Arkansas Governor's Commission on Global Warming

Energy Supply (ES)
Technical Work Group
Meeting #10, July 25, 2008

Office of the Governor
Center for Climate Strategies

Agenda

1. Introductions
2. Review and Approval of Prior Call Summary
3. Dates and Times for Future GCGW and TWG meetings
4. Review Goals for GCGW Meeting #8 (July 31, 2008)
5. Continued Review and Revision of Priority Policy Option Designs and Inputs for Quantification
6. Review of Next Steps for TWG
7. Confirm Agenda, Date and Time for Next Meetings
8. Public Comments and Announcements

Future GCGW and CC TWG Meetings

- GCGW Meetings (9:30 am - 4:30 pm Central)
  - #8: Thursday, July 31, 2008
  - #9: Tuesday, Sept. 9, 2008
  - #10: Thursday, Sept. 25, 2008
- ES TWG Meetings
  - Future Meetings: TBD
- Final Recommendations to Governor
  - Friday, October 31

Goals for GCGW Meeting #8 (July 31, 2008)

- Goals: Obtain GCGW comments on and approval of TWG recommendations on pending priority policy options

Development of Quantification for Priority Policy Options

ES-1: Green Power Purchases and Marketing
ES-2: Technology Research & Development
ES-3a: Renewable Portfolio Standard (RPS)
ES-3b: Renewable Energy Feed-In Tariff (REFIT)
ES-4: Grid-Based Renewable Energy Incentives and/or Barrier Removal
ES-5: Approaches Benefiting From Regional Application
ES-6: Combined Heat and Power
ES-7: Geological Underground Sequestration for New Plants
ES-8: Transmission System Upgrades
ES-9: Nuclear Power
ES-10: Carbon Tax
ES-11: Efficiency Improvements and Repowering of Existing Plants

Review of Quantification

See Reference Materials
(Slides 10 through 96)

Next Steps for ES TWG

- Continue review of policy option quantification
- Continue development of remaining elements of template for pending priority policy options
- Respond to comments from GCGW meeting

Next ES TWG Meeting

- **Agenda**:
  - Continue to develop quantification inputs and review results for priority policy options
- **Dates/Times for Next TWG Calls**
  - Future calls TBD

Public Input, Announcements

Reference Materials

Preliminary Results for the Arkansas Energy Supply GHG Forecast and Analysis of Standalone Mitigation Options

Outline

- Analytical framework
- Sales forecast
- Capacity expansion
- Gross generation forecast
- Primary energy forecast
- Electricity imports/exports forecast
- GHG emission forecast
- Key inputs and results for mitigation options (ES-1, ES-2, ES-3A, ES3B, ES-4, ES-5, ES-6, ES-7

Analytical Framework

Overall framework for developing the GHG mitigation analysis:

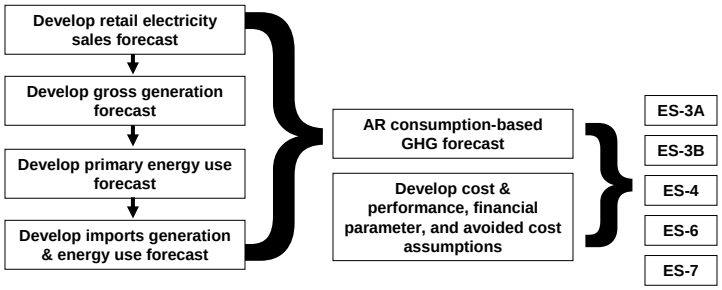
- Assume a planning horizon of 2005 - 2025;
- Consider two Reference Scenarios as follows:
  - **Reference Scenario #1:** Include **all** planned capacity additions EXCEPT the Hempstead plant;
  - **Reference Scenario #2:** Include **all** planned capacity additions INCLUDING the Hempstead plant;
- Assume a electricity sales growth rate over the 2005-2025 period as the previously discussed GHG forecast 1.37%/year
- Consider a range of sources regarding cost and performance assumptions for new electric generating capacity

The basic approach we've used in this memo….

- Explicitly document input data and results regarding the GHG forecast, including the following:
  - Sales forecast;
  - Planned capacity/retirement schedule
  - Generation forecast;
  - Primary energy use forecast.
  - GHG emissions forecast
- Explicitly document input data and results regarding the GHG mitigation analysis, including the following:
  - Cost & performance assumptions for new capacity
  - Financial parameter assumptions
  - Avoided electric expansion costs
  - GHG reductions and costs associated with each of the quantifiable energy supply mitigation options on a standalone basis
- Continue to solicit feedback from the ES TWG regarding any input data or assumptions that needs to be corrected/revisited

We've followed the steps in the flow diagram below for the standalone analysis of GHG mitigation options….

- For utilities….. non-utility generators…. commercial CHP…and… industrial CHP….
- For each Reference Scenario….



Spreadsheets where GHG emissions & mitigation option analysis are calculated available upon request….

- For the GHG forecast, the following spreadsheets have been developed:
  - Reference Scenario #1: "AR ES GHG forecast- BAU1.xls"
  - Reference Scenario #2: "AR ES GHG forecast- BAU2.xls"
- For the assumptions used to analyze mitigation options, the following spreadsheet has been developed:
  - "AR mitigation option assumptions.xls"
- For analysis of mitigation options, the following spreadsheet **folders** have been developed:
  - ES-3A
  - ES-3B
  - ES-4
  - ES-6
  - ES-7

Default assumptions have been assumed for the following….

- Electricity sales forecast
- Transmission and distribution losses (%)
- Utility/NUG Capacity expansion profile
- New capacity cost & performance characteristics
- Natural gas and other fossil fuel price projections
- Retirement schedule of 2005 capacity
- Shares of AR CHP generation to meet on-site and retail electricity demand
- Shares of AR utility/NUG generation to meet on-site and retail electricity demand
- Characteristics of out-of-state utilities/NUGs providing electricity to meet AR demand
- GHG emission factors
- Financial parameters

Default assumptions can be readily changed to explore alternative scenarios….

- Key objective is to have the TWG reach consensus on values for the complete set of default assumptions.
- Until then, the default assumptions included in the spreadsheet calculations are considered provisional

Sales forecast

Default approach

- Obtain historical electricity sales by sector for AR for the Base Year, 2005
- Assume growth rate through 2025 in AR is the same as for the surrounding SPP/SERC region, using AEO2007 outputs
- Revise sales forecast as appropriate based on input from the ES TWG

Focusing on electricity sales for AR in 2005….

- Total retail electricity sales in AR for the 2005 Base Year were 46,165 GWh (Source: US Electric Utility Sales data available from http://www.eia.doe.gov/cneaf/electricity/page/sales_revenue.xls)
- Here's the breakdown of electricity sales by sector:

	2005
Total	
Residential Sales	17,134
Commercial Sales	11,366
Industrial Sales	17,665
Transportation Sales	0
Other Sales	0
All Sector Sales	46,165

For the period 2006-2025….

