs, generating technology commercial availability, and natural gas price projection.

POWER CONVERSION RESOURCE	PERCENTAGE OF TOTAL POWER GENERATION			
	2020		2030	
	AEO2008	BCSE	AEO2008	BCSE
Coal	49.9	44.2	54.2	41.2
Natural Gas	17.6	18.5	14.1	23.2
Nuclear	18.4	17.9	17.5	16
Renewables	12.4	17.5	12.6	17.4
Other	1.6	1.9	1.7	2.1
TOTAL	100	100	100	100

BCSE PROJECT RESULTS: Electricity Generation Relative to Reference Case

- For 2030, the model projects an even larger shift from coal, but natural gas generation is now the primary beneficiary, increasing market share by 9 percentage points.
  - Natural gas generation also benefits from a further decline in nuclear generation share to 16% due to capacity retirement.
- Renewables generation remains flat based on the RPS specifications post-2020, but still represents a 5 percentage point share increase relative to the Reference Case.
- This shift in resources in 2030 is primarily due to the switch in relative costs between coal, natural gas, and nuclear technologies as impacted by the BCSE technology assumptions, as well as the RPS specifications.
  - This change to the mix of power generation technologies and resource consumption manifests itself in average higher cost-of-electricity and significant CO_2 emissions reduction relative to the Reference Case





BCSE PROJECT RESULTS: Energy Efficiency Impacts Relative to Reference Case

- The BCSE Scenario posits a more aggressive adoption of energy-saving technologies in the three primary demand sectors: Commercial, Residential, and Industrial.
  - The impact of this technological improvement is to significantly reduce the energy required to provide required goods and services, *fully mitigating the impact of increased energy costs (natural gas and electricity) that result from BCSE's other modeling assumptions*.
  - Residential sector, energy intensity, expressed in MMBtu per Household, improved by approximately 3.7 percent over the Reference Case in 2020, and by 6.9 percent in 2030.
  - Commercial sector energy intensity, expressed in thousands of Btu's per square foot, showed an aggregate improvement of approximately 5.3 percent in 2020 and 8.8 percent in 2030 relative to the Reference Case.
  - Industrial sector energy intensity, expressed in thousands of Btu's per dollar of shipments, showed an improvement of approximately 2.5 percent in 2020, and 7.3 percent by 2030 over the Reference Case.
- The improvements in energy intensity are the primary drivers of the reduction in energy consumption in the demand sectors, and result from efficiency improvements embodied in the *high technology* scenarios developed by EIA.

BCSE SCENARIO ENERGY INTENSITY IMPROVEMENTS RELATIVE TO THE REFERENCE CASE

Energy Intensity Improvements		
Percent Change Relative to Reference Case		
	2020	2030
Residential (Million Btu per Household)	3.7	6.9
Commercial (Thousand Btu per Sq. Ft.)	5.3	8.9
Industrial (Thousand Btu per $ of Shipment)	2.5	7.3

BCSE PROJECT RESULTS: Energy Efficiency Impacts Relative to Reference Case

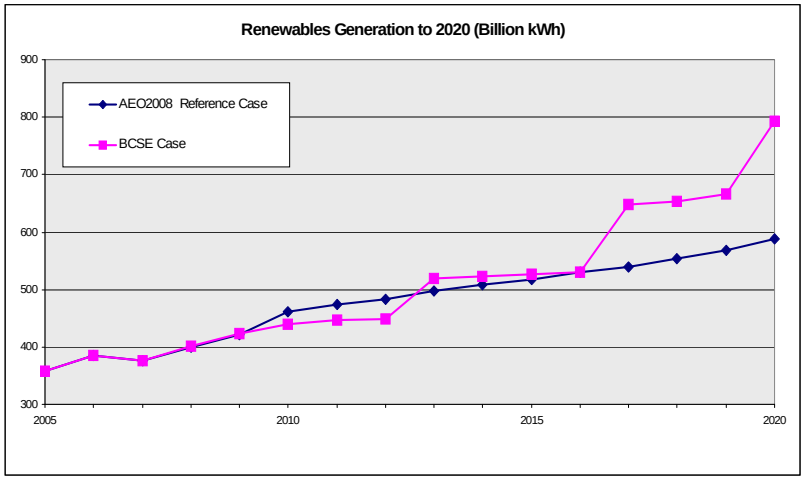
- Reductions in energy demand in the Commercial and Residential sectors (noted elsewhere) can be traced directly to improvements in energy efficiency, as the BCSE Scenario projects nominal increases in both the number of households and commercial floorspace relative to the Reference Case.
  - Changes in Industrial consumption can also be traced to the relative growth in non-manufacturing and non-energy intensive areas, as shown in the following table.
  - Energy-intensive manufacturing, on the other hand, shows a decrease in the BCSE Scenario relative to the Reference Case, where efficiency gains do not completely compensate for energy price increases.
  - *However, the model projects that the net impact of these changes is to produce a higher growth in GDP than is projected under the Reference Case.*

