BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

Docket No. 10M-245E

IN THE MATTER OF COMMISSION CONSIDERATION OF PUBLIC SERVICE COMPANY OF COLORADO PLAN IN COMPLIANCE WITH HOUSE BILL 10-1365, "CLEAN AIR-CLEAN JOBS ACT."

CROSS-ANSWER TESTIMONY

OF

LESLIE GLUSTROM

OCTOBER 8, 2010

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LIST OF EXHIBITS

(NOTE: There were 18 Attachments to Ms. Glustrom's Answer Testimony in this 10M-245E Docket, so numbering for the Cross Answer Testimony will begin with Exhibit LWG-19.)

Exhibit LWG-19
Peabody Energy 8-K—September 15, 2010
Power Point to Barclays Energy-Power Conference
Available from http://www.peabodyenergy.com/Investors/IRHome.asp

Exhibit LWG-20
Peabody Energy 8-K, July 23, 2008
Press Release Announcing Results for Period Ending June 30, 2008
Available from http://www.peabodyenergy.com/Investors/IRHome.asp

Exhibit LWG-21
E. China province forecasts power shortages in summer as coal supplies dwindle
Xinhua, May 28 2010
Available from http://business.globaltimes.cn/china-economy/2010-05/536558.html

Exhibit LWG-22
Coal India unable to meet supply targets
Hindu Business Line, Sept. 16, 2010
Available from
http://www.thehindubusinessline.com/2010/09/17/stories/2010091752660400.htm

Exhibit LWG-23
A global coal production forecast with multi-Hubbert cycle analysis
Patzek, T.W. and Croft, G.D. *Energy* 35, 3109-3122 (2010)

Exhibit LWG-24
Chapter D—National Coal Resource Assessment—Coal Resource Availability, Recoverability and Economic Evaluations--A Summary
USGS Professional Paper 1625-F, Luppens et. al. (2009)
Available from http://pubs.usgs.gov/pp/1625f/

Exhibit LWG-25
EIA Coal Reserves Data—1997 Update, Chapter 1
Available from http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html

Exhibit LWG-26
Top 15 Coal States Production 1985-Present (Sept 2009)
Based on Energy Information Administration Annual Coal Reports available at
http://www.eia.doe.gov/cneaf/coal/page/acr/acr_sum.html

Exhibit LWG-27
Direct Testimony of Xcel Witness Thomas Imbler
Docket 06S-234EG Colorado Public Utilities Commission
Available from www.dora.state.co.us

Exhibit LWG-28
Cost Benefit Analysis—Replacing Ontario's Coal Fired Electricity Generation
Prepared for the Onatario Ministry of Energy (2005)
Available from
http://www.mei.gov.on.ca/en/pdf/electricity/Cost%20Benefit%20Analysis%20DSS%20Report%20-%20Executive%20Summary.pdf

Exhibit LWG-29
The Hidden Costs of Energy—Report in Brief
National Academy of Sciences (2009)
Available from http://www.nap.edu/openbook.php?record_id=12794&page=R1#

Exhibit LWG-30
Hotter and Drier—The West's Changed Climate
Rocky Mountain Climate Organization (2008)
Available from
http://www.rockymountainclimate.org/website%20pictures/Hotter%20and%20Drier.pdf

Exhibit LWG-31
Perspectives on Climate Change and Sustainability
Chapter 20, Intergovernmental Panel on Climate Change, AR4, Yohe et al. (2007)
Available from http://ipcc.ch

Exhibit LWG-32
Public Service Company of Colorado 120 Day Report April RFP
Docket 07A-447E (2009)
Available from www.dora.state.co.us

Exhibit LWG-33
Cost of Cycling Analysis for Pawnee Station Unit 1: Phase 1 Top Down Analysis
Aptech Engineering for Xcel Energy (2008)
Submitted December 1, 2008, Docket 07A-447E. Available from www.dora.state.co.us

Exhibit LWG-34
Final Environmental Impact Statement Coal Lease by Application Wright Area—Executive Summary
Bureau of Land Management (2010)
Available from Bureau of Land Management, Casper Wyoming Office

Exhibit LWG-35
No Analysis of Powder River Basin Coal Supplies by PSCo
Discovery Response LWG 5-11, Docket 07A-447E (2008)
Attachment 48 to Answer Testimony of Leslie Glustrom, 07A-447E
Available from www.dora.state.co.us

Exhibit LWG-36
No Analysis of Colorado Coal Supplies by PSCo
Discovery Response LWG 5-12, Docket 07A-447E (2008)
Attachment 49 to Answer Testimony of Leslie Glustrom, 07A-447E
Available from www.dora.state.co.us

I. INTRODUCTION AND SUMMARY

Q: PLEASE STATE YOUR NAME, ADDRESS AND CONTACT INFORMATION

A: My name is Leslie Glustrom. I live at 4492 Burr Place, Boulder, Colorado. My phone number is 303-245-8637 and my e-mail address is lglustrom@gmail.com.

Q: DID YOU SUBMIT ANSWER TESTIMONY IN THIS DOCKET?

A: Yes.

Q: PLEASE SUMMARIZE THE PURPOSE OF YOUR CROSS-ANSWER TESTIMONY.

A: The purpose of my testimony is to provide the Commission with the following information and recommendations related to the Answer Testimony provided by other parties on September 17, 2010.

1) **Coal Supply Constraints:** Several parties (e.g. Peabody Energy, Colorado Mining Association, Associated Governments of Northwest Colorado) either state or imply a strong preference for relying on coal for the future, but none of the witnesses for these parties has provided a detailed assessment of economically recoverable coal supplies. Due to the very serious (but not yet widely recognized) constraints on US and world-wide coal supply, it is unlikely that coal will provide a reliable and economically beneficial fuel source very far into this century.[1] Coal supply constraints have already been experienced in Colorado and the short life spans of the country's largest mines-including those that supply Colorado coal plants—indicate that future reliance on coal is

[1] There are reports of large coal deposits in Mongolia that are not yet developed, but it would not appear to be economical to import coal from Mongolia to Colorado. An example of a report on the Mongolian coal supplies can be found at http://asianenergy.blogspot.com/2010/02/mongolian-coal-deposit-tavan-tolgoi-at.html . Presently Mongolia is a small coal producer at about 5 million tons per year. See http://www.mbendi.com/indy/ming/coal/as/mn/p0005.htm#Projects

not well placed. Further details are provided below and in the exhibits accompanying this Cross-Answer Testimony.

2) **Rising Coal Costs:** Parties that support a continued strong reliance on coal have generally failed to analyze recent increases in coal costs or the fundamental issues that are driving up coal costs. This issue was discussed at length in Ms. Glustrom's Answer Testimony and additional information is provided below.

3)**Failure to Recognize Colorado's Abundant Renewable Energy Potential:** Parties that support continued strong reliance on coal-fired generation for Xcel's Colorado system, generally assume that the choice for electric generation is a binary choice between coal and natural gas, without recognizing the abundant supply of renewable energy resources in Colorado and their ability to both be complemented by natural gas generation and in turn to displace significant amounts of natural gas-produced electricity. Colorado's abundant renewable energy potential and the existence of thousands of megawatts (MW) or renewable energy projects that are ready to brought on line in Colorado is discussed below.

4) **Difficulties of Integrating Increasing Levels of Renewable Energy with Coal Plants; Failure to Account for Increased Costs of Coal Cycling:** Parties that support continued strong reliance on coal plants for Xcel's Colorado system, have generally failed to recognize the difficulties associated with trying to accommodate increased levels of renewable energy with coal plants that are not easy to cycle. Parties that advocate strong future reliance on coal have generally not included any costs associated with cycling coal plants and as discussed below, these are likely to become

increasingly important in the coming years and decades. More information is provided below.