- Average annual retail sales growth rate in the forecast period is assumed to be as follows: (source: AEO2007)

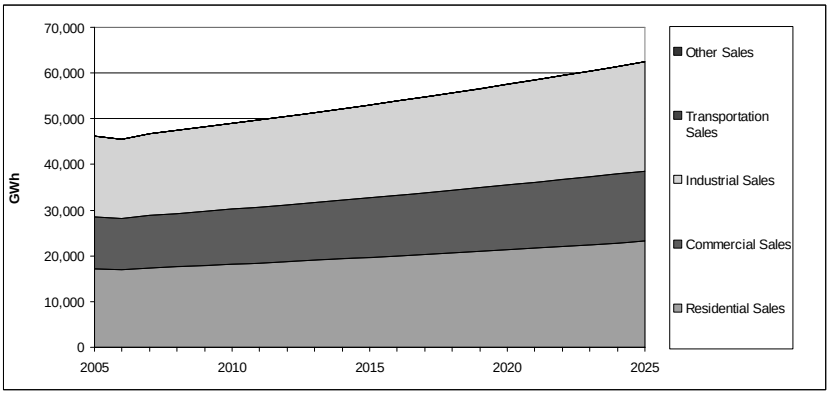
	2005	2025	Growth (%/yr)
Total			
Residential Sales	17,134	23,120	1.51%
Commercial Sales	11,366	17,604	2.21%
Industrial Sales	17,665	19,888	0.59%
Transportation Sales	0	0	NA
Other Sales	0	0	NA
All Sector Sales	46,165	60,612	1.37%

For the period 2006-2025…

- Average annual retail sales growth rate in the forecast period is assumed to be the same as that of the SPP region (source: AEO2007)

	2005	2025	Growth (%/yr)
Total			
Residential Sales	17,134	23,120	1.51%
Commercial Sales	11,366	17,604	2.21%
Industrial Sales	17,665	19,888	0.59%
Transportation Sales	0	0	NA
Other Sales	0	0	NA
All Sector Sales	46,165	60,612	1.37%

Results…



Capacity expansion

Default approach

- Obtain in-state electric generating capacity for the Base Year, 2005
- Obtain state planned annual capacity retirement/derating schedule
- Obtain state planned annual capacity addition schedule, with and without Hempstead plant
- Revise capacity expansion plan as appropriate based on input from the ES TWG

Electric generating capacity in 2005 …

- Plant type-specific AR nameplate capacity data (MW) was obtained from EIA-906 and EIA-860 forms, and are summarized below

	Utilities	Cogenerators
Coal	3,958	0
Natural Gas	1,845	247
Other Gases	0	0
Petroleum	17	0
Nuclear	1,845	0
Hydroelectric	1,337	0
Geothermal	0	0
Solar/PV	0	0
Wind	0	0
MSW Landfill gas	0	2
Biomass	0	15
Other wastes	0	0
Pumped storage	0	0
	9,002	264

Focusing on planned capacity retirements/deratings during the period 2006-2025 …

- The default assumption is the following schedule of planned capacity retirements

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroelectric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Planned capacity additions during the period 2006-2025 …

- Plant type-specific AR annual capacity addition data (MW) was obtained from Form EIA-906 for the 2006-2010 period (this information is available at http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html)
  - For natural gas, the database does not specify whether these are combustion turbines or combined cycle units. **The default assumption is that the unit has not been built**
  - **The coal plant capacities were assumed to be 665 MW for Plum Point and 600 MW for Hempstead based on state docket materials**

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Coal	0	0	0	0	0	665	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroelectric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	665	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0

Reference Scenario #1: Net capacity additions (MW) during the period 2006-2025 …

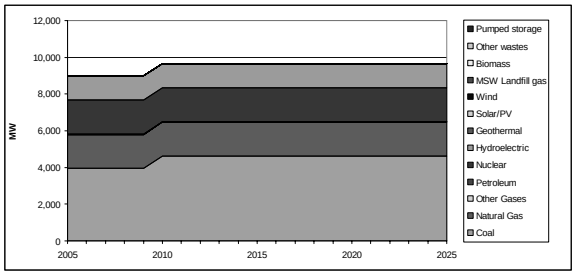
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Coal	0	0	0	0	0	665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroelectric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reference Scenario #2: Net capacity additions (MW) during the period 2006-2025 …

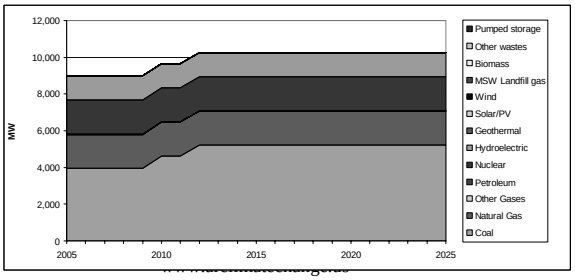
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Coal	0	0	0	0	0	665	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroelectric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	665	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0

- **Reference Scenario #1:**

Results…



- **Reference Scenario #2:**



Gross generation forecast

Default approach

- Obtain historical net electricity generation by generator type for AR for the Base Year, 2005
- Assume on-site power plant electricity use in AR is the same as for the surrounding SPP/SERC region (using AEO2007 outputs) to calculate gross generation in the Base Year, 2005
- For existing units operational during the planning period, assume annual gross generation for 2006-2025 equals 2005 levels
- Revise gross generation forecast as appropriate based on input from the ES TWG

Focusing on on-site electricity use at utility/NUG power stations …

- Electric power production at utilities/NUGs is typically reported net of power used on-site. In order to reflect the total level of GHG emissions, an estimate of on-site power use is needed.
- AEO2007 provides estimates of on-site power use by region (national average was 0.9% in 2005);
- **Default assumption: on-site power use at electric utilities/NUGs in AR follow the same pattern as in the SPP/SERC regions (0.8% in 2005).**

Applying on-site electricity use to AR utilities and non-utility generators net generation in 2005…

- Total net generation in AR for the 2005 Base Year was 44,542 GWh
- Total gross generation in AR for the 2005 Base Year was 44,909 GWh
- Here's the breakdown in AR gross generation, by fuel type, for 2005 (GWh):

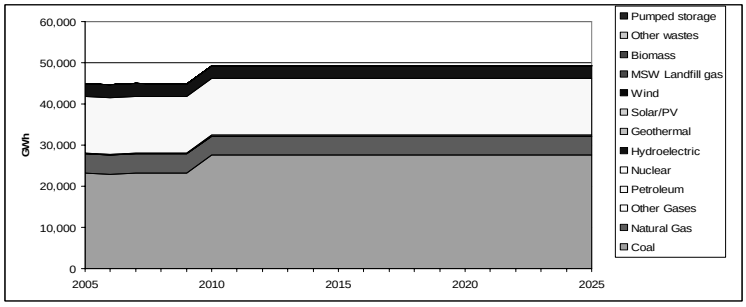
Utilities and non-utilities	
Coal	23,129
Natural Gas	4,684
Other Gases	0
Petroleum	164
Nuclear	13,802
Hydroelectric	3,108
Geothermal	0
Solar/PV	0
Wind	0
MSW Landfill gas	0
Biomass	0
Other wastes	0
Pumped storage	21
Total (production-based)	44,909

Capacity factor assumptions for planned capacity additions…

- New power stations:
  - Plum point: 75%
  - Hempstead: 75%
- Existing power stations:
  - All stations: same capacity factor as in 2005

