Risk Evaluation for Commercial Deployment of CCS
Innovative Approaches to Mobilize Financing for Early Plants

Presentation to IEA – WCI CCS Experts Group with IEA GHG R&D Program (New York)

Preliminary Risk Rating Results:
Coal-based Plants with CCS
May 28-29 2007

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Research direction
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OFFICES & PROJECTS

- Boulder (CO)
- Washington D.C.
- London
- San Jose
- Cambria
- Rio de Janeiro
- Fortaleza
- Sao Paulo

Renewable Power Production
- Build, own and operate an asset base of renewable energy projects
- Wind & hydro in Latin America
- Biomass in U.S.

CleanTech Fund
- Raising capital for small-scale generation projects in Latin America
- Invested in 3 projects

Carbon Services
- Broker carbon credits in regulated and voluntary markets
- Carbon project identification and development support

Consulting
- Access deal flow
- Provide intellectual capital to company and clients
- Support development of U.S. Strategy

Raised $100M on London AIM in Feb. 2006

Baseline without Regulations on Carbon: 104 GW of coal added by 2030

**EIA 2008 Projection:** MORE fossil use by 2030 in N.America

EIA has reduced projections of natural gas use and raised forecasts for coal.

**AEO 2008:**
In the AEO2008 reference case, electricity generation from natural-gas-fired power plants increases sharply from 2006 to 2008 and then flattens for the next decade, growing by 3 percent from 2008 to 2016. After 2016 generation from new coal, nuclear, and renewable plants displaces some natural-gas-fired generation (Figure 7). In the AEO2008 reference case, 741 bkwhs of electricity is generated from natural gas in 2030, 21 percent less than the 937 bkwhs in 2030 in the AEO2007 reference case. Additions to coal-fired generating capacity in the AEO2008 reference case total 104 GW from 2006 to 2030.

**Figure 1. Energy prices, 1980-2030 (2006 dollars per million Btu)**

**Figure 2. Electricity generation by fuel, 1970-2025 (billion kilowatthours)**

**Figure 3. Electricity generation by fuel, 1980-2030 (billion kilowatthours)**
Average Age of U.S. Coal Plants (320 GWe)

Planned Coal Plants Delayed

Past Capacity Announcements vs. Actual

Figure 1

Historically, actual capacity has been shown to be significantly less than proposed capacity. For example, the 2002 report listed 11,455 MW of proposed capacity for the year 2006 when actually only 329 MW were constructed.

Source: 2007 data Global Energy Decisions – Velocity Suite
2002 – 2005 data – Previous NETL Tracking New Coal-Fired Power Plants Reports

OSAP 10/10/2007

Risk Rating on CCS for WCI – May 2008 AD Paterson
Despite numerous cancellations, some plants are underway, but CCS is seen as too costly.

ENR (2/27/08):
“For construction contractors, the immediate situation is not dire. About 25 major coal projects totaling more than 15,000 MW now are under construction. Twenty other projects totaling more than 10,000 MW have secured most of their major permits and are poised to enter construction soon.”

“Coal projects that are well under way include:
• CPS Energy’s 750-MW J.K. Spruce Unit 2 in San Antonio, TX;
• Santee Cooper’s 600-MW Cross Unit 4 in Cross, SC;
• Springfield (IL) City Water Light & Power’s 200-MW Dallman Unit 4;
• East Kentucky Electric Cooperative’s 278-MW Spurlock Unit 4 plant in Maysville, KY.”

Projected CO2 Emissions, 1990 – 2030

“Major Emitters” (Top 10) matter most. U.S.+China = 50% in 2030

Kyoto signers were 55% in 2002; but will only be 35% in 2030.
“Where are the U.S. CO2 Emissions”

**EIA Baseline: U.S. CO2 Emissions by Sector, 2000**

Power sector drew early attention, but transportation is crucial also.

Source: EIA, AEO 2003

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**Electricity broken out by end-use sector.**

Difficulty in dealing with transport sector emissions plagues EU as well.