5) **Failure to Account for the External Costs of Coal:** Parties that support continued heavy reliance on coal plants have generally failed to account for the external public health and environmental costs of coal. While difficult to quantify with accuracy, many studies support the fact that there are significant public health and environmental costs of coal. Key studies will be discussed below and are provided for the Commission's consideration.

6) **The Societal Cost of Carbon:** Several parties that support continued heavy reliance on coal plants note that the United States has not yet put a price on carbon emissions, but they have failed to note that whether US policies recognize it or not, there is broad scientific and policy consensus that there is a societal cost for emissions of carbon dioxide. While estimates of the cost vary depending on a variety of assumptions, there is every reason to believe that the societal cost of carbon is **not** zero and that it is significant—if not precisely known. Key studies will be summarized below and are provided for the Commission's consideration.

7) **The Impossibility of Truly "Green" Coal Given the Laws of Thermodynamics:** Parties that support continued heavy reliance on coal fired power plants fail to recognize the workings of the Laws of Thermodynamics and their implications for hopes of making coal "clean and green." To begin with, the First Law of Thermodynamics, stated simply, says that "Energy and matter are conserved: they can't be created or destroyed." Attempting to remove pollutants from one waste stream (e.g. the air) simply puts these pollutants into another waste stream (e.g. coal ash). Atoms

(such as sulfur or mercury) can not be created or destroyed—they are just being put into a different waste stream. The Second Law of Thermodynamics, also stated simply, says that "Every time energy or matter is transformed, the entropy (or disorder) of the Universe increases." All efforts to make coal "clean" will require the transformation of energy and matter—and these transformations invariably lead to increased entropy production and sooner or later, society perceives this entropy as pollution of one form or another.

In addition, every transformation of matter or energy (including efforts to make coal "clean") will require energy (because all work requires energy) and this need for energy will increase the cost of producing coal-fired electricity (while not really cleaning it up.) Parties who have attempted to paint a vision of "clean and green" coal have failed to acknowledge the workings of the Laws of Thermodynamics. More information is provided below.

8) **The Status of Carbon Capture and Storage Technology:** Other parties are likely to address the barriers to widespread commercial carbon capture and storage techniques, but to help ensure a complete record, key updates outlining the challenges are provided for the Commission's consideration. Given the technical, economic and legal challenges facing carbon capture and storage proposals, the Commission would not be wise to assume that this technology will be available anytime soon. In addition, the coal supply constraints discussed in this Cross Answer Testimony mean that assumptions about "cheap and abundant" supplies of coal in this century are not well supported.

9) **The Impact of Coal on Xcel's Current Colorado Rates:** Several parties who support continued strong reliance on coal-fired power plants do not seem to be aware of

Xcel's current Colorado rates or the role that coal has played in increasing those rates. To ensure a complete and accurate record, information on the role of coal in increasing Xcel's Colorado rates is provided for the reference of other parties.

Q: PLEASE SUMMARIZE THE BASIS FOR THE RECOMMENDATIONS IN YOUR CROSS-ANSWER TESTIMONY.

A: The information that supports the recommendations of my Cross-Answer Testimony is summarized below in outline format for ease of reading. Additional information is provided in the attached Exhibits. [2](There were 18 Attachments that accompanied Ms. Glustrom's Answer Testimony in this 10M-245E docket, so the Exhibits accompanying this Cross Answer Testimony will begin with Exhibit 19.)

II. INTERNATIONAL COAL SUPPLY CONSTRAINTS

- While most Americans are oblivious to the issues of coal supply and cost, there is abundant information detailing how coal supply constraints are already being felt around the world and of the resulting increases in coal costs. One example of information on international coal supply constraints is a September 15, 2010 powerpoint presentation made to a Barclays Energy-Power investor group by Peabody Energy Chairman and Chief Executive Officer ("CEO"). A copy of this presentation was included with an 8-K filing made to the Securities and Exchange Commission by Peabody Energy on September 15, 2010. A copy of that 8-K filing and the Barclays presentation is Exhibit LWG-19.

[2] There were 18 Attachments included with Ms. Glustrom's Answer Testimony so the Exhibits associated with this Cross Answer Testimony will start with Exhibit 19.

- The Peabody Energy presentation included in Exhibit LWG-19 includes the following information on international coal demand and expected supply constraints (identified by slide in the Barclays presentation:
    - Most of the world has lower Gross Domestic Product ("GDP"), electricity use and steel production per capita than countries such as the United States, Germany and Japan. (See slides 6-8 in Exhibit LWG-19.) Peabody considers this a sign that the rest of the world is in the early stages of what Peabody Energy refers to as "Coal's Supercycle." (See slide 5 in Exhibit LWG-19.)
    - Increases in GDP, electricity use and steel production in much of the developing world are expected to lead to large increases in coal demand, led by increased demand in Asia. (See slides 10-12, 16, 18-19 in Exhibit LWG-19.)
    - Short supply of seaborne coal over the next five years is expected to create "strong pricing drivers." (See slide 13 in Exhibit LWG-19.)
    - China and India are expected to be increasingly dependent on coal imports in the coming years. (See slides 18-20 in Exhibit LWG-19.)
    - As a result of the present coal supply and demand situation internationally, Peabody Energy expects to see increased margins in the coming years. (See slide 4 in Exhibit LWG-19.)

- Another example of international coal supply constraints is found in Exhibit LWG-20 which is an 8-K report containing Peabody Energy's July 23, 2008 press

release on earnings and which detailed the growing coal supply constraints found around the world including:

  - Strong increased demand from India and coal supply constraints in South Africa and elsewhere (See page 4 in Exhibit LWG-20.)
  - 60 coal plants sitting idle in China due to coal supply constraints (See pages 2-4 in Exhibit LWG-20.)
  - Increasing prices and profits for Peabody Energy from coal sales (See for example page 2 in Exhibit LWG-20.)

- Exhibits LWG-21 and LWG-22 are examples of the numerous media stories detailing coal supply constraints in India and China.
- A recent academic study of coal production Hubbert Curves projects that global peak coal is imminent. The authors of the paper predict global coal production to peak in 2011. See Exhibit LWG-23.
- Increased concern about the effects of climate change and the numerous health and environmental impacts of burning coal is leading to increased opposition to international coal trade. For example, on September 26, 2010, Rising Tide activists shut down Australia's largest coal port at Newcastle.[3]
- All of these developments related to international coal supply constraints are reasons for the Colorado Public Utilities Commission to limit exposure to what could be significant supply and price shocks related to future heavy reliance on

[3] A Reuter's story on Rising Tide activists shutting down Australia's largest coal port, is available at the following link http://uk.reuters.com/article/idUKTRE68P00X20100926 . A report on the action shutting down the Australian coal port from the Australian branch of Rising Tide is available here http://www.risingtide.org.au/ .

coal fired generation. Coal supply constraints in the United States and Colorado are discussed below.