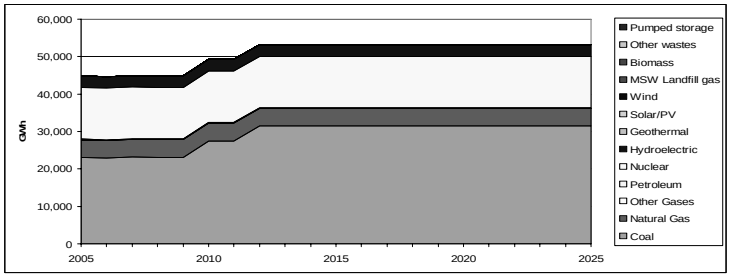
Results for Reference Scenario #1…

Utilities and non-utilities																							
Coal	23,129	22,899	23,184	23,134	23,134	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503	27,503
Natural Gas	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
Nuclear	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802
Hydroelectric	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Total (production-based)	44,909	44,678	44,963	44,913	44,913	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282	49,282



Results for Reference Scenario #2…

Utilities and non-utilities																						
Coal	23,129	22,899	23,184	23,134	23,134	27,503	27,503	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445	31,445
Natural Gas	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684	4,684
Other Gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
Nuclear	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802	13,802
Hydroelectric	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108	3,108
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar/PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSW Landfill gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other wastes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumped storage	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Total (production-based)	44,909	44,678	44,963	44,913	44,913	49,282	49,282	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224	53,224



Primary energy forecast

Default approach

- Obtain historical primary energy use by power plant fuel type for AR for the Base Year, 2005
- Calculate average heat rates by fuel type for the Base Year, 2005
- For existing units operational during the planning period, assume average heat rates for 2006-2025 equals 2005 levels
- Revise primary energy use forecast as appropriate based on input from the ES TWG

Focusing on heat rates for 2005 for electric utilities and non-utility generators…

- Using reported primary energy use for 2005 (**bolded numbers below**), heat rates for electric utilities and non-utility generators were determined….

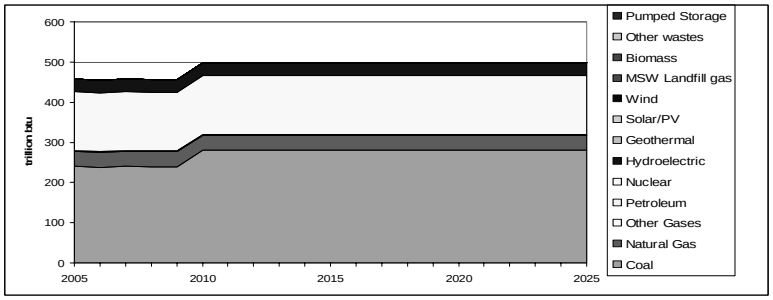
Utilities and non-utilities	**trills**	GWh	btu/kWh
Coal	**240.5**	23,129	10,398
Natural Gas	**37.3**	4,684	7,964
Other Gases	**0.0**	0	NA
Petroleum	**1.8**	164	10,702
Nuclear	**146.1**	13,802	10,582
Hydroelectric	**32.1**	3,108	10,320
Geothermal	**0.0**	0	NA
Solar/PV	**0.0**	0	NA
Wind	**0.0**	0	NA
MSW Landfill gas	**0.0**	0	NA
Biomass	**0.0**	0	NA
Other wastes	**0.0**	0	NA
Pumped Storage	**0.2**	21	10,500
Total (production-based)	**457.9**	44,909	10,196

Heat rate assumptions for planned capacity additions in AR…

- New power stations:
  - Plum point: 9,425 btu/kWh (Source: http://sec.edgar-online.com/2007/02/08/0001193125-07-023538/Section19.asp
  - Hempstead: 9,000 btu/kWh (Source: direct testimony of James A. Kobyra in docket 06-1254-U
- Existing power stations:
  - All stations: same heat rate factor as in 2005

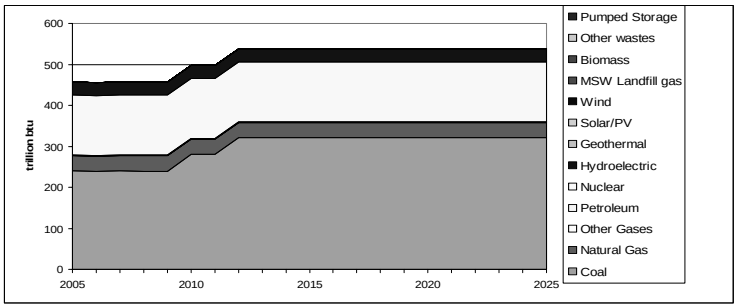
Results for AR for Reference Scenario #1…

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Utilities and non-utilities																					
Coal	240.5	237.9	240.3	239.3	239.3	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5
Natural Gas	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3
Other Gases	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Nuclear	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1
Hydroelectric	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar/PV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSW Landfill gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total (production-based)	457.9	455.3	457.8	456.8	456.8	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9	497.9



Results for AR for Reference Scenario #2…

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Utilities and non-utilities																					
Coal	240.5	237.9	240.3	239.3	239.3	280.5	280.5	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7
Natural Gas	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3
Other Gases	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Nuclear	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1
Hydroelectric	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solar/PV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSW Landfill gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumped Storage	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total (production-based)	457.9	455.3	457.8	456.8	456.8	497.9	497.9	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1	538.1



Electricity imports/exports forecast

Default approach …

- Any/all imported power assumed to be from the SPP/SERC region
- Any/all exported power assumed to go to the SPP/SERC region
- Imports (GWh) are calculated as follows:

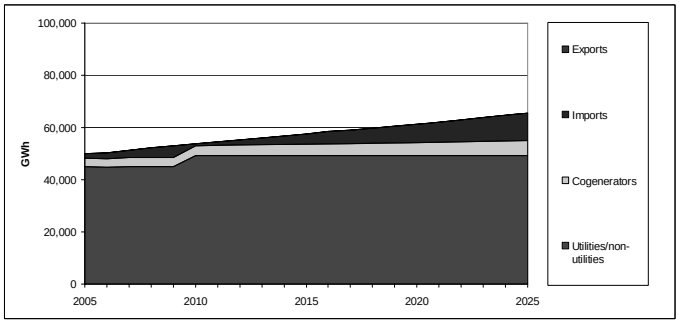
  Imports = Forecasted sales / (1 – T&D losses) – [generation from utilities/non-utilities + generation purchased from CHP facilities]

- Exports (GWh) are calculated as follows:

  Exports = | Forecasted sales / (1 – T&D losses) – [generation from utilities/non-utilities + generation purchased from CHP facilities] |

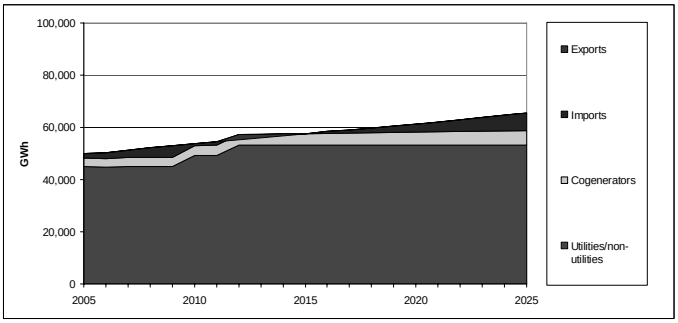
Results for Reference Scenario #1…

	2005	2010	2015	2020	2025
All Sector Sales	46,165	49,604	53,237	56,725	60,612
Losses (%)	7.7%	7.7%	7.6%	7.5%	7.6%
Required gross generation (GWh)	50,034	53,762	57,608	61,325	65,573
Available AR gross generation (GWh)					
Utilities/non-utilities	44,909	49,282	49,282	49,282	49,282
Cogenerators	3,252	3,762	4,329	4,942	5,635
Total	**48,161**	**53,044**	**53,612**	**54,225**	**54,917**
Required imports/exports (GWh)					
Imports	1,873	718	3,997	7,102	10,658
Exports	0	0	0	0	0