2000
“Where are the U.S. CO2 Emissions”

EIA: U.S. CO2 Emissions by Sector, 2030 est.

Absent a massive turnover in equipment, CO2 emissions keep rising.

Coal fired electricity continues to rise in total because of higher gas prices.

Electricity broken out by end-use sector.

Source: EIA, AEO 2008
“Inconvenient” Challenges for North America...

1. Retail electricity competition and merchant power mostly failed in the U.S., with major bankruptcies (PG&E, SCE)... and many states remain committed to rate regulation, especially for baseload.

2. Consumers don’t buy electricity based on price, anyway; it’s an essential good – and many utilities mask price signals.

3. New electricity supply is heavily constrained due to natural limits (wind, sunlight, resources) and regulations no matter the option.

4. EE and DSM are vital, but are not sufficient with growth... nor can they replace a lot of “old coal” units (>200,000 MWe).

5. U.S. regional differences in electricity fuel mix, prices, and access to renewable resources are severe. Several regions use coal for >60%.

6. “Urgent” cap and trade (2012, 2020) in the EU is a mixed bag: emissions are not lower, and other measures (feed-in tariffs, regulations, direct subsidies, local tax policy) are in the mix.

7. Because of a huge U.S. budget deficit and national debt, federal fiscal options are limited; need risk-based incentives.
National averages mask very sharp regional differences

**Differing Electricity Mix by Region (EEI), 2005**

http://www.eei.org/
U.S. carbon emission reduction goals cannot be met without CCS

**EPRI “Carbon Constrained” Scenario for Electricity**

EPRI used AEO 2007 as the reference, and then looked at what might be technically feasible by 2030. They are evaluating economics now to further review this “carbon constrained” case. **CCS is a crucial slice of action needed.**

### EIA Base Case 2007

<table>
<thead>
<tr>
<th>Technology</th>
<th>EIA 2007 Reference</th>
<th>Target</th>
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</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.5%/yr</td>
<td>Load Growth ~ +1.1%/yr</td>
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<tr>
<td>Renewables</td>
<td>30 GWe by 2030</td>
<td>70 GWe by 2030</td>
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<tr>
<td>Nuclear Generation</td>
<td>12.5 GWe by 2030</td>
<td>64 GWe by 2030</td>
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<tr>
<td>Advanced Coal Generation</td>
<td>No Existing Plant Upgrades</td>
<td>150 GWe Plant Upgrades</td>
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<tr>
<td></td>
<td>40% New Plant Efficiency by 2020–2030</td>
<td>46% New Plant Efficiency by 2020; 49% in 2030</td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Vehicle Sales by 2017; +2%/yr Thereafter</td>
</tr>
<tr>
<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
</tr>
</tbody>
</table>

*Achieving all targets is very aggressive, but potentially feasible.*
**2008 Updated Prism...Technical Potential for CO₂ Reductions**

EPRI used AEO 2007 as first reference, and then looked at what might be technically feasible by 2030. CCS is a crucial slice of action needed.

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**U.S. Electric Sector CO₂ Emissions (million metric tons)**

<table>
<thead>
<tr>
<th>Technology</th>
<th>EIA 2008 Reference</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.05%/yr</td>
<td>Load Growth ~ +0.75%/yr</td>
</tr>
<tr>
<td>Renewables</td>
<td>55 GWe by 2030</td>
<td>100 GWe by 2030</td>
</tr>
<tr>
<td>Nuclear Generation</td>
<td>15 GWe by 2030</td>
<td>64 GWe by 2030</td>
</tr>
<tr>
<td>Advanced Coal</td>
<td>No Heat Rate Improvement for Existing Plants</td>
<td>1-3% Heat Rate Improvement for 130 GWe Existing Plants</td>
</tr>
<tr>
<td>Generation</td>
<td>40% New Plant Efficiency by 2020–2030</td>
<td>46% New Plant Efficiency by 2020; 49% in 2030</td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Light-Duty Vehicle Sales by 2017; 33% by 2030</td>
</tr>
<tr>
<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
</tr>
</tbody>
</table>

*Energy Information Administration (EIA) Annual Energy Outlook (AEO)*

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Risk Rating on CCS for WCI – May2008 ADPaterson
Costs of natural gas and electricity **without** CCS will run much higher.