III. US COAL SUPPLY CONSTRAINTS

- Parties that advocate for continued strong reliance on coal for generation on Xcel's Colorado system appear to assume that coal will continue to show up for decades to come and that the price will remain low—yet no witnesses in this docket (including any of those that support strong continued reliance on coal) apparently[4] offers a detailed assessment of coal supplies or recent or projected coal cost increases. The truth about U.S. coal supplies is very different than the "200 year supply" that is often quoted in the media. A detailed assessment of US coal supplies can be found in Attachment 6 to Ms. Glustrom's Answer Testimony in this 10M-245E docket.
- A careful assessment of information from the Energy Information Administration ("EIA"—which does not assess coal "reserves" for economic accessibility), the United States Geologic Survey ("USGS"—which does assess coal supplies for economic recoverability and typically finds that less than 20% of US coal supplies are likely to be economically recoverable) combined with an analysis of the remaining life span of the major US coal mines, including those in the Powder River Basin (which typically have less than a 20 year life span and many are under 10 years) leads to the conclusion that our planning horizon for moving beyond coal is much closer to 20 years than to 200 given the very serious

[4] This is a large and complicated docket. Ms. Glustrom has been unable to locate a thoughtful assessment of coal supplies or future cost projections in the testimony filed to date in this docket. If Ms. Glustrom has missed such a detailed assessment of future coal supplies and costs in the testimony and exhibits in this docket she apologizes.

geologic, legal, economic and transportation constraints facing future coal mine expansion. The very real and very serious constraints on US coal supply have been repeatedly overlooked by essentially everyone in the United States—government officials, coal-dependent utilities, the media and even most academics. The Attachments and Exhibits included with Ms. Glustrom's testimonies provide the interested reader with relatively easy access to the information that is available—but which has been generally ignored until recently.

> A detailed assessment of US coal supplies indicates that our planning horizon for moving beyond coal is much closer to 20 years than to the 200 years that is so often claimed.[5]

- Much of the coal in the United States is **not** expected to be economically recoverable. Studies in various coal regions of the US have been undertaken as part of the National Coal Resource Assessment ("NCRA"), with the studies on

[5] The details on why the planning horizon for moving beyond coal in the United States is closer to 20 years than to 200 is found in the Answer and Cross-Answer Testimony of Leslie Glustrom in this 10M-245E docket and the accompanying Attachments and Exhibits. One key to understanding the confusion is to recognize that the Energy Information Administration ("EIA") has been publishing coal "reserve" information as though the coal reserves will be economically accessible—when in reality the EIA had no information on economic recoverability of US coal supplies and readily acknowledges that. A detailed assessment of coal supplies identifies very significant coal supply constraints already facing the United States (and the rest of the world) and which are likely to become increasingly obvious as more utilities, regulators, industry representatives and elected officials begin to examine the information that is available—but generally ignored—on US coal supply constraints (and increasing costs.) Much of this information can be found in the Attachments and Exhibits submitted by Ms. Glustrom in this docket and summarized in her testimonies.

economic recoverability summarized in Chapter D of the NCRA which is Exhibit LWG-24). As seen on page 12 of Exhibit LWG-24, the USGS has repeatedly found that less than 20% of the coal resources considered is likely to be economically recoverable.

- The fact that Energy Information Administration estimates of coal reserves (that have so often led to the erroneous statement about the US having a "200 year supply of coal") have not been assessed for economic recoverability is acknowledged in the first few sentences of Chapter 1 of the 1997 EIA Coal Reserve Update. (See Exhibit LWG-25). The full EIA 1997 coal reserve update is available from the following link: http://www.eia.doe.gov/cneaf/coal/reserves/front-1.html. The EIA says the following about its estimates of coal "reserves."

> **The usual understanding of the term "reserves" as referring to quantities that can be recovered at a sustainable profit cannot technically be extended to EIA's estimated recoverable reserves because economic and engineering data to project mining and development costs and coal resource market values are not available.** (See page 1 of Exhibit LWG-25; Emphasis and underlining added.)

- An analysis of coal production by the top 15 coal-producing states in the United States indicates that all of the top 15 states are apparently past the peak in their coal production except Wyoming and Montana. (See Exhibit LWG-26.) While it is possible that production could increase significantly in the states that are past peak, given the geologic, economic, legal and transportation constraints that are facing future coal mine expansion, large future increases in production do not appear likely.

- The parties that propose strong reliance on coal don't provide any perspective on the growing opposition to coal mining—both to Mountain Top Removal ("MTR") in the eastern United States[6] and to leasing of federal coal[7] and failure to enforce reclamation standards in the western United States. Increasing regulation and/or the increased enforcement of existing regulations could easily lead to increased production costs for coal which have not been recognized by the parties promoting continued strong reliance on coal for Xcel's system in Colorado. Information on coal mine reclamation efforts in Wyoming can be found in Attachment 11 to the Answer Testimony of Ms.Glustrom in this 10M-2545E docket.
- Information on the life spans of the largest coal mines in Wyoming can be found in the Final Environmental Impact Statement for the Wright Area Coal Leasing by Application. The Executive Summary of the Wright Area FEIS is included as Exhibit LWG-34. The Tables on pages ES-15 through ES-16 indicate that the existing coal mines in the Wright area—the largest in the country which combined contribute over 20 percent of our country's coal all have life spans of less than 10 years. The FEIS examines possible expansions of these Wright area mines, but even if the expansions, many of which require working around or moving surface constraints such as roads and the joint PRB rail line, the expansions typically only add less than 10 years to the life

[6] A *Los Angeles Times* story on the Mountain Top Removal protest in front of the White House on September 27, 2010 which led to the arrest of approximately 100 people can be found at http://articles.latimes.com/2010/oct/03/nation/la-na-mining-20101003 .

[7] A summary of the effort by Wild Earth Guardians to challenge coal leasing in the Powder River Basin of Wyoming can be found at the following link http://www.wildearthguardians.org/library/paper.asp?nMode=1&nLibraryID=861 . The legal filings can be accessed from the given link.

span of the mine.[8] Table 3-7 on page 3-14 of the Wright Area Coal Lease Application Final Environmental Impact Statement is reproduced below. It shows how the amount of overburden will be increasing in the areas that the mines expand into. Moving more overburden is highly likely to increase the costs of producing the coal (and reclaiming the disturbed areas) and will likely lead to increases in the costs of coal in future years.

Table LWG-1
Increased Overburden for the Wright Area Coal Mine Proposed Expansions
Powder River Basin, Wyoming

Table from page 3-14, Final Environmental Impact Statement Wright Area Coal Lease by Applications, Wyoming Bureau of Land Management (2010)

3.0 Affected Environment and Environmental Consequences

Table 3-7. Average Overburden, Interburden, and Coal Thicknesses and Approximate Postmining Surface Elevation Changes of the Six WAC LBA Tracts.

LBA Tract and Configuration	Overburden Thickness (ft)	Interburden Thickness (ft)	Total Coal Thickness (ft)	Swell Factor (percent)	Coal Recovery Factor (percent)	Postmining Elevation Change[1]
North Hilight Field						
Proposed Action	246	1	61	16	92	16.6 ft lower
Alternative 2	246	1	61	16	92	16.6 ft lower
South Hilight Field						
Proposed Action	292	94	81	16	92	12.8 ft lower
Alternative 2	292	94	81	16	92	12.8 ft lower
West Hilight Field						
Proposed Action	428	32	93	16	92	12.0 ft lower
Alternative 2	428	32	93	16	92	12.0 ft lower
Alternative 3	428	32	93	16	92	12.0 ft lower
Existing Black Thunder Mine Leases						
No Action Alternative for North, South and West Hilight Field LBA Tracts	282	Included with overburden	78	16	92	26.6 ft lower
West Jacobs Ranch						
Proposed Action	475	0	102	18	90	6.3 ft lower
Alternative 2	486	0	104	18	90	6.1 ft lower
Existing Jacobs Ranch Mine Leases						
No Action Alternative for West Jacobs Ranch LBA Tract	168	9	57	18	90	19.4 ft lower
North Porcupine						
Proposed Action	343	0	75	15.5	92	15.8 ft lower
Alternative 2	354	0	75	15.5	92	13.9 ft lower
South Porcupine						
Proposed Action	346	11	76	15.5	92	14.7 ft lower
Alternative 2	347	10	76	15.5	92	14.7 ft lower
Existing North Antelope Rochelle Mine Leases						
No Action Alternative for North and South Porcupine LBA Tracts	211	17	71	15.5	92	30.0 ft lower

[1] Reclaimed (postmining) surface elevation change calculated as: ((overburden thickness + interburden thickness) × swell factor) − (coal thickness × coal recovery factor).