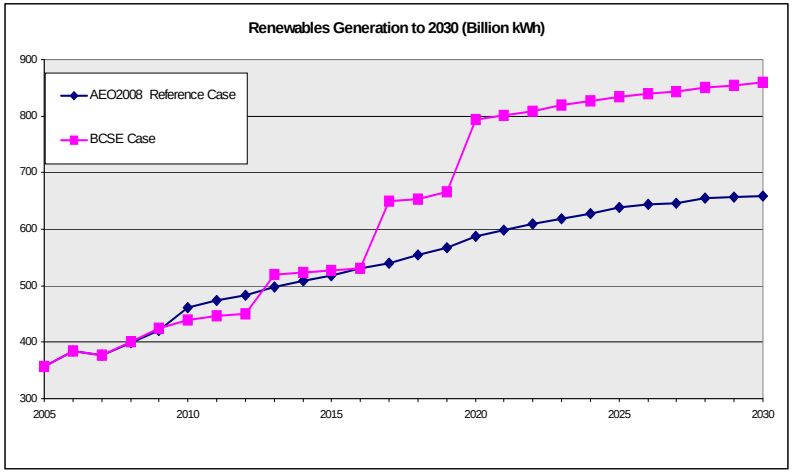
BCSE SCENARIO ENERGY INTENSITY IMPROVEMENTS RELATIVE TO THE REFERENCE CASE

Selected Indicators Percent Change from Reference Case		
	2020	2030
GDP	1.8	3.1
Residential Households	0.6	0.9
Commercial Floorspace	0.12	0.15
Industrial Output (Value of Shipments)	-1.1	2.2
Non-Manufacturing	5.3	5.3
Energy Intensive Mfg.	-5.2	-3
Non-Energy Intensive Mfg.	-2.2	2.6

BCSE PROJECT RESULTS: Renewable Energy Conversion Trends Relative to Reference Case

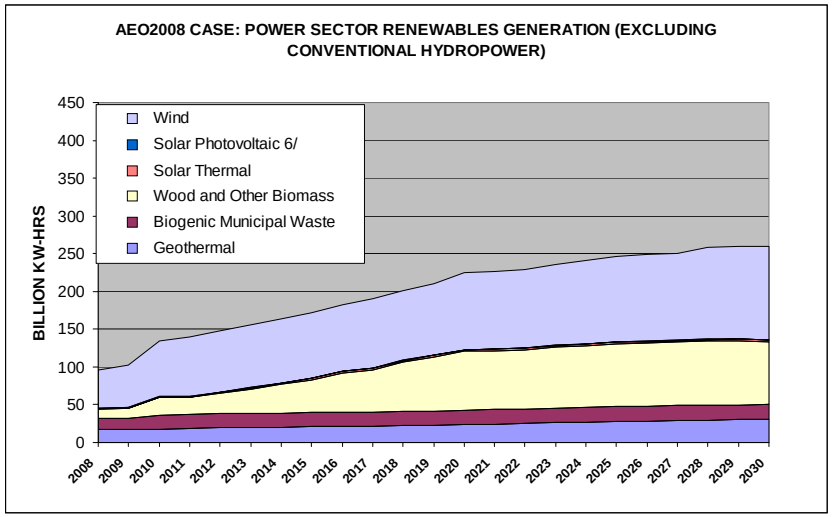
- In the aggregate, electricity generation from renewable sources increases relative to the Reference Case, showing a 35 percent increase in 2020, and 31 percent in 2030.
  - This increase in generation significantly exceeds the relative growth in generating capacity which, in 2020, is approximately 6.5 percent lower than in the Reference Case;
  - In 2030 this trend is reversed, with capacity under the BCSE scenario exceeding the Reference Case by 12 percent.
- Total renewables generation is projected to increase from about 12.5 percent of total electricity generation in both 2020 and 2030 to 17.5 percent in both of those years.
  - This includes both the power sector and end-use generation in the residential, commercial, and industrial sectors.
  - Growth in renewables and natural gas compensates for projected declines in coal and nuclear power generation.