Results for Reference Scenario #2…

	2005	2010	2015	2020	2025
All Sector Sales	46,165	49,604	53,237	56,725	60,612
Losses (%)	7.7%	7.7%	7.6%	7.5%	7.6%
Required gross generation (GWh)	50,034	53,762	57,608	61,325	65,573
Available AR gross generation (GWh)					
Utilities/non-utilities	44,909	49,282	53,224	53,224	53,224
Cogenerators	3,252	3,762	4,329	4,942	5,635
Total	**48,161**	**53,044**	**57,554**	**58,167**	**58,859**
Required imports/exports (GWh)					
Imports	1,873	718	55	3,160	6,716
Exports	0	0	0	0	0

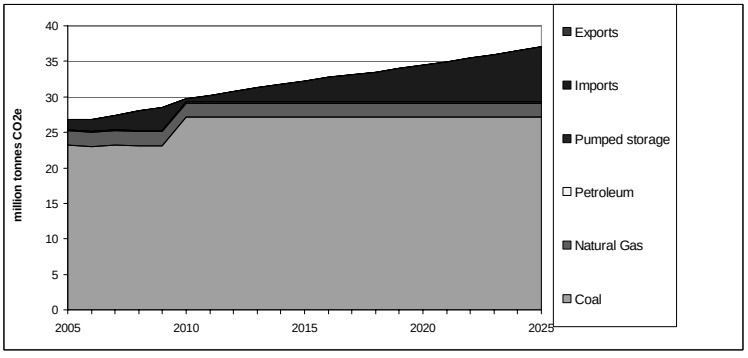


GHG emission forecast

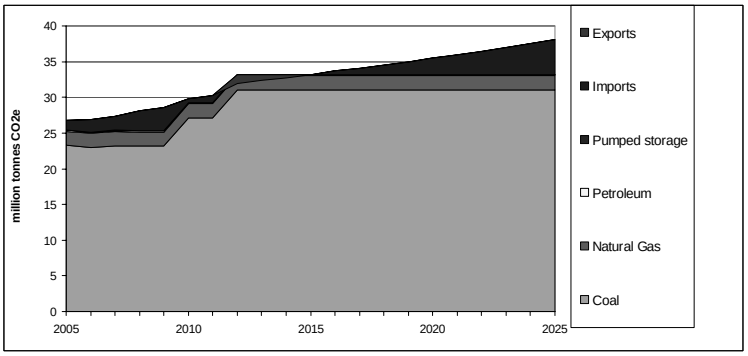
Default approach …

- In-state power production: Multiply annual levels of primary energy use at AR power stations by GHG emission factors for CO2, CH4, N2O, CO2e (units of tonnes per mmbtu) for the period 2005-2025
- Power imports: Multiply annual levels of primary energy use associated with power imports to AR by the appropriate emission factor, assuming the average mix in the SPP/SERC region
- Power exports: Multiply annual levels of primary energy use associated with power imports to AR by the appropriate emission factor, assuming the average mix in AR

Results for Reference Scenario #1…



Results for Reference Scenario #2…



ES-1: Green power purchases

The analysis of ES-1 is being undertaken by the RCI TWG…

ES-2

Technology research & development fuels

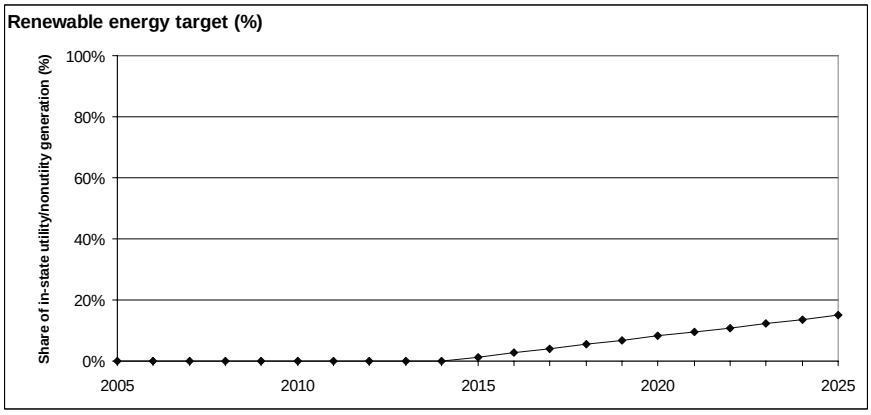
ES-2 has been deemed unquantifiable by the ES TWG…

ES-3A: Renewable Energy Portfolio

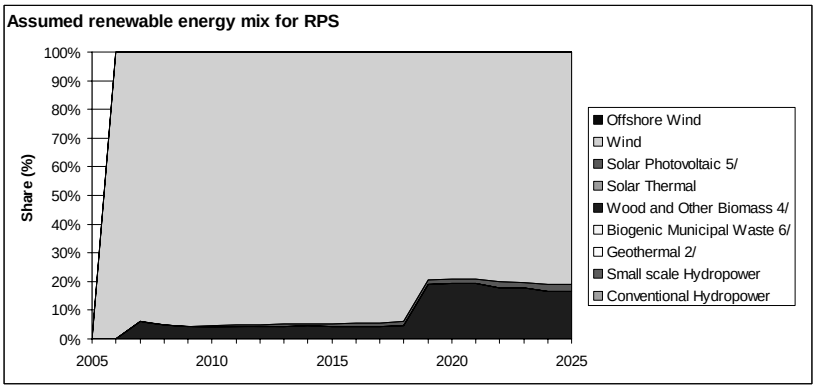
Default analytical approach …

- Relative to two cases
  - Reference Scenario #1 (i.e., without Hempstead)
  - Reference Scenario #2 (i.e., with Hempstead)
- Assume AEO2008 outputs represent least cost expansion plan for each NERC region modeled.
- Assume renewable energy mix for the **SPP** region best approximates the AR renewable resource base
- Use combination of NETL and EIA cost and performance assumptions
- Assume 2% engineer, procure, construct adder (as per NETL)
- Assume 50% capital cost for the EIA estimate of wind to reflect recent studies
- Compare new renewable resources to avoided costs in AR: $58.28/MWh (source: 2008 Entergy Arkansas Avoided Cost Filing as provided by AR RCI TWG)

Renewable energy target…



Renewable least cost renewable energy mix (based on AEO2008 for SPP region)…



Assumed cost and performance characteristics of new renewable capacity in AR…

	Cost component							
	Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate		
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh	Source	EPC Percentage
Hydroelectric	1,530	0	13.13	3.30	47%	10,107	EIA	2%
Geothermal	1,530	0	13.13	3.30	47%	10,107	EIA	2%
MSW	1,627	0	107.50	0.01	75%	13,648	EIA	2%
Landfill gas	1,627	0	107.50	0.01	75%	13,648	EIA	2%
Biomass	1,871	0	50.18	2.96	75%	8,911	EIA	2%
Solar	4,406	0	10.99	0.00	35%	10,280	EIA	2%
Wind	1,845	0	28.51	0.00	35%	10,280	EIA	2%