Final EIS, Wright Area Coal Lease Applications

[8] The Jacobs Ranch mine proposed expansion would provide more than a 10 year expansion, but the Jacobs Ranch mine is the smallest mine in the Wright Area, providing less than 5% of our country's coal.

These increasing levels of overburden (and the probable increased production costs) are typical for proposed expansions of the Powder River Basin("PRB") mines as the expansions involve retrieving coal that is farther down the sides of the "basin" that is the nature of the coal formation in the Powder River **Basin**. Further information is available in the Attachments accompanying the Answer Testimony of Leslie Glustrom in this 10M-245E docket.

- Exhibits LWG-35 and LWG-36 indicate that until recently PSCo had not conducted any analyses of long term coal supplies from either the Powder River Basin or Colorado coal mines.

IV. COLORADO COAL SUPPLY CONSTRAINTS

- Colorado has already experienced coal supply constraints involving Colorado coal. These are documented in Attachment 14 to the Answer Testimony of Ms. Glustrom in this 10M-245E docket, discussing the *force majeure* events and the failure of Colorado coal mines to deliver coal they were contracted to deliver to Xcel's Colorado coal plants in late 2008 and early 2009.
- Colorado has already experienced coal supply constraints for coal coming to Colorado from Wyoming as discussed in Exhibit LWG-27. These constraints were the result of train track problems that interrupted coal deliveries in 2005 and 2006. Further information on these coal supply disruptions can be found in the 06S-234EG docket at the Colorado PUC.
- According to page 10 of PSCo's 10-K filed with the Securities and Exchange Commission on March 1, 2010, at the time PSCo only had 19% of its coal contracted for 2012. The low percentage of coal that PSCo has contracted for in

2012 and beyond is an indication that PSCo has few (if any) long term coal contracts that extend for more than about 3 years.

- Several other witnesses have testified as to the price volatility and long-term supply and cost risks associated with natural gas.[9] Given what is known about international, national and Colorado constraints on coal supply and potential cost risk, Xcel rate payers will be best protected if the Commission minimizes the long-term commitment to generation resources that require either coal or natural gas—consistent with the need to provide adequate back-up generation and voltage support. This supports the arguments made by several witnesses not to make a decision about the second 1 x 1 combined cycle plant at Cherokee at this point in time.

V. RISING COAL COSTS

- Through the decade from 1990-2000 and the early part of the 2000-2010 decade, Xcel (and many other utilities) had long term coal contracts that kept the cost of coal low and stable. Beginning in 2005, Xcel' long-term coal contracts for its Colorado coal plants began to expire (See Exhibit LWG-27) and the cost of coal for Xcel's Colorado plants began to increase significantly.
- In 2005, Xcel paid an average of $1/MMBTU (million British Thermal Units) and in 2009 Xcel paid just over $1.50/MMBTU for coal for its Colorado coal plants. That is, Xcel's cost of coal for its Colorado coal plants went up over 50% in a four year period—or over 10% per year from 2005-2009. Details on Xcel's cost

[9] For an example of testimony on the long-term supply and price risks associated with natural gas, see the Answer Testimony of David Montgomery on behalf of Peabody.

of coal for its Colorado coal plants was provided in the Answer Testimony and Attachments of Leslie Glustrom in this 10M-245E Docket.

- Data from the Energy Information Administration on the average cost of coal delivered to Colorado electric utilities from 2005-2009, as shown in Table LWG-2 below also shows the significant increases in coal costs for Colorado utilities that began in 2006.

Table LWG-2
Average Cost of Coal Delivered to Colorado Electric Utilities
2005-2009

Data from EIA Electric Power Monthly Reports
(Year end data from the March reports of the following year.)
Available from http://www.eia.doe.gov/cneaf/electricity/epm/matrix96_2000.html

Year	2005	2006	2007	2008	2009
Average Cost of Coal Delivered ($/MMBTU)	1.06	1.27	1.26	1.43	1.56
Percent change Year-Over-Year		19.8%	–0.8%	13.5%	9.1%

- Despite the clear evidence from its own coal costs, Xcel continues to assume that the cost of coal will increase about 2% per year. See for example, Supplemental Attachment J submitted by Xcel in this 10M-245E Docket on June 30, 2010 which shows less than a 2% per year increase in coal costs from 2009-2046. Despite several requests from Ms. Glustrom for Xcel to model coal costs at an escalation rate of 5-10% per year or more—and despite two decisions from the

Colorado PUC directing Xcel to do so,[10] Xcel continued to model coal at an escalation rate of 2% per year or less. While Xcel provided a "high-coal cost" scenario, this scenario only assumed that costs were 120% of the assumed coal costs. The variable that has the largest impact on future coal costs is the escalation rate as shown in the Answer Testimony of Leslie Glustrom in this 10M-245E docket and summarized below.

[Rest of page left intentionally blank.]

[10] By Decision C10-0808, the Commission gave the following direction to Xcel (i.e. "Public Service"):

> We shall therefore require Public Service to consider the comments raised by the parties in their July 6, 2010 filings in order **to ensure that the modeling sensitivities will provide a sufficiently wide swath of possibilities**. **In other words, the bounds of the sensitivities should address the parties' views on the model inputs and assumptions** so that the results will assist them in assessing the merits of the emission reduction plan and the proposed alternatives in the Company's August 2010 filing. (Decision C10-0808, ¶38, pages 14-15. Emphasis added).

By Decision C10-0853, the Commission restated its intention to require Xcel to run a sufficiently wide swath of scenarios that cover the parties position on the assumptions used. The Commission statement in Decision C10-0583 is as follows:

> By Decision C10-0808, mailed on July 30, 2010, we required Public Service to consider the comments of Ms. Glustrom and other parties regarding the inputs and assumptions to the STRATEGIST modeling. The "sensitivities" that Public Service will conduct are intended to illustrate the impacts of a range of reasonable views of projected fuel costs, such that parties, including Ms. Glustrom, can draw conclusions about their own positions on the costs and rate impacts of Public Service's emission reduction plan. (Decision C10-0853, ¶11, page 3).

When Xcel did not model sensitivities that included a range of coal cost escalations to include the 5-15% range suggested by recent 10% per year coal cost increases, the Commission (in Decision C10-0963) declined to enforce their earlier direction to Xcel on the modeling of a "sufficiently wide swath of possibilities" when it came to fuel costs.

Table LWG-3
Summarized Coal Costs* from
Supplemental Attachment J,[11] Plus 20% "High" Coal Costs
Compared to 5% and 10% Per Year Escalation Costs [12]

Year	(A) Coal Cost From Supplemental Attachment J	(B) 120% of The Coal Cost in (A)	(C) Coal Cost Escalated at 5% Per Year	(D) Coal Cost Escalated at 10% Per Year
2010	**$1.77**	**$2.12**	**$1.77**	**$1.77**
2020	**$2.07**	**$2.48**	**$2.88**	**$4.59**
2030	**$2.11**	**$2.53**	**$4.70**	**$11.91**
2040	**$2.47**	**$2.96**	**$7.65**	**$30.89**
2046	**$3.02**	**$3.62**	**$9.76**	**$49.74**

- It is clear from Table LWG-3 that using coal cost escalation rates of 5% and 10% per year lead to much higher coal costs than those assumed in Xcel's "high-coal cost" scenario. Given that Xcel's coal costs have been increasing at a rate above 10% per year for the last four years and that an analysis of the geologic, legal and economic constraints facing coal mine expansion indicates that it will be increasingly difficult—and expensive—to extract the remaining coal on the

[11] Supplemental Attachment J was submitted by Xcel in this 10M-245E Docket on June 30, 2010 as part of the "Fourth Production of Documents."
[12] Coal costs escalated at 5% or 10% per year can be quickly calculated using an online compound interest calculator such as http://www.moneychimp.com/calculator/compound_interest_calculator.htm .

planet, then it becomes critical to consider the possible economic impacts of significantly increasing coal costs.