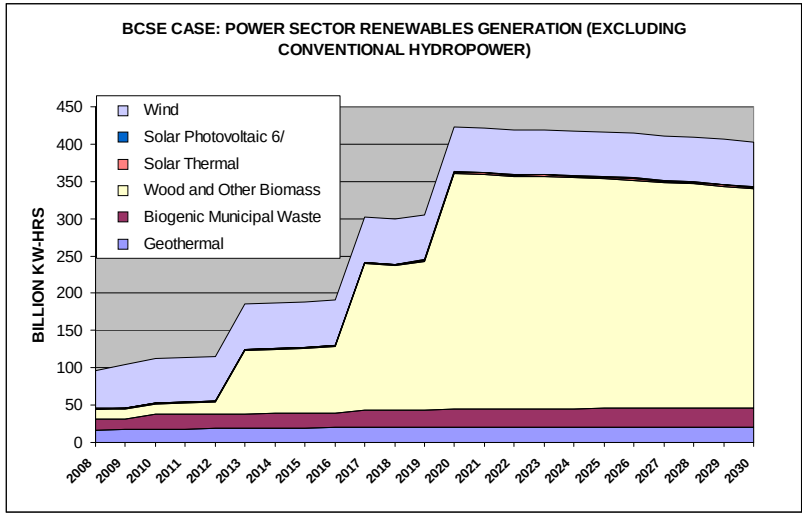




BCSE PROJECT RESULTS: Renewable Energy Conversion Trends Relative to Reference Case

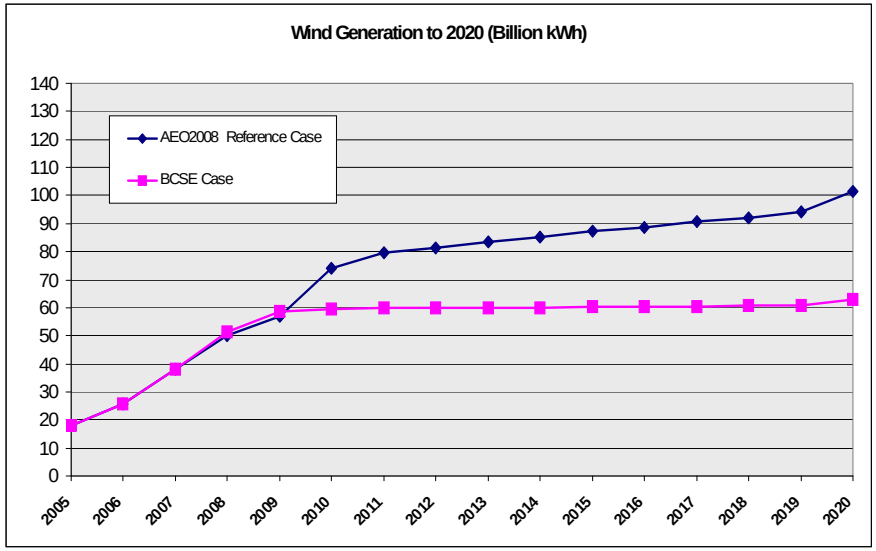
- The vast bulk of the growth in renewable generation comes from biomass, notwithstanding lower capacity additions under the BCSE Scenario.
  - There are two categories of direct biomass-consuming technologies associated with the power sector – 'wood gasification combined cycle' and 'co-firing in coal-fired units.' It is the latter that NEMS is choosing to increase significantly because the model sees biomass co-firing as the least expensive renewables choice to meet the RPS.
  - The co-firing costs mostly depend on the cost of biomass material that is co-fired, primarily assumed to be urban wood and mill wastes. There is a cost input for co-firing that is supposed to represent the levelized cost of incorporating wood co-firing, but these input assumptions were not changed.