Estimated levelized costs for new renewable electric capacity (2005$/MWh) in AR…

Capacity type	Capacity	Transmission	Fixed O&M	Variable O&M	Fuel	Total
Hydroelectric	59.9	0.0	3.1	3.3	0.0	66.3
Geothermal	40.4	0.0	3.1	3.3	0.0	46.8
MSW	27.1	0.0	16.2	0.0	0.0	43.2
Landfill gas	27.1	0.0	16.2	0.0	0.0	43.2
Biomass	31.1	0.0	7.5	2.9	22.0	63.6
Distributed solar PV	157.0	0.0	0.0	0.0	0.0	160.5
Wind	65.7	0.0	9.2	0.0	0.0	74.9

Results…

		GHG Reductions (MMtCO2e)			Net Present Value		
Policy No.	Policy Option	2015	2025	Total 2009-2025	2009–2025 (Million $)	Effectiveness ($/tCO$_2$e)	Level of Support
Scenario #1	Plum point build in 2010; no build of new Hempstead plant	0.6	6.8	40.5	$240	$5.93	Pending
Scenario #2	Plum point build in 2010; build Hempstead in 2012	0.7	7.2	43.2	$259	$6.01	Pending

ES-3B: Feed-in tariffs

Default analytical approach …

- Relative to two cases (i.e., with and without Hempstead)
- Relative to 3 variations of German experience with feed-in tariffs:
  - 1/2 the effectiveness of the German experience
  - 3/4 the effectiveness of the German experience
  - Fully equivalent to the effectiveness of the German experience
- Relative to three sensitivities:
  - Feed-in tariff level set to achieve same RE generation as RPS
  - Feed-in tariff level set to complement RPS with small scale support (additional 5% from feed-in tariffs by 2025)
  - Feed-in tariff level set to achieve 25% RE generation by 2025
- Translates to 6 scenarios, 3 sensitivities each (18 sets of results)
- Focus on wind and solar PV only (reasonably good data available)
- Assume societal cost of the option is the cost of the tariff itself
- All other assumptions same as ES-3A

Feed-in tariff effect in Germany

a) Wind generation (units as noted)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Small scale wind capacity tariff ($/kWh)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Large scale wind capacity tariff ($/kWh)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Wind capacity (MW)	60	600	1,140	1,680	2,220	2,760	3,300	3,840	4,380	4,920	5,460	6,000
Small scale capacity (placeholder assumption)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Large scale capacity (placeholder assumption)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

a) Solar PV generation (units as noted)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Small scale solar PV tariff ($/kWh)										0.65	0.65	0.65
Large scale solar PV tariff ($/kWh)										0.61	0.61	0.61
Solar PV capacity capacity (MW)										600	1,350	2,100
Small scale capacity (placeholder assumption)										90%	90%	90%
Large scale capacity (placeholder assumption)										10%	10%	10%

Results for the *No-build* Hempstead Case…

		GHG Reductions (MMtCO2e)			Net Present Value		
Policy No.	Policy Option	2015	2025	Total 2009-2025	Value (Million $)	Effectiveness ($/tCO$_2$e)	Level of Support
Scenario #1	Build Plum Point only; half the efficacy of the German experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.6	6.8	40.5	-$604	-$14.9	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.3	13.5	-$255	-$18.9	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.0	11.3	67.5	-$737	-$10.9	Pending
Scenario #2	Build Plum Point only; three fourths of the efficacy of the German experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.6	6.8	40.5	-$685	-$16.9	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.3	13.5	-$264	-$19.6	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.0	11.3	67.5	-$962	-$14.2	Pending
Scenario #3	Build Plum Point only; One-to-one with the Germand experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.6	6.8	40.5	-$726	-$17.9	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.3	13.5	-$269	-$19.9	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.0	11.3	67.5	-$1,074	-$15.9	Pending

Results for the *Build* Hempstead Case…

Policy No.	Policy Option	GHG Reductions (MMtCO2e) 2015	2025	Total 2009-2025	Net Present Value (Million $)	Effectiveness ($/tCO$_2$e)	Level of Support
Scenario #4	Build Plum Point & Hempstead; half the efficacy of the German experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.7	7.2	43.2	-$632	-$14.6	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.4	14.4	-$273	-$19.0	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.1	12.0	71.9	-$738	-$10.3	Pending
Scenario #5	Build Plum Point & Hempstead; three fourths of the efficacy of the German experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.7	7.2	43.2	-$726	-$16.8	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.4	14.4	-$284	-$19.7	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.1	12.0	71.9	-$1,000	-$13.9	Pending
Scenario #6	Build Plum Point & Hempstead; One-to-one with the Germand experience						
	Sensitivity #1: Feed-in tariff level set at a level to achieve same renewabele energy generation as RPS	0.7	7.2	43.2	-$773	-$17.9	Pending
	Sensitivity #2: Feed-in tariff level set at a level to complement RPS with small scale support (5% by 2025)	0.2	2.4	14.4	-$289	-$20.1	Pending
	Sensitivity #3: Feed-in tariff level set at a level to achieve 25% renewable generation by 2025	1.1	12.0	71.9	-$1,131	-$15.7	Pending

ES-4: Grid-Based Renewable Energy Incentives

Under preparation…

ES-5: Regional Approaches

ES-5 has been deemed unquantifiable by the ES TWG; alternative guidance to be provided to the GCGW

ES-5: CHP

Under preparation…

ES-7: CO2 Sequestration from new Fossil Plants

Default analytical approach …

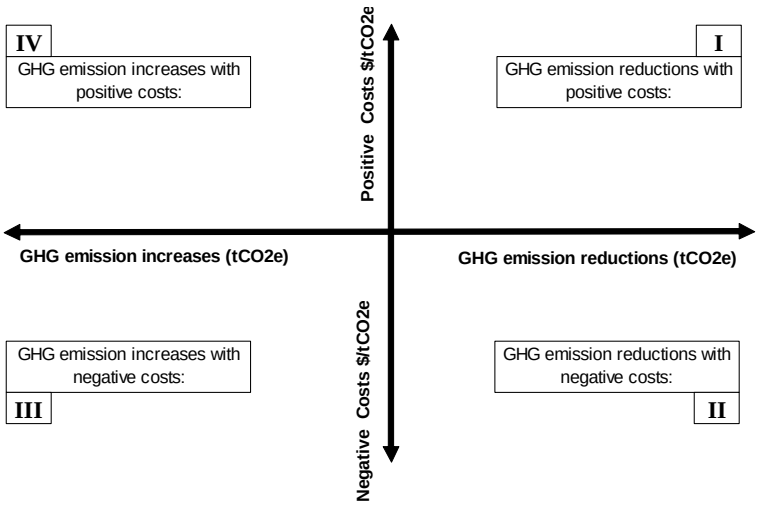
- Analysis undertaken relative to the following scenarios and sensitivities