- The increased costs of coal supply for the Cherokee 4, Pawnee and Valmont plants for key periods of time assuming coal cost escalation rates between 5% and 15% per year are summarized in the tables LWG-4 through LWG-6 below.

Table LWG-4
Potential Increased Cost of Coal for the Cherokee 4 Coal Plant from 2017-2022
Assuming 5%, 10% and 15% Per Year Increases Above 2009 Coal Cost Escalation Provided by Xcel*

Annual Percentage Increase in the Cost of Coal	Potential Increased Cost of Coal 2017-2022**
5% Per Year	$120 Million in Additional Cost
10 % Per Year	$382 Million in Additional Costs
15% Per Year	$774 Million in Additional Costs

*2009 Coal Costs Provided by Xcel in Response to Discovery Response LWG 2-4, Docket 10M-245E which is Attachment 3 to the Answer Testimony of Leslie Glustrom in this 120M-245E Docket. Cost escalation presumably used by Xcel derived from Supplemental Attachment J filed by Xcel in this Docket on June 30, 2010.

**Spreadsheets showing calculations of increased cost above those apparently calculated by Xcel were provided in response to PSCo Discovery Request 1-1 to LWG; Response provided by Leslie Glustrom to Xcel on September 22, 2010.)

- Table LWG-4 above indicates that merely for the 5-year period from 2017-2022, using a more realistic coal cost escalation rate for the Cherokee 4 coal plant could lead to increased costs ranging from $120 million (for a 5% per year escalation rate) to $774 million (for a 15% per year escalation rate). While no one can accurately predict future fossil fuel costs, the Commission should consider the possibility that if coal costs increase at 5% per year or more—which there is good

reason to believe they will—then keeping the Cherokee 4 coal plant running until 2022 could cost ratepayers several hundred million more dollars in fuel costs that are passed straight through to rate payers under Xcel's Electric Commodity Adjustment. [13]

Table LWG-5
Increased Cost of Coal for the Pawnee Coal Plant
from 2017-2022 and 2022 to 2041
Assuming 5% and 10% Per Year Increases
Above 2009 Coal Cost and Escalation Rate Provided by Xcel*

Annual Percentage Increase in the Cost of Coal	Potential Increased Cost of Coal 2017-2022**	Potential Increased Cost of Coal 2022-2041**
5% Per Year	$90 Million in Additional Costs	$761 Million in Additional Costs
10 % Per Year	$287 Million in Additional Costs	$3,989 Million (e.g. $3.99 Billion) in Additional Costs

*2009 Coal Costs Provided by Xcel in Response to Discovery Response LWG 2-4, Docket 10M-245E which is Attachment 3 to the Answer Testimony of Leslie Glustrom in this 120M-245E Docket. Cost escalation presumably used by Xcel derived from Supplemental Attachment J filed by Xcel in this Docket on June 30, 2010.

**Spreadsheets showing calculations provided in response to PSCo Discovery Request 1-1 to LWG; Response provided by Leslie Glustrom to Xcel on September 22, 2010.)

- Table LWG-5 above indicates that a coal cost escalation rate between 5% and 10% per year could add hundreds of millions of dollars of increased costs to Xcel's projections for keeping the Pawnee coal plant operating past 2017. Attempting to operate the Pawnee coal plant to 2041[14] with coal costs escalating

[13] For a summary of Xcel's rates, see Tariff Sheets 20-23 under Colorado electric tariffs at www.xcelenergy.com.
[14] Xcel has proposed a retirement date of 2041 for Pawnee in in Discovery Request LWG 1-6 which is Attachment 5 to the Answer Testimony of Leslie Glustrom in this 10M-245E Docket.

at 10% per year could lead to almost $4 billion in increased coal costs.[15] If coal costs escalate at a higher rate than 10% per year, then of course the additional costs would be even higher. Xcel bears none of the risk for these future fuel costs, but does earn increased revenue from investments that are put into rate base and granted the weighted average cost of capital when determining Xcel's cost of service. As a result, there is additional need for the Commission to consider the potential impact on rate payers of future fossil fuel costs that are not adequately reflected in the modeling scenarios run by Xcel for this 10M-245E docket and as shown in Tables LWG-4 through LWG-6.

Table LWG-6
Potential Increased Cost of Coal
for the Valmont 5 Coal Plant from 2011-2017
Assuming 5%, 10% and 15% Per Year Increases
Above 2009 Coal Cost and Escalation Rate Provided by Xcel*

Annual Percentage Increase in the Cost of Coal	Potential Increased Cost of Coal 2011-2017**
5% Per Year	$29 Million in Additional Costs
10 % Per Year	$86 Million in Additional Costs
15% Per Year	$156 Million in Additional Costs

*2009 Coal Costs Provided by Xcel in Response to Discovery Response LWG 2-4, Docket 10M-245E which is Attachment 3 to the Answer Testimony of Leslie Glustrom in this 120M-245E Docket. Cost escalation presumably used by Xcel derived from Supplemental Attachment J filed by Xcel in this Docket on June 30, 2010.

[15] Xcel's models discount future fuel costs (at a rate of 7% -ck) in accordance with Decision C09-0829. This practice of discounting future fuel costs tends to reduce the Present Value Revenue Requirement (PVRR) for fossil fuel generating options, but this is a questionable practice because discounting is a practice that allows Xcel to compare the time value of money and investment streams that occur over extended periods of time. Yet, it is not Xcel that will be paying the coal costs, but rather rate payers and rate payers are not known for investing their money in ways that will allow them (or their children or grandchildren) to pay future fuel costs for Xcel's fossil fuel generating fleet.

**Spreadsheets showing calculations provided in response to PSCo Discovery Request 1-1 to LWG; Response provided by Leslie Glustrom to Xcel on September 22, 2010.)

- Table LWG-6 shows that the potential additional costs that could be borne by rate payers from keeping the Valmont 5 coal plant in Boulder operating from 2011 to 2017 range from $29 million (at a 5% per year escalation rate) to $186 million (at a 15% per year escalation rate. As the Commission considers the decision of whether to keep the Valmont 5 coal plant operating, it is important to consider these potential increased costs of coal.
- Xcel bears none of the risk for the potential future fuel costs, but typically does earn increased revenue from investments that are put into rate base and granted the weighted average cost of capital when determining Xcel's cost of service. As a result, there is additional need for the Commission to consider the potential impact on rate payers of future fossil fuel costs that are not adequately reflected in the modeling scenarios run by Xcel for this 10M-245E docket and as shown in Tables LWG-4 through LWG-6.
- While the future cost of natural gas is also uncertain—and likely to be increasing at a significant rate, gas turbines can cycle more easily than coal plants and can thereby be used to complement fuel-free renewable energy technologies with variable generation profiles such as wind and solar. This issue will be discussed further below.