**EPRI: Increase in Real Electricity Prices…(2000 to 2050)**

**Limited Portfolio**  
Just EE/RE + Gas  

+260%  

**Full Portfolio**  
With Coal – CCS + Nuclear  

+45%

Both Scenarios meet the same economy-wide CO₂ Cap*  

*Economy-wide CO₂ emissions capped at 2010 levels until 2020 and then reduced at 3%/yr
Natural gas accounts for most growth since 1990; overall demand +33%
“Sure, we are more efficient... then we plug more stuff in or buy more.”

At 34 minutes a day, Renewables (non-hydro) have a long way to go to replace coal (~12 hours a day). More likely, RE will curb carbon emissions some, and help diversify our fuel base further. Most importantly, RE can help dampen gas price volatility, and reduce some LNG imports.

Regional access to RE differs widely.

Biofuels cannot replace transport fuel rapidly.
Drivers Differ in EU vs. USA... and how to engage Asia?

EU is pushing an “urgent” cap:
- They can’t harmonize 27 national tax systems (social contracts)
- An “urgent” (2020) cap is a policy mandate that serves to maintain coalition parliamentary governments
- They want CDM as a means to channel funds to emerging nations
- They are shifting from coal to gas, with market pricing of electricity, rather than regulated pricing
- EU economies face demographic decline, and are stagnant – only 10 million added in EU per decade
- EU is casting energy security on Russian/FSU gas, and need to tax profits from fossil economy – with some interest in coal with CCS.

USA can choose and engage Asia:
- We have a common federal tax system (and active tax lawyers)
- State incentives can supplement and help tailor approaches
- U.S. will be at 50% coal for power, and China, India are using more coal
- USA and Asia are still growing! But, U.S. growth is concentrated in “Red” states; ...“Blue” states are older, colder and losing young people. N.America will add 40-50 million people per decade
- Asia leads in building new reactors and U.S. has big stake in nuclear for national security... and GHG gains
- Our future requires baseload and RE, including PHEVs (electrify transport), -- a “steady” cap geared to capital markets (2040) would be useful
Europe hopes to avert a false economy in carbon
By Fiona Harvey, June 28 2006 19:38 | Financial Times of London
“What came close to putting the scheme on life support was data released between late April and mid-May which showed that last year – the first the scheme had been in operation – businesses covered by it had been given more permits than they needed because member states had overestimated demand.”

“The problem with short term cap and trade (2020) is that it does not give a stable price for carbon – price volatility makes it more difficult to attract lenders for new systems and innovative technology.”
The next “credit” crisis: carbon credits? (March 2008)
UK Regulator (FSA) Posts Risks on Carbon Trading

UK watchdog warns on carbon trading / March 2008
By Fiona Harvey and Ed Crooks
Published: March 31 2008 22:05 | Financial Times of London

The Financial Services Authority does not govern the carbon market but the watchdog listed risks in a report on carbon regulation:

- The lack of links between emissions trading markets;
- Some companies authorised for other financial markets may have misled customers by citing FSA authorisation;
- Unsuitable products being sold to investors, which could "potentially lead to damage to consumers or to disorderly trading, and a lack of confidence in market";
- The potential lack of appropriate experience among practitioners;
- The quality of information available about emission quantities and allowances;
- The lack of market liquidity.

http://www.ft.com/cms/s/b03dbc7a-06cf-11db-81d7-0000779e2340.html

**Will new capacity have to be built before climate actions are in place?**

- **Challenge:** New capacity is needed before federal legislation is expected to be resolved and litigated.