Scenario #1	no build of new Hempstead plant BAU **(THIS IS THE BAU)**
Scenario #2	build Hempstead in 2012 with no mitigation or technology upgrade
Scenario #3	build Hempstead in 2012 with transition to CCS with CO2 piped to MS for enhanced oil recovery
Scenario #4	build Hempstead in 2012 with transition to CCS with CO2 stored in AR
Scenario #5	build Hempstead in 2012 as IGCC
Scenario #6	build Hempstead in 2012, but with mitigation
	Sensitivity 6(a) - NGCC-repowering
	Sensitivity 6(a) - Offsets
Scenario #7	no build of Hempstead, replaced with expanded energy efficiency, renewable energy, and natural gas
	Sensitivity 7(a) - displacement by energy efficiency and wind
	Sensitivity 7(a) - displacement by energy efficiency, wind, and NGCC
Scenario #8	build Hempstead in 2020 with transition to CCS with CO2 stored in AR

Summary of key assumptions …

Key Assumptions		Capacity (MW)	Type	Capacity factor (%)	Heat rate (btu/kWh) No CCS	Heat rate (btu/kWh) With CCS	Online year	Carbon capture (%)	Carbon capture online year
Scenario #1	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead	NA	NA	NA	NA	NA	2026	NA	NA
Scenario #2	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead	600	Pulv coal	75%	9,000	NA	2012	0%	NA
Scenario #3	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead	600	Pulv coal	75%	9,000	15,366	2012	83%	2020
Scenario #4	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead	600	Pulv coal	75%	9,000	15,366	2012	83%	2020
Scenario #5	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead replacement	600	IGCC	75%	8,922	NA	2012	0%	NA
Scenario #6a	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead replacement	600	NGCC	75%	6,719	NA	2012	0%	NA
Scenario #6b	Plum point	665	Pulv coal	75%	9,425	NA	2010	0%	NA
	Hempstead replacement	600	CO2 offsets	75%	NA	NA	2012	0%	NA
Scenario #7a	Plum point	665	Pulv coal	75%	9,425	NA	2010	NA	0
	Hempstead replacement	600	EE & wind	NA	NA	NA	2012	NA	0
Scenario #7b	Plum point	665	Pulv coal	75%	9,425	NA	2010	NA	0
	Hempstead replacement	600	EE, wind, NG	75%	NA	NA	2012	NA	0
Scenario #8	Plum point	665	Pulv coal	75%	9,425	9,425	2010	83%	2020
	Hempstead	600	Pulv coal	75%	9,000	9,000	2020	83%	2020

Summary of potential results . . .



Background for analysis of Scenario #1 …

- Plum Point plant comes online as scheduled in 2010 (665 MW)
- Hempstead is assumed to NOT be built
- Any in-state electric generation deficit associated with meeting in-state electricity demand is assumed to be met from imports from the SPP/SERC region
- This is considered the "Business-as-Usual Scenario" (i.e., the scenario against costs and GHG emissions of other scenarios will be compared

Background for analysis of Scenario #2 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) with no CO2 mitigation technology
- Any in-state electric generation deficit NOT associated with meeting in-state electricity demand is assumed to be exported to the SPP/SERC region;
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Higher share of coal relative to total in-state electricity generation

Background for analysis of Scenario #3 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) with no CO2 mitigation technology
- Hempstead plant (only) undergoes a retrofit in 2020 for carbon capture, transmission, storage (out-of-state), and monitoring;
- 50-mile connector pipeline is built between Hempstead plant and existing CO2 pipeline in Mississippi
- Plum Point plant remains a pulverized coal unit with no CCS
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Higher share of coal relative to total in-state electricity generation
  - Coal-fired CO2 emissions in the 2020-2025 period still higher
  - Higher costs associated with CCS technology including connector pipeline to existing CO2 pipeline in MS

Background for analysis of Scenario #3 (cont'd) …

- Assumed retrofit technology is chemical absorption with monoethanolamine (MEA); note: could also consider oxy-firing technology
- 50 mile connector pipeline in AR to an existing CO2 pipeline located out-of-state (e.g., in MS)
- Connector pipeline is designed to be capable of a mass flow rate between 5 and 40 MtCO2/yr
- Assumes carbon capture retrofitting cost and performance characteristics as below (source: Appendix 3.E of "The Future of Coal: Options for a Carbon-Constrained World, MIT, 2007:

	MEA	Oxy-firing
derating	41%	36%
Coal plant capacity factor (%)	75%	75%
Incremental Capital cost (2005$/kW)	1,604	1,044
Incremental Capital cost (2005$/kWh)	0.0000	0.0000
Incremental O&M cost (2005$/kWh)	0.0121	0.0161
Heat rate before retrofit (btu/kWh)	9,749	9,749
Heat rate after retrofit (btu/kWh)	16,644	15,164
efficiency penalty (btu/kWh)	6,895	5,416
efficiency penalty (%)	71%	56%
Carbon capture (%)	83%	84%

Background for analysis of Scenario #4 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) with no CO2 mitigation technology
- Hempstead plant undergoes a retrofit in 2020 for carbon capture and storage;
- 450-mile pipeline is built between Hempstead plant and ultimate CO2 enhanced oil recovery (EOR) storage site in AR
- Plum Point plant remains a pulverized coal unit with no CCS
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Higher share of coal relative to total in-state electricity generation
  - Coal-fired CO2 emissions in the 2020-2025 period still higher
  - Higher costs associated with CCS technology including pipeline to existing EOR site in AR

Background for analysis of Scenario #4 (cont'd) …

- CO2 is assumed to be sequestered in EOR recovery sites in AR (note: good potential sites exist in AR as summarized in table below from recent study (NETL, 2008))

Table 3. Major Oil Reservoirs Screened as Favorable for CO2-EOR

Basin/Area	Major Oil Reservoirs Data Base	
	# of Total Reservoirs	# Favorable For CO2-EOR
1. Alaska	42	32
2. California	187	86
3. Gulf Coast (AL,FL, MS, LA)	298	155
4. Mid-Continent (OK, AR, KS, NE)	246	102
5. Illinois/Michigan	172	72
6. Permian (W.TX, NM)	228	190
7. Rockies (CO,UT,WY)	187	92
8. Texas, East/Central	213	161
9. Williston (MT, ND, SD)	95	54
10. Louisiana Offshore	156	99
11. Appalachia (WV, OH, KY, PA)	188	68
Total	2,012	1,111

- Costs and performance characteristics same as for Scenario #3

Background for analysis of Scenario #5 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) as an IGCC plant with CO2 stored in AR
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Higher share of coal relative to total in-state electricity generation
  - Higher costs associated with IGCC technology relative to pulverized coal

Background for analysis of Scenario #5 (cont'd) …

- The cost & performance characteristics of IGCC units are taken from a recent NETL study and are summarized below

Assumed cost and performance characteristics of new capacity in AR

	Cost component							
	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate		
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh	Source	EPC Percentage
IGCC	1,803	0	34.40	6.33	80%	8,922	NETL	2%

–Source: NETL, 2007 "Cost and Performance Baseline for Fossil Energy Plants", DOE/NETL-2007/1281, August 2007 (available at http://www.netl.doe.gov/energy-analyses/pubs/Bituminous%20Baseline_Final%20Report.pdf)

Background for analysis of Scenario #6 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) but with two sensitivities
  - A) Plant comes online in 2012 as an NGCC instead of a pulverized coal unit
  - B) Plant comes online in 2012 but CO2 offsets are purchased
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Share of coal
    - A) Higher share of NG relative to total in-state electricity generation
    - B) Higher share of coal relative to total in-state electricity generation
  - Costs
    - Higher costs associated with NGCC technology relative to pulverized coal
    - Higher costs associated with purchase of offsets **(assumed to be $15/tCO2e)**