VI. RISKS ASSOCIATED WITH COAL CONTRACTS

- The fact that coal contracts can include price reopeners and other price adjustment features is acknowledged by Peabody Energy. For example, the Peabody Energy 10-K filed February 24, 2010 [16] said the following on page 6 about its intentions for US coal supply contracts:

> *U.S.* We expect to continue selling a significant portion of our coal under long−term supply agreements. Customers continue to pursue long−term sales agreements as the importance of reliability, service and predictable prices are recognized. The terms of coal supply agreements result from competitive bidding and extensive negotiations with customers. Consequently, the terms of these agreements vary significantly in many respects, including price adjustment features, price reopener terms, coal quality requirements, quantity parameters, permitted sources of supply, treatment of environmental constraints, extension options, force majeure, and termination and assignment provisions. Our strategy is to selectively renew, or enter into new, long−term supply agreements when we can do so at prices we believe are favorable.

- As noted in the paragraph above from page 6 of Peabody's 2009 Annual Report, Peabody's coal contracts include a number of clauses that protect Peabody's interests. These "price adjustment features, price reopener terms…force majeure and termination and assignment provisions." are similar to the uncertainties that Peabody witness Montgomery raised about natural gas supply contracts, including the proposed contract with Anadarko.
- Page 18 of Peabody's 2009 Annual 10-K report adds the following regarding their ability to reopen coal contracts:

> Many of our coal supply agreements contain provisions that permit the parties to adjust the contract price upward or downward at specified times. We may adjust these contract prices based on inflation or deflation and/or changes in the factors affecting the cost of producing coal, such as taxes, fees, royalties and changes in the laws regulating the mining, production, sale or use of coal. In a limited number of contracts, failure of the parties to agree on a price under those provisions may allow either party to terminate the contract. We sometimes experience a reduction in coal prices in new long−term coal supply agreements replacing some of our expiring contracts. Coal supply agreements also typically contain force majeure provisions allowing temporary suspension of performance by us or the customer during the duration of specified events beyond the control of the affected party. Most coal supply agreements contain provisions requiring us to deliver coal meeting quality thresholds for certain characteristics such as Btu, sulfur content, ash content, grindability and ash fusion temperature. Failure to meet these specifications could result in economic penalties, including price adjustments, the rejection of deliveries or termination of the contracts. Moreover, some of these agreements permit the customer to terminate the contract if transportation costs, which our customers typically bear, increase substantially. In addition, some of these contracts allow our customers to terminate their contracts in the event of changes in regulations affecting our industry that restricts the use or type of coal permissible at the customer's plant or increase the price of coal beyond specified limits.

[16] All of Peabody Energy's Securities and Exchange Commission filings can be found on the Peabody Energy website under information for investors. The direct link is http://www.peabodyenergy.com/Investors/IRHome.asp .

- On page 38 of Peabody Energy's 2009 Annual Report, the company said the following about the risks associated with coal mining:

> As discussed more fully in Item 1A. Risk Factors, our results of operations in the near−term could be negatively impacted by the rate of the economic recovery, adverse weather conditions, unforeseen geologic conditions or equipment problems at mining locations and by the availability of transportation for coal shipments. On a long−term basis, our results of operations could be impacted by our ability to secure or acquire high−quality coal reserves, find replacement buyers for coal under contracts with comparable terms to existing contracts, or the passage of new or expanded regulations that could limit our ability to mine, increase our mining costs, or limit our customers' ability to utilize coal as fuel for electricity generation. In the past, we have achieved production levels that are relatively consistent with our projections. We may adjust our production levels further in response to changes in market demand.

The risks discussed by Peabody related to geology, weather, equipment, ability to acquire high-quality coal reserves, expanded regulation of mining and increased mining costs are all risks that would also be borne by Xcel's Colorado rate payers if Xcel retains its high reliance on coal as suggested by the witnesses for Peabody Energy, the Colorado Mining Association and the Associated Governments of Northwest Colorado.

Given uncertainties about supply and cost of both natural gas and coal, the Commission can best protect Xcel ratepayers from these risks by minimizing long-term commitments to either fossil fuel—consistent with the need to maintain adequate generation capacity and transmission stability.

VII. EXTERNAL COSTS OF COAL

- Exhibit LWG-28 is a summary of a cost benefit analysis done in the Canadian province of Ontario showing that adding in health costs adds significant costs to the production of electricity with coal. Page 3 of the analysis notes that while the costs of producing electricity from coal plants is only about $37/MWh (or 3.7 cents/kwh), when the environmental and health costs are added, the costs rise to $164/MWh (or 16.4 cents/kwh). Once Ontario realized the large environmental

and health costs it was paying for producing electricity with coal, it made a commitment to retire all of its coal plants by 2014.[17]

- Exhibit LWG-29 is a summary of the 2009 National Academy of Sciences study on the Hidden Costs of Energy.[18] Again (on page 2), the NAS study notes that the non-climate pollution arising from coal-fired generation adds significant costs if it were included in the cost of electric generation. The NAS put the average cost at 3.2 cents/kwh of coal-fired generation, with dirtier plants contributing higher costs and cleaner plants contributing fewer of the costs. External costs associated with climate impacts were estimated to cause between 1 and 10 cents/kwh of societal costs. (See page 3, Exhibit LWG-29).
- Exhibit LWG-31 is a study of environmental impacts from climate change in the West including increased drought, less water, increased forest loss, reduced agricultural yields and increased forest fires. Again, these are very real costs that should be factored into the decisions of the PUC related to future reliance on coal-fired generation by Xcel in Colorado.
- A full description of the science of climate change can be found in the reports of the Intergovernmental Panel on Climate Change found at www.ipcc.ch. The costs of a changing climate and real and very serious whether we are talking about dead and dying forests in Colorado, increased forest fires in the West, increased tropical storms in the oceans or increased flooding around the globe, or the acidification of oceans, loss of coral reefs or loss of significant numbers of

[17] A September 29, 2010 update on Ontarios efforts to close its coal plants, and it ability to move the retirement of four of the plants up to October 1, 2010 can be found at http://www.foxbusiness.com/markets/2010/09/29/official-ontario-shut-power-plants-coal-phase/ .

[18] The full National Academy of Sciences report can be found at **http://www.nap.edu/catalog/12794.html** .

species. Emissions of carbon dioxide from coal plants is the largest single contributor of greenhouse gas emissions in Colorado[19] and the Commission should consider the very real economic impacts of carbon dioxide emissions (and of the ability of natural gas plants to create a bridge to a renewable energy future as discussed below) when deciding how strongly Xcel should rely on coal-fired generation in Colorado in the coming years.

- To get a feel for the very real economic impacts of climate change on Colorado, the University of Colorado has produced a number of videos that discuss the economic and ecological impacts of a warmer and drier Colorado. Two of these videos can be found at the following links:

  http://learnmoreaboutclimate.colorado.edu/full-scientist-interviews-and-links/a-hotter-drier-colorado

  http://learnmoreaboutclimate.colorado.edu/full-scientist-interviews-and-links/listening-to-colorados-ecology

- To get an estimate of the approximate magnitude of the external costs associated with Xcel's Colorado coal plants, some rough calculations can be done using the number of MWh produced by Xcel's plants in 2008 and 2009. These numbers can be found in Attachments 2 and 3 to Ms. Glustrom's Answer Testimony. These numbers range from about 1 million MWh per year (e.g. Valmont 5) to about 3.5 million MWh (Pawnee in 2008). If external costs are assigned a value of $30/MWH (or 3 cents/kwh) then operation of Xcel's larger Colorado coal plants

[19] The inventory of Colorado's greenhouse gas emissions can be found at http://www.coloradoclimate.org/ewebeditpro/items/O14F13894.pdf . In 2005, coal-fired emissions were calculated to contribute 34.9 million metric tons of CO2 equivalent to total emissions of 116.1 million metric tons in Colorado. For 2010, coal-fired generation was projected to contribute 40 million metric tons of CO2 equivalent to total emissions of 129.3 million metric tons.

that are being considered in this docket (e.g. Cherokee 4, Valmont 5 and Pawnee) are adding between $30 and $90 million a year in external costs in Colorado. Exhibits LWG 29 through 31 would indicate that 3 cents/kwh is probably a conservative estimate of the external costs of operating coal plants. While exact numbers are impossible to determine, clearly the external costs associated with generating electricity from coal are real and substantial and should be factored into the Commission's decision in this docket.