- **Expect climate change legislation to be implemented**
  - 49% expect by...
  - 93% expect by...

- **Expect to take significant climate actions themselves**
  - 43% expect
  - 70% expect

- **New capacity required to meet regional supply needs**
  - 12%
  - 43%
  - 75%

- **59% expect CO2 capture required**

Source: Survey by GF Energy of Utility Executives in North America, April 2007
Opportunities & Challenges for CCS

• **Opportunities for CCS in New Baseload**
  • We need to build new baseload to meet new demand, retire “high carbon” units
  • Natural gas price volatility and prices provide an opening to build alternatives
  • “Plenty o’ capital” is available and can be mobilized if risks are addressed

• **Challenges**
  • *Long-term* CCS remains unproven; large scale demos, RD&D needed
  • Geological feasibility, transport affects plant siting and technical designs
  • Uncertainty over CCS liability later must be addressed to arrange financing now…

• **Approach**
  • Risks can be delineated, addressed based on experience and insurance models
  • Utilize carbon offsets and state incentives to bolster mitigation mechanisms
  • Price signals to the CAPITAL markets are more important than to consumers

• **Key Threats**
  • Consumers and PUCs don’t want to pay more, and vote against higher rates
  • Regional differences and lack of political will run high – consensus is elusive
Lehman Brothers Roundtable at NARUC (Nov. 2007), “A Day at the Bond Market”

**Bond Market Roundtable on Energy & CCS**

$2 Trillion under management

Roundtable participants: Doug Cortez, formerly with Fluor Engineering; Dan Ford, Lehman Brothers; Jim Hempstead, Moody’s; Sandy Hochstetter, Arkansas Electric Coop; Lindene Patton, Zurich America; Barbara Tyran, EPRI; Klaus Lambeck, Ohio Public Utilities Commission staff; Mike Smith, Southern States Energy Board; Julie Jorgensen, Excelsior Energy; Faith Klaus, Lehman Brothers. With 32 bond fund managers. Moderator: Andrew Paterson, Econergy
How big is the U.S. Bond Market (1996 – 2007)?

**U.S. Bond Market: Big Enough at $30 Trillion**

Energy infrastructure is financed in bond market, which sees $6-7T a year in new bond issuance, about $80-100B for power providers.

![Chart showing U.S. Bond Market Debt Levels (Market Size)]

**U.S. Bond Market Debt Levels (Market Size)**

- **$30,000**
- **$25,000**
- **$20,000**
- **$15,000**
- **$10,000**
- **$5,000**
- **$0**

Source: SIFMA

Risk Rating on CCS for WCI – May 2008 AD Paterson
**Bond Fund Viewpoints (32 responses; > $2 Trillion under management)**

**Bond Market on Energy Policy** *(Lehman Roundtable at NARUC, Nov 2007)*

1. Able to meet most U.S. needs with EE RE
3. New GHG bill enacted by 2012
4. GHG regs likely from EPA by 2015
5. Cap-and-trade better than carbon tax
6. Can handle near-term with natural gas
7. CCS needed at outset for coal plants
8. CCS costs can be covered by rates
9. States best to regulate CCS liability
10. State RPS standards better than Fed RPS

**Observations:**
- Wide agreement that EE / RE will not offer enough.
- New nuclear is possible.
- GHG legislation likely, though regs may take longer than 2015.
- Not clear that cap-and-trade is better than tax. Lot of policy confusion.
- Just building gas turbines will fall short of demand.
- CCS terms, liability, and recovery of cost not clear yet. Policy unsettled.
- State RPS clearly better than federal RPS (Electric rates governed by states).
CCS Alliance for Risk-based Policy

For Deployment of Coal-based Projects with CCS

Risks ➔ Mitigation Approaches ➔ Actions Needed

CCS Alliance Scope:
I) Risk Study for CCS Deployment (coal power plants or energy projects with CCS)
II) Legal research on critical issues, risks and formulation of mitigation options