Background for analysis of Scenario #6 (cont'd) …

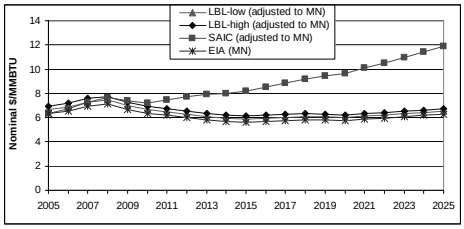
- For Scenario 6(a), the cost & performance characteristics of NGCC units are taken from a recent NETL study and are summarized below

Assumed cost and performance characteristics of new capacity in AR

	Cost component							
	Overnight Capital	Trans	Fixed O&M	Variable O&M	Cap factor	Heat rate		
	2005 $/kW	2005 $/kW	2005 $/kW-yr	2005 mills/kWh	%	btu/kWh	Source	EPC Percentage
Natural Gas CC	551	0	9.57	1.29	65%	6,719	NETL	2%

Background for analysis of Scenario #6 (cont'd) …

- The default NG fuel price forecast was adopted after a review of AEO2008 outputs for the West South Central region, a recent LBL study, and a recent SAIC study;
- The SAIC forecast in the trajectory below has been used in the analysis thus far



Sources:

1) EIA, 2008, AEO2008; **2)** LBL, 2006, memo Mark Bolinger and Ryan Wiser, Berkeley Lab (LBNL). December http://eetd.lbl.gov/ea/emp/reports/53587_memo.pdf; **3)** SAIC, 2007 "Greenhouse Gas Initiatives Analysis using the National Energy Modeling System A Study Performed for the Natural Gas Council, October

Background for analysis of Scenario #7 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online as scheduled in 2012 (600 MW) but with two sensitivities
  - A) Hempstead plant output is displaced, as practicable, by energy efficiency and wind generation
  - B) Hempstead plant output is displaced, as practicable, by energy efficiency, wind/natural gas generation
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Share of coal
    - A) and B): Lower share of fossil-fueled resources relative to total in-state electricity generation
- Costs
    - A) and B): Different costs associated with new resources

Background for analysis of Scenario #7 (cont'd) …

- Recently, several states have established legislative targets for demand side energy efficiency. For example:
  - **Minnesota** established a trajectory of energy savings for electric utilities in through recent legislation (i.e., 216B.241 ENERGY CONSERVATION IMPROVEMENT) in which Subd. 1c. specified that "…each individual utility and association shall have an annual energy-savings goal equivalent to 1.5 percent of gross annual retail energy sales unless modified by the commissioner under paragraph (d)…."
  - **12 Midwestern states:** The Midwest Governor's Association on November 15, 2007, at its Midwest Energy Summit agreed upon a region-wide goal for energy efficiency savings to "…Meet at least 2 percent of regional annual retail sales of natural gas and electricity through energy efficiency improvements by 2015, and continue to achieve an additional 2 percent in efficiency improvements every year thereafter."
- Assumed a default upper bound for energy efficiency savings of 2%/yr, based on the Midwestern states target
- Cost & performance for renewables and NGCC as indicated earlier

Background for analysis of Scenario #8 …

- Plum Point plant comes online as scheduled in 2010 (665 MW) with no CO2 mitigation technology
- Hempstead plant also comes online in 2020 (600 MW) as a pulverized coal unit but with CCS
- 450-mile pipeline is built between Hempstead plant and ultimate CO2 enhanced oil recovery (EOR) storage site in AR
- Key changes relative to the "Business-as-Usual Scenario" (i.e., Scenario #1) that affect costs and GHG emissions:
  - Lower imports from SPP/SERC region
  - Higher share of coal relative to total in-state electricity generation
  - Coal-fired CO2 emissions in the 2020-2025 period still higher
  - Higher costs associated with CCS technology including pipeline to existing EOR site in AR

Generation results for 2025 …

		Total Coal Generation (GWH)	Total NG Generation (GWH)	Total Exported Generation (GWH)	Total Imported Generation (GWH)	Total Generation (production-based) (GWH)	Total Generation (consumption based) (GWH)
Scenario #1	no build of Hempstead plant BAU (THIS IS THE BAU)	27,599	7,691	0	10,658	54,917	65,573
Scenario #2	build Hempstead with no mitigation or technology upgrade	31,541	7,691	0	6,716	58,859	65,573
Scenario #3	build Hempstead with transition to carbon capture and storage with co2 going to the current pipeline in MS used to supply co2 for enhanced oil recovery	31,541	7,691	0	6,716	58,859	65,573
Scenario #4	same as Scenario #3 but carbon stored in underground formations in Arkansas, if possible	31,541	7,691	0	6,716	58,859	65,573
Scenario #5	build Hempstead plant with other technology upgrades, such as IGCC	31,541	7,691	0	6,716	58,859	65,573
Scenario #6a	Sensitivity 6(a) - NGCC-repowering in place of Hempstead	27,599	11,633	0	6,716	58,859	65,573
Scenario #6b	Sensitivity 6(b) - Offsets for Hempstead	27,599	11,633	0	6,716	58,859	65,573
Scenario #7a	Sensitivity 7(a) - displacement of Hemsptead generation by energy efficiency and wind	27,599	7,691	0	6,716	57,647	64,361
Scenario #7b	Sensitivity 7(b) - displacement of Hemsptead generaetion by energy efficiency, wind, and NGCC	27,599	9,055	0	6,716	57,647	64,361
Scenario #8	same as Scenario #4 but with Hempstead built in 2020; carbon stored in underground formations in Arkansas, if possible	31,541	7,691	0	6,716	58,859	65,573

Annual CO2e emission results for 2025 …

		Total Coal CO2e (MtCO2e)	Total NG CO2e (MtCO2e)	Total Exported CO2e (MtCO2e)	Total Imported CO2e (MtCO2e)	Total CO2e (production-based) (MtCO2e)	Total CO2e (consumption based) (MtCO2e)
Scenario #1	no build of Hempstead plant BAU (THIS IS THE BAU)	27.22	3.88	0.00	7.84	31.42	39.25
Scenario #2	build Hempstead with no mitigation or technology upgrade	30.65	3.88	0.00	4.94	34.85	39.78
Scenario #3	build Hempstead with transition to carbon capture and storage with co2 going to the current pipeline in MS used to supply co2 for enhanced oil recovery	29.67	3.88	0.00	4.94	33.87	38.80
Scenario #4	same as Scenario #3 but carbon stored in underground formations in Arkansas, if possible	29.67	3.88	0.00	4.94	33.87	38.80
Scenario #5	build Hempstead plant with other technology upgrades, such as IGCC	30.62	3.88	0.00	4.94	34.82	39.75
Scenario #6a	Sensitivity 6(a) - NGCC-repowering in place of Hempstead	27.60	5.30	0.00	4.19	33.23	37.41
Scenario #6b	Sensitivity 6(b) - Offsets for Hempstead	27.60	5.30	0.00	4.19	33.23	37.41
Scenario #7a	Sensitivity 7(a) - displacement of Hemsptead generation by energy efficiency and wind	26.82	3.88	0.00	4.94	31.02	35.95
Scenario #7b	Sensitivity 7(b) - displacement of Hemsptead generaetion by energy efficiency, wind, and NGCC	26.82	4.37	0.00	4.94	31.51	36.45
Scenario #8	same as Scenario #4 but with Hempstead built in 2020; carbon stored in underground formations in Arkansas, if possible	23.99	3.88	0.00	4.94	28.20	33.13