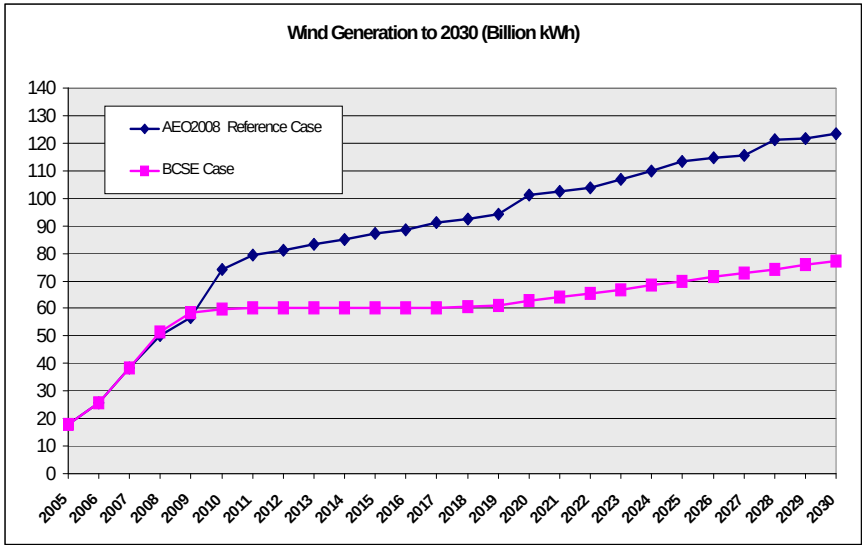




BCSE PROJECT RESULTS: Renewable Energy Conversion Trends Relative to Reference Case

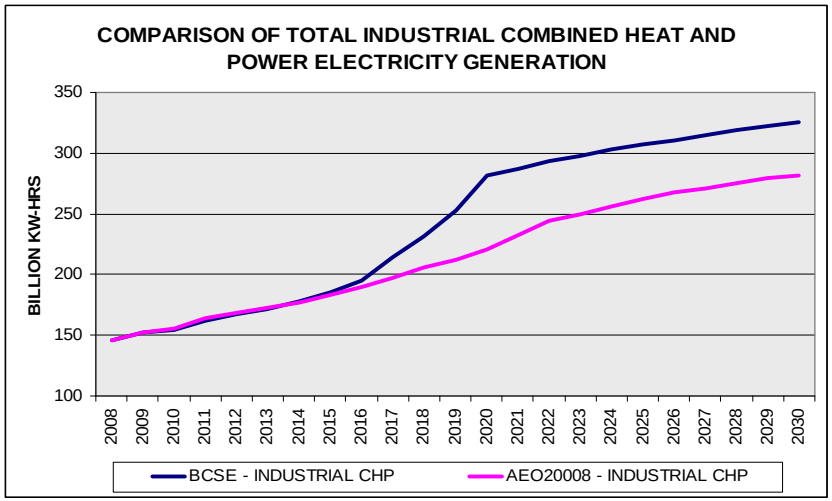
- Wind generation falls approximately 38 percent lower than that reported in the AEO2008 Reference Case because the capital and fixed O&M costs for onshore wind technology were significantly increased compared with EIA's input values.
  - Biomass co-firing was deemed the cheaper option by the model.
  - Similarly, geothermal generation is not as cost competitive under the BCSE Scenario.