A) Risk Analysis

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>Key Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Tech-CCS</td>
<td>Capital cost with CCS too high</td>
</tr>
<tr>
<td>2) Reg-CCS</td>
<td>State rules on CCS not clear</td>
</tr>
</tbody>
</table>

Analysis based on Interviews of key actors: (results of Risk Study)

<table>
<thead>
<tr>
<th>#</th>
<th>Risk</th>
<th>Description</th>
<th>Probability</th>
<th>Impact</th>
<th>Severity</th>
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</thead>
<tbody>
<tr>
<td>13</td>
<td>Reg</td>
<td>Unknown EPA carbon caps</td>
<td>4.2</td>
<td>4.1</td>
<td>17.4</td>
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<tr>
<td>1</td>
<td>Tech</td>
<td>Capital costs on CCS high</td>
<td>4.5</td>
<td>4.3</td>
<td>18.1</td>
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<tr>
<td>17</td>
<td>Reg</td>
<td>Water use regulated on CCS</td>
<td>3.5</td>
<td>4.0</td>
<td>14.0</td>
</tr>
<tr>
<td>12</td>
<td>Reg</td>
<td>Water permits for CCS not clear</td>
<td>3.1</td>
<td>3.9</td>
<td>12.3</td>
</tr>
<tr>
<td>19</td>
<td>Reg</td>
<td>CO2 allowances don’t fund CCS</td>
<td>3.4</td>
<td>4.0</td>
<td>13.9</td>
</tr>
<tr>
<td>32</td>
<td>Reg</td>
<td>EPA regulations for CCS not clear</td>
<td>3.2</td>
<td>3.9</td>
<td>12.5</td>
</tr>
<tr>
<td>14</td>
<td>Reg</td>
<td>Future carbon limits tighten</td>
<td>2.6</td>
<td>4.2</td>
<td>11.6</td>
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<tr>
<td>24</td>
<td>Tech</td>
<td>High cost of basic materials</td>
<td>3.1</td>
<td>3.6</td>
<td>11.7</td>
</tr>
<tr>
<td>Overall Average</td>
<td></td>
<td></td>
<td>2.9</td>
<td>3.6</td>
<td>10.5</td>
</tr>
</tbody>
</table>

B) Mitigation Mechanisms

Government
- Loan guarantees
- Grants (DOE, etc.)
- Tax subsidies
- Injection regulations
- Permitting approaches
- Carbon emission rules
- Federal “Energy Bank”
- Revolving loans

Industry / Investors
- Insurance / bonding
- Engineering backups
- Long-term contracts
- Site review, feasibility
- Collateral, backup supply

C) Government Actions needed for Mitigation

(Match actions with mechanisms)

Near-term / Long-term
- Appropriations
- Legislation
- Tax bill
- Regulation
- Agency action
- Executive order (?)
- Reserves (e.g., SPRO)
- Others?

Risk Rating on CCS for WCI – May 2008 ADPaterson
For Deployment of Coal-based Projects with CCS

Approach to Commercial Risk Framework


Regulatory and policy risks

Coal projects with CCS cannot complete financing without a comprehensive commercial risk analysis by creditors, typically in a project finance framework.

Deployment = project finance.

Technical and operating risks

Market risks

Close Financing

Repayment and profit

Source: Scully Capital

Design & Development | Engineering & Construction | Operations & Maintenance

Risk Rating on CCS for WCI – May 2008 APaterson
Plot of Risks Based on their Attributes (Likelihood, Severity of Impact)

- **Accidents**
  - (Plant fires, or spikes in feedstock costs or a gas price slump with loss of competitiveness)

- **“Show-Stoppers”**
  - (e.g., high capital costs with CCS, or lack of clarity about carbon regs)

- **Marketing and Operations**
  - (Workforce issues, coal transport, transmission congestion, etc.)