VIII. RECOGNIZING COLORADO'S ABUNDANT POTENTIAL FOR WIND, SOLAR AND OTHER RENEWABLE ELECTRICITY GENERATION

- Parties that are advocating for a continued strong reliance on coal in Colorado attempt to portray Xcel's plan as a plan to simply replace coal-fired generation with natural gas generation. These parties do not appear to recognize a) the potential for renewable energy generation in Colorado, b) the potential to displace natural gas generation with renewable generation or c) the difficulties and costs associated with cycling coal plants to complement renewable energy generation.
- According to page 10 of Xcel's "120-Day Report" filed on its April 2009 Request for Proposal (filed in the 07A-447E Docket at the Colorado PUC and included here as Exhibit LWG-32), Xcel received a total of over 15,000 MW of renewable energy bids as shown in the table reproduced from the 120-Day Report below.

[Rest of page left intentionally blank.]

Table LWG-7
Table 2 from Xcel's 120-Day Report in the 07A-447E Docket Summarizing the Bids Received in the April 2009 Request for Proposal

Table 2 Summary of All-Source Bids

Technology	Number of Bids	Nameplate Capacity (Rounded to the Nearest 50 MW)
Gas-Fired	25	5,800
Wind	49	10,800
Solar (PV and Thermal)	28	2,150
Solar (PV and Thermal) with Storage or Gas Backup	8	1,250
Non-Solar with Storage	3	1,150
Total	113	21,150

(Table above from page 10 of Xcel's "120-Day Report" on the bids received in April 2009 as part of the 07A-447E Colorado Resource Plan. The report is included as Exhibit LWG-32.)

- As shown in Table 9.2 on page 103 of Xcel's Emission Reduction Plan (KTH-2), Xcel's peak load is typically less than 7,000 MW, so while there are many issues related to integrating increasing amounts of renewable energy onto the existing grid, the fact that Xcel received over 15,000 MW of renewable energy resources in its April 2009 Request for Proposal indicate that Colorado has abundant wind and solar resources that will produce electricity from low- or no-cost, renewable fuels. The modeled impacts of adding various combinations of these resources to Xcel's Colorado system are shown in Exhibit LWG-32 the "120 Day Report" from the 07A-447E Docket.

- Under Decision C09-1257 in the 07A-447E Docket, Xcel is moving ahead with approximately 750MW of wind and 280 MW of solar (dependent on the resolution of various transmission issues). (See ¶ 28, page 12, Decision C09-1257, Docket 07A-447E) This will leave approximately 14,000 MW of renewable energy projects that were bid into the April 2009 RFP but which are not being moved forward. Even considering the possibility that some of the April 2009 bids are not viable, there are likely still many thousands of MW of wind, solar and other renewable energy projects ready to provide electricity to Colorado ratepayers at prices that are competitive. As additional amounts of renewable energy are added to Xcel's Colorado system, these can be used to displace kwh produced by the natural gas turbines being considered in this 10M-245E "Clean Air Clean Jobs" plan. While no energy generating technology is completely "clean" (due in a fundamental fashion to the Laws of Thermodynamics discussed in this Cross Answer Testimony), the use of wind, solar and other renewable energy generating technologies can help avoid significant amounts of pollution and help build a 21st century electric generating infrastructure for the state.

IX. ACCOUNTING FOR THE COSTS OF INTEGRATING RENEWABLE ENERGY WITH COAL

- Parties that advocate for continued strong reliance on coal for Xcel's Colorado system, have generally not considered the costs associated with attempting to integrate large amounts of wind and solar into a system that is heavily reliant on coal plants. Due to the slower ramp rates of coal plants and the "wear and tear" that comes from attempting to cycle the coal plants to follow the variable

generation of renewable energy sources such as wind and solar. Attempting to cycle coal plants can also lead to operating the plants at less than their optimal capacity there are both technical challenges and economic impacts of attempting to move to greater reliance on renewable energy when the renewable energy is complemented by coal plants as compared to natural gas plants. A study done for Xcel that begins to examine these costs is included as Exhibit LWG-33.

- While the exact costs of cycling coal plants to follow load in the presence of increased amounts of renewable energy are not well established, these costs are highly likely to be positive and increasing in coming years, as discussed in Exhibit LWG-33.

X. SOCIETAL COSTS OF CARBON EMISSIONS

- Many of the parties that promote continued strong reliance on coal-fired generation note that the United States has not yet enacted a "price on carbon." These parties, fail however to recognize or discuss what is generally known as the Social Cost of Carbon. Whether the US Congress enacts a price on carbon, the US economy (and all other economies and ecosystems) are bearing the very real costs of a warming planet. Numerous studies have assessed the costs that will be incurred due to a changing climate and then have assigned a cost per ton of carbon emitted. Exhibit LWG-31 discusses many of these studies on the social cost of carbon.
- Exhibit LWG-31 is Chapter 20 of the Working Group II report of the Intergovernmental Panel on Climate Change ("IPCC") 2007 report. All IPCC

reports can be downloaded for free from www.ipcc.ch. The Executive Summary by the IPCC authors concludes the following with respect to the Social Cost of Carbon on page 813 in Exhibit LWG-31):

> **Climate change will result in net costs into the future, aggregated across the globe and discounted to today; these costs will grow over time [20.6.1, 20.6.2] (very high confidence).**
> More than 100 estimates of the social cost of carbon are available. They run from US$-10 to US$+350 per tonne of carbon. Peer-reviewed estimates have a mean value of US$43 per tonne of carbon with a standard deviation of US$83 per tonne. Uncertainties in climate sensitivity, response lags, discount rates, the treatment of equity, the valuation of economic and non-economic impacts and the treatment of possible catastrophic losses explain much of this variation including, for example, the US$310 per tonne of carbon estimate published by Stern (2007).

Quote from Chapter 20, Report of Working Group II, Intergovernmental Panel on Climate Change, 2007 report. (See Exhibit LWG-31)

XI. THE IMPOSSIBILITY OF "GREEN COAL" GIVEN THE LAWS OF THERMODYNAMICS

- The Laws of Thermodynamics are discussed in most physics, engineering and biochemistry text books. Biochemists[20] need to know the Laws of Thermodynamics because these laws help predict what can and will happen as living systems attempt to create "order out of chaos" without violating the Laws of Thermodynamics.[21] An internet explanations of the Laws of Thermodynamics can be found at the following link:

  http://physics.about.com/od/thermodynamics/a/lawthermo.htm

[20] Ms. Glustrom is trained as a biochemist with a B.S and an M.S. in Biochemistry.
[21] For a sample discussion of the Laws of Thermodynamics in a biochemistry textbook, see Section 1.3 in Chapter 1 of *Lehninger's* Principles of Biochemistry, David Nelson and Michael M. Cox , W.H. Freeman and Company, New York, 4th Edition (2005)

- Simply stated the Laws of Thermodynamics are often summarized as follows:

> **First Law of Thermodynamics**: Energy and matter can not be created or destroyed—only transformed.
>
> **Second Law of Thermodynamics:** Every transformation of energy and matter increases the entropy of the universe.

Even more simply stated, some have characterized the First Law of Thermodynamics as "We can't win," and the Second Law of Thermodynamics as "We can't break even."