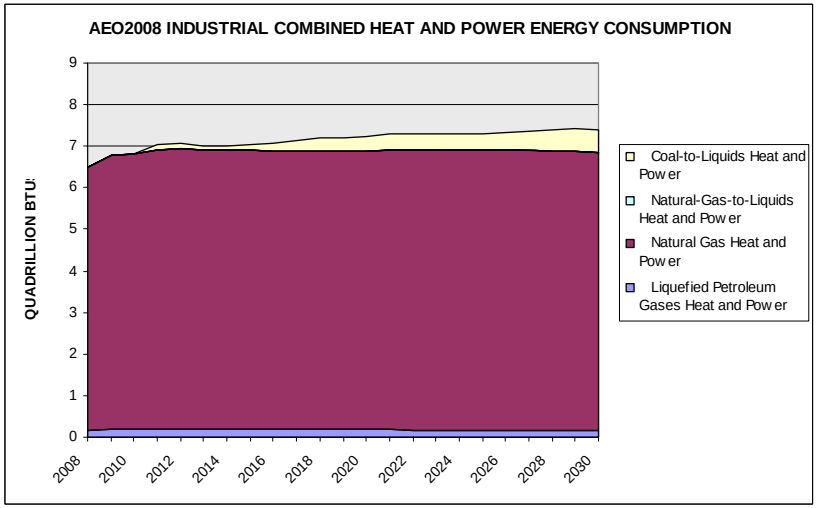


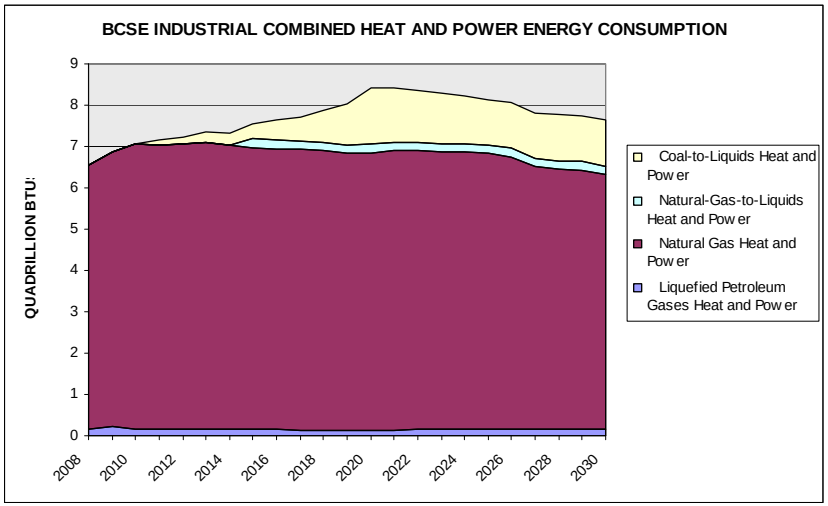


BCSE PROJECT RESULTS: Combined Heat and Power Energy Consumption Relative to Reference Case

- BCSE case increases industrial combined heat and power energy consumption
  - Natural gas CHP is projected to decline slightly due to a higher natural gas price forecast.
  - Due to the higher crude oil price projection input to the model, coal-to-liquids CHP increases significantly and natural gas-to-liquids CHP is brought on-line.
  - It then follows, that industrial CHP power generation is projected to increase under the BCSE assumptions.