- **Externalities**
  - (e.g., pollution)

- **Negotiating space for public and private sectors**

- **Probability of Event**
  - Low Likelihood
  - Higher Likelihood

- **Impact if Event Occurs**
  - Low Impact
  - Higher Impact

Risk Rating on CCS for WCI – May 2008 AD Paterson
Deploying CCS creates a large drain on plant production, so capital costs run much higher.

Capital costs spiraled higher since 2005, but costs are up for all energy projects.

Respondents expect that CCS equipment will work, and do not see CO2 transport as a major issue, nor do they see a storage site failure as likely.

The major issue is CAPITAL COST, not labor costs.
Coal with CCS **TECHNICAL** Risks: Probability vs. Impact

**Low prob / High impact:**
- Insurance, futures contracts
- CCS site tech failure
- Operating accident
- CCS equip downtime
- CO2 transport difficult

**High prob / High impact:**
- Government credit, incentives
- High baseline plant capital cost
- High capital cost with CCS
- "Thin" EPC warranty wrap on total plant performance
- Tight EPC capacity (engineering firms)

**Overall average:**

1.0  2.0  3.0  4.0  5.0

**Severity of Impact ->**

For Deployment of Coal-based Projects with CCS
Risk Ratings: REGULATORY

Regulatory uncertainties (federal + state) about CCS costs and liability threaten financing.

Preliminary Rating of Risks (probability x impact)

- State air permitting delays
- Uncertain EPA carbon regs
- Future carbon limits tighter
- CO2 allowances don't fund CCS
- Regional support lags on plants
- State regs on CCS not clear
- Nat'l subsidies lag on plants
- Nat'l incentives for CCS lacking
- Water use regs tightened

21 respondents

Overcoming higher costs is essential but not enough. Subsidies are needed.

Regulatory uncertainties pose "show stopper risks":
- Carbon legislation and EPA performance standards are not defined.
- State regs are not clear enough yet to resolve CCS cost and liability issues.
- Incentives are not in place to offset CCS costs.

A tightening of water regs does not pose much risk.
For Deployment of Coal-based Projects with CCS

Coal with CCS REGULATORY Risks: Probability vs. Impact

- Future carbon limits tightened threatening shutdowns
- State rules unclear on CCS liability
- Nat'l subsidies (loan, tax) for early plants lag
- Water use regs tightened
- Nat'l subsidies for CCS shy
- State air permit delays
- Regional incentives inadequate
- CO2 allowances not adequate for CCS costs

Low prob / Low impact: Industry practices
High prob / Low impact: Regulatory clarity; specs
Low prob / High impact: Insurance, futures contracts
High prob / High impact: Government credit, incentives

21 ratings

Overall average
Lack of subsidies and uncertainty about liability for CCS make financing very difficult.

“First mover” risks on early plants are prohibitive for owner utilities, bond holders, or PUCs; and engineering firms cannot economically offer enough warranty (or “wrap”) to cover risks feasibly.

EOR / EGR is not readily available in all regions, or volumes are not adequate to offset costs of carbon capture and storage.

Clarity is needed on CCS liability to close financing.
Risk Rating on CCS for WCI – May 2008

For Deployment of Coal-based Projects with CCS

Coal with CCS MARKET Risks: Probability vs. Impact

- Low prob / High impact: Insurance, futures
- Overall average
- High prob / High impact: Government credit,

Lower natural gas prices
CCS liability threatens financing
Financing difficult (more equity, terms)
EPA regs unclear on CCS injection, liability
Revenue from EOR not adequate

Customer default
Interest rates rise
EPA regs unclear on CCS injection, liability
Market or PUC rates inadequate for CCS
Revenue from EOR not adequate

Load growth lags
Transport of CO2 expensive
Coal prices rise
Transmission congestion
Old coal units run longer (lax enforcement)

Low prob / Low impact: Industry practices
High prob / Low impact: Regulatory clarity; specs
For Deployment of Coal-based Projects with CCS