- All efforts to make coal "clean" will require the transformation of energy and matter—and these transformations can neither create nor destroy matter or energy and will invariably lead to increased entropy production. As a result, society will soon realize that we "can't win" and we also "can't break even" if we try to make coal "clean." Sooner or later, society perceives the entropy that is formed during the transformation of energy and matter (e.g. in a coal plant of any kind) as pollution of one form or another and this pollution will then need to be addressed while costs for doing so mount. For example, as pollutants such as sulfur, nitrogen or mercury are taken out of the air emissions from coal plants, the products of these efforts to clean up coal typically end up in solid waste streams—which also need disposal—and sooner or later these solid waste streams (which contain heavy metals and acid-forming pollutants) typically find their way into water supplies, thereby contaminating the substance the water supplies that are essential for all life. The coal ash spill in Tennessee in late December 2008[22] reminds us that energy and matter can't be created or destroyed—only transformed and these

[22] The coal ash spill in Tennessee in December 2008 was covered in a series of New York Times articles. See for example http://www.nytimes.com/2008/12/27/us/27sludge.html .

transformed waste products sooner or later make it into the environment, and then into our awareness and finally into regulations. Western Resource Advocate witness Eric Shaeffer details current and pending coal ash and water regulations that are likely to increase the cost of coal-fired production.

- As many have observed about gravity, "The Laws of Thermodynamics never sleep," and all the ads bought on TV and in the print media and all the high-powered experts that money can buy, won't allow the coal industry—or anyone else—to violate the Laws of Thermodynamics.

XII. STATUS OF CARBON CAPTURE AND STORAGE TECHNOLOGIES

- Witnesses who suggest that carbon dioxide emissions from coal plants can be managed with what are called "carbon capture and Storage" ("CCS") technologies fail to discuss when these technologies are expected to be commercially available or what they will cost. The Commission should not expose Colorado rate payers to potential large rate impacts for a technology that is a long way from being commercially available.
- For example, the Norwegian effort at carbon capture and storage at the Sleipner project has seen a nine fold increase in cost estimates since the original estimate in 2006 according to a Reuters news report. The original estimate was $700 million crowns. Now the estimate is over 6 billion crowns. The link to the recent news story is below

http://af.reuters.com/article/energyOilNews/idAFLDE68T0EC20100930

- One of the technologies that has been suggested as allowing easier capture of carbon dioxide is the building of what are called Integrated Gasification and Combined Cycle ("IGCC") (also sometimes referred to as "clean coal" plants.) The effort of Duke Energy to build an IGCC plant in Edwardsport, Indiana has met with large cost over runs and considerable scandal in the Indiana Utility Regulatory Commission. The cost of the 613 MW Edwardsport, Indiana coal plant is now close to $3 billion—or almost $5,000/kw—before even considering operating or carbon capture and storage costs. Two recent media articles discussing the events in Indiana are at the links below. Cost increases at the Duke Edwardsport Indiana IGCC plant are discussed at **http://www.insideindianabusiness.com/newsitem.asp?ID=43719 .** The recent scandals in the Indiana Utility Regulatory Commission ("IURC") and the firing of the head of the IURC as a result of issues involving the Duke IGCC plant are discussed here http://www.southbendtribune.com/article/20101005/Biz/101009663/1013/Biz

XIII. XCEL'S CURRENT COLORADO RATES AND RECENT RATE INCREASES RELATED TO COAL

- While the Colorado Commission clearly knows this information, it appears that other parties, including those that are advocating continued strong reliance on coal-fired generation, are not aware of Xcel's current Colorado electric rates. Xcel's Colorado rates can be obtained from the Company's website, with the direct link being: http://www.xcelenergy.com/SiteCollectionDocuments/docs/psco_elec_entire_tarif

f.pdf . Tariff sheet 20 at this link provides the following summary of Colorado residential electric rates:

Winter and Summer Tier 1 Rates	(October 1, 2010)	8.79 cents/kwh
Summer Tier 2 Rates	(October 1, 2010)	13.25 cents/kwh

These rates will vary slightly when Xcel files its Electric Commodity Adjustment changes on a quarterly basis to reflect changes in the cost of the coal and natural gas used to generate electricity by Xcel's Colorado generating fleet—but it is clear that Xcel's Colorado rates are not under 9 cents/kwh,[23] for example as stated in Colorado Mining Association Witness Bezdek's testimony. (See e.g. page 35, line 16, and the top of page 36, Dr. Bezdek's Answer Testimony).

- For the role that coal has played in Xcel's recent rate increases in Colorado see the testimonies of Xcel witnesses Brockett, Hyde and Mills in the 08S-520E and 09AL-299E dockets. In addition to the costs associated with the building of the new Unit 3 coal plant in Pueblo (known to Xcel as Comanche 3), Xcel's recent rate increases were also driven by increased operating costs at its coal plants including increased costs for water and pollution control. These were documented in the hearing exhibits of both the 08S-520E and the 09AL-299E dockets.

[23] During the second quarter of 2010 when Answer Testimony was submitted (on September 17, 2010) in this 10M-245E docket, Xcel's rates were approximately 9.2 cents/kwh for Winter and Summer Tier I rates and 13.9 cents/kwh for Summer Tier II rates. On October 1, 2010 Xcel's Electric Commodity Adjustment went from about 3.2 cents/kwh (for 2010 Q3) to about 2.7 cents/kwh (for 2010 Q4) as shown at http://xcelenergy.com/Colorado/Company/About_Energy_and_Rates/Energy%20Prices%20(Rates%20and%20Tariffs)/Pages/Colorado_Electric_Commodity_Adjustment.aspx .

XIV. CONCLUSION

- The Commission should discount the testimony of witnesses that support a strong continued reliance on coal for Xcel's Colorado system because they:
    - Fail to consider the very real coal supply constraints around the world, in the United States and in Colorado
    - Fail to acknowledge recent large increases in the costs of coal
    - Fail to consider the significant external costs of burning coal
    - Fail to recognize Colorado's abundant potential for renewable energy including thousands of MW of wind and solar projects that are ready to be built.
    - Fail to recognize the difficulties and associated costs with trying to integrate increasing amounts of renewable energy electricity with coal plants
    - Fail to consider that regardless of whether the US Congress enacts a price on carbon dioxide emissions, there is a real and significant "societal cost of carbon" that our society is paying—even if it is not assessed as a formal "price on carbon."
    - Fail to recognize that "the Laws of Thermodynamics never sleep" and no amount of money or expert witness testimony can suspend these laws and allow for truly "green coal" options.
    - Fail to recognize the lack of commercial availability of Carbon Capture and Storage technologies and the cost over runs that are being experienced in CCS projects as well as in "clean coal" IGCC projects.

- Fail to recognize the recent increases in Xcel's Colorado electric rates and the role that coal plants have played in these rate increases.

- To protect ratepayers from the uncertainties of price and supply related to both natural gas and coal, the Commission should minimize the commitment at this time to both old coal and new natural gas so that Colorado rate payer investments can be freed up for increased commitment to Colorado-based wind and solar projects as part of the 2011 Resource Plan expected to be filed by Xcel in 2011 with a decision in 2012.

- While Ms. Glustrom shares strong concerns about supplies, prices and life-cycle emissions associated with natural gas, the road to a cleaner energy future lies through increased reliance on natural gas which has the ability to complement the variable generation of fuel-free renewable energy sources such as wind and solar. Coal plants are not easily cycled and continued heavy reliance on coal will not allow Xcel to modernize its generation fleet and lay the foundation for a transition to the clean energy future that awaits us.

Q: DOES THIS CONCLUDE YOUR CROSS-ANSWER TESTIMONY?

A: Yes. Thank you.