Annual CO2e emission reduction results for 2025 …

		Total Coal CO2e reductions (MtCO2e)	Total NG CO2e reductions (MtCO2e)	Total Exported CO2e reductions (MtCO2e)	Total Imported CO2e reductions (MtCO2e)	Total CO2e reductions (production-based) (MtCO2e)	Total CO2e reductions (consumption based) (MtCO2e)
Scenario #1	no build of Hempstead plant BAU (THIS IS THE BAU)	0.00	0.00	0.00	0.00	0.00	0.00
Scenario #2	build Hempstead with no mitigation or technology upgrade	-3.43	0.00	0.00	2.90	-3.43	-0.53
Scenario #3	build Hempstead with transition to carbon capture and storage with co2 going to the current pipeline in MS used to supply co2 for enhanced oil recovery	-2.45	0.00	0.00	2.90	-2.45	0.45
Scenario #4	same as Scenario #3 but carbon stored in underground formations in Arkansas, if possible	-2.45	0.00	0.00	2.90	-2.45	0.45
Scenario #5	build Hempstead plant with other technology upgrades, such as IGCC	-3.40	0.00	0.00	2.90	-3.40	-0.50
Scenario #6a	Sensitivity 6(a) - NGCC-repowering in place of Hempstead	-0.39	-1.42	0.00	3.65	-1.81	1.84
Scenario #6b	Sensitivity 6(b) - Offsets for Hempstead	-0.39	-1.42	0.00	3.65	-1.81	1.84
Scenario #7a	Sensitivity 7(a) - displacement of Hemsptead generation by energy efficiency and wind	0.40	0.00	0.00	2.90	0.40	3.30
Scenario #7b	Sensitivity 7(b) - displacement of Hemsptead generaetion by energy efficiency, wind, and NGCC	0.40	-0.49	0.00	2.90	-0.09	2.81
Scenario #8	same as Scenario #4 but with Hempstead built in 2020; carbon stored in underground formations in Arkansas, if possible	3.22	0.00	0.00	2.90	3.22	6.12

Cumulative CO2e emission reduction results 2009-2025 …

		Total Coal CO2e reductions (MtCO2e)	Total NG CO2e reductions (MtCO2e)	Total Exported CO2e reductions (MtCO2e)	Total Imported CO2e reductions (MtCO2e)	Total CO2e reductions (production-based) (MtCO2e)	Total CO2e reductions (consumption-based) (MtCO2e)
Scenario #1	no build of Hempstead plant BAU (THIS IS THE BAU)	0.00	0.00	0.00	0.00	0.00	0.00
Scenario #2	build Hempstead with no mitigation or technology upgrade	-48.02	0.00	0.00	38.09	-48.02	-7.61
Scenario #3	build Hempstead with transition to carbon capture and storage with co2 going to the current pipeline in MS used to supply co2 for enhanced oil recovery	-61.55	0.00	0.00	38.09	-61.55	-20.96
Scenario #4	same as Scenario #3 but carbon stored in underground formations in Arkansas, if possible	-61.55	0.00	0.00	38.09	-61.55	-20.96
Scenario #5	build Hempstead plant with other technology upgrades, such as IGCC	-47.60	0.00	0.00	38.09	-47.60	-7.19
Scenario #6a	Sensitivity 6(a) - NGCC-repowering in place of Hempstead	-6.22	-19.91	0.00	44.58	-26.13	20.63
Scenario #6b	Sensitivity 6(b) - Offsets for Hempstead	-6.22	-19.91	0.00	44.58	-26.13	20.63
Scenario #7a	Sensitivity 7(a) - displacement of Hemsptead generation by energy efficiency and wind	5.60	0.00	0.00	38.09	5.60	45.78
Scenario #7b	Sensitivity 7(b) - displacement of Hemsptead generaetion by energy efficiency, wind, and NGCC	5.60	-7.14	0.00	38.09	-1.54	38.66
Scenario #8	same as Scenario #4 but with Hempstead built in 2020; carbon stored in underground formations in Arkansas, if possible	19.33	0.00	0.00	17.41	19.33	36.75

Cost results …

		NPV (E6 2005$)	CSC (2005$/tCO2e)
Scenario #1	no build of Hempstead plant BAU (THIS IS THE BAU)	0	0
Scenario #2	build Hempstead with no mitigation or technology upgrade	-819	108
Scenario #3	build Hempstead with transition to carbon capture and storage with co2 going to the current pipeline in MS used to supply co2 for enhanced oil recovery	413	-20
Scenario #4	same as Scenario #3 but carbon stored in underground formations in Arkansas, if possible	413	-20
Scenario #5	build Hempstead plant with other technology upgrades, such as IGCC	-800	111
Scenario #6a	Sensitivity 6(a) - NGCC-repowering in place of Hempstead	-363	-50
Scenario #6b	Sensitivity 6(b) - Offsets for Hempstead	0	0
Scenario #7a	Sensitivity 7(a) - displacement of Hemsptead generation by energy efficiency and wind	10	0
Scenario #7b	Sensitivity 7(b) - displacement of Hemsptead generaetion by energy efficiency, wind, and NGCC	-304	-8
Scenario #8	same as Scenario #4 but with Hempstead built in 2020; carbon stored in underground formations in Arkansas, if possible	2,852	78

Summary results …

		GHG Reductions (MMtCO2e)			Net Present Value		
				Total	2009–2025	Cost- Effectiveness	
Policy No.	Policy Option	2015	2025	2009-2025	(Million $)	($/tCO$_2$e)	Level of Support
Scenario #1	no build of new Hempstead plant BAU (THIS IS THE BAU)						
Scenario #2	build Hempstead in 2012 with no mitigation or technology upgrade	-3.4	-3.4	-7.6	-$819	$107.7	Pending
Scenario #3	build Hempstead in 2012 with transition to CCS with CO2 piped to MS for enhanced oil recovery	-5.9	-2.5	-21.0	$413	-$19.7	Pending
Scenario #4	build Hempstead in 2012 with transition to CCS with CO2 stored in AR	-5.9	-2.5	-21.0	$413	-$19.7	Pending
Scenario #5	build Hempstead in 2012 as IGCC	-3.4	-3.4	-7.2	-$800	$111.2	Pending
Scenario #6a	build Hempstead in 2012, but with mitigation (NGCC-repowering)	-0.4	-0.4	7.3	-$363	-$49.6	Pending
Scenario #6b	build Hempstead in 2012, but with mitigation(Offsets)	-0.4	-0.4	0.0	$0	$0.0	Pending
Scenario #7a	no build of Hempstead, replaced with expanded energy efficiency, renewable energy, and natural gas (energy efficiency & wind)	0.4	0.4	45.8	$10	$0.2	Pending
Scenario #7b	no build of Hempstead, replaced with expanded energy efficiency, renewable energy, and natural gas (energy efficiency, wind, & NGCC)	0.4	0.4	38.7	-$304	-$7.9	Pending
Scenario #8	build Hempstead in 2020 with transition to CCS with CO2 stored in AR	0.0	3.2	36.7	$2,852	$77.6	Pending