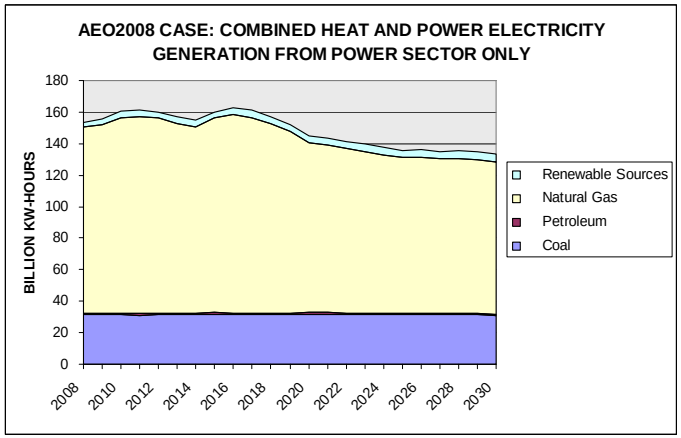


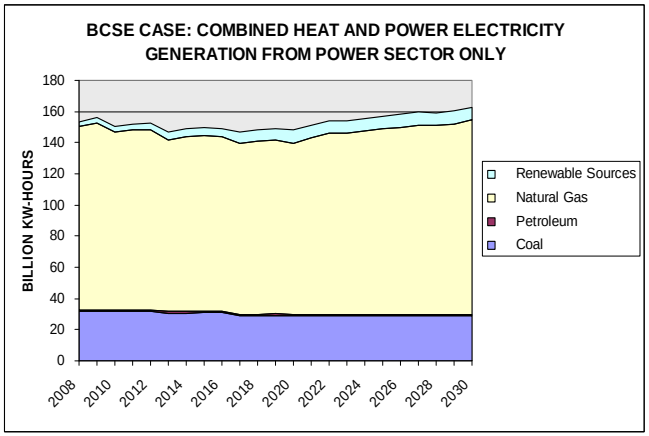




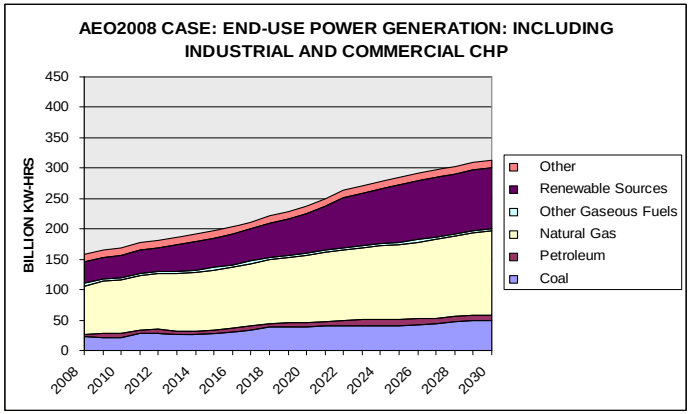
BCSE PROJECT RESULTS: Combined Heat and Power Energy Consumption Relative to Reference Case

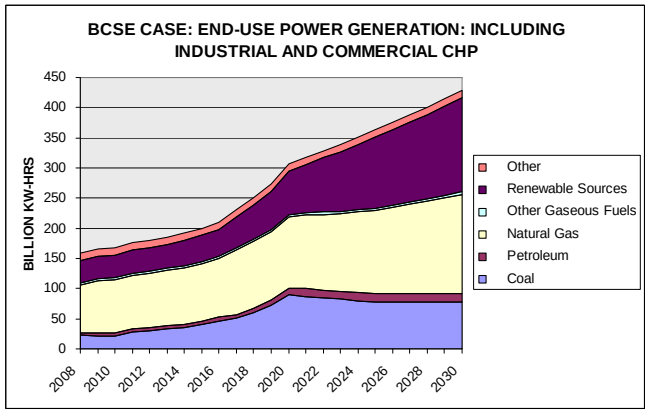
For Power Sector-only CHP electricity generation, the BCSE case results in an initial reduction in growth of CHP generation to 2020, but then modest growth in both natural gas and renewables-based CHP.





- Total end-use power generation, accounting for industrial and commercial CHP, is projected to grow 29 percent by 2020 and 37 percent by 2030. Growth occurs for all fuel types, but particularly for natural gas and renewables.





Contact Information

SAIC's energy and climate change team contact information:

Rick Irby
Ph: 703-676-5236
Email: irbyr@saic.com

Jay Ratafia-Brown
Ph: 703-676-6343
Email: jay.a.ratafia-brown@saic.com

John Meyer
Ph: 703-676-3776
Email: john.r.meyer@saic.com