**Risk Study: Technical, Regulatory, Market Risks**

<table>
<thead>
<tr>
<th>Q #</th>
<th>Q Type</th>
<th>Coal Gen with CCS</th>
<th>Probability</th>
<th>Impact</th>
<th>Severity</th>
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<td>7</td>
<td>Tech - CCS</td>
<td>Capital costs on CCS high</td>
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<td>4.3</td>
<td>17.1</td>
</tr>
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<td>18</td>
<td>Reg</td>
<td>Nat'l subsidies lag on plants</td>
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<td>State regs on CCS not clear</td>
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<td>Nat'l incentives for CCS lacking</td>
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<td>CO2 allowances don't fund CCS</td>
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<td>28</td>
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<td>Finance difficult (equity, terms)</td>
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<td>31</td>
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<td>EPA regs unclear on CCS</td>
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<td>34</td>
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<td>CCS liability threatens financing</td>
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<tr>
<td>33</td>
<td>Market-CCS</td>
<td>EOR revenue inadequate for CCS</td>
<td>3.9</td>
<td>3.4</td>
<td>13.2</td>
</tr>
<tr>
<td>16</td>
<td>Reg</td>
<td>Regional support lags on plants</td>
<td>3.4</td>
<td>3.7</td>
<td>12.6</td>
</tr>
<tr>
<td>27</td>
<td>Market-CCS</td>
<td>Market/PUC rates low for CCS</td>
<td>3.2</td>
<td>3.9</td>
<td>12.5</td>
</tr>
<tr>
<td>14</td>
<td>Reg - CCS</td>
<td>Future carbon limits tighter</td>
<td>2.8</td>
<td>4.2</td>
<td>11.8</td>
</tr>
<tr>
<td>4</td>
<td>Tech</td>
<td>High cost of basic materials</td>
<td>3.3</td>
<td>3.6</td>
<td>11.7</td>
</tr>
<tr>
<td>1</td>
<td>Tech</td>
<td>High capital cost (w/o CCS)</td>
<td>3.1</td>
<td>3.8</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td><strong>Overall Average</strong></td>
<td></td>
<td><strong>2.9</strong></td>
<td><strong>3.6</strong></td>
<td><strong>10.5</strong></td>
</tr>
</tbody>
</table>

From interviews of key actors (owners, builders, financial entities, agencies, states) critical risks in three major areas are evaluated in a project finance credit analysis framework. Risks are rated (1 to 5) for “likelihood” and “impact” if a risk event occurs. The product (25 point scale) provides a “severity” of risk for specific events affecting deployment with CCS.

Sample respondents: Conoco, GE, Siemens, Air Liquide, Warley Parsons, CH2M Hill, GTC, Excelsior Energy, Burns & McDonnell, Oglethorpe, Eastman Chemical, Hensley, Pace Energy, and EPRI, WCI.
Preliminary Risk Ratings on CCS – SUMMARY

- Capital costs have run up since 2005, but costs are up for projects worldwide.
- Respondents expect that CCS equipment will work, and do not see CO2 transport as a major issue, nor do they see a CCS site failure as likely. CAPITAL COST for the plant with CCS is the key barrier, not labor costs.
- Subsidies are needed to overcome higher costs, but that is not enough.
  (Subsidies could be paid for by injection fees on CO2, or user levies on coal)
- Regulatory uncertainties pose “show stopper” risks for deployment of CCS:
  – Carbon emission legislation and EPA regulatory rules on CCS are not defined.
  – State regulations are not clear enough yet to resolve CCS cost and liability issues.
  – Incentives (tax credits, loans, allowances) are not in place to offset higher CCS costs.
  – A tightening of water regulations does not pose much of a risk currently.
- “First mover” risks are prohibitive for owner utilities, bondholders, or PUCs; and engineering firms cannot economically offer enough warranty (or “wrap”) to cover risks. Few owners want to finance early CCS demos and plants.
- EOR is not readily available in all regions, or demand is not adequate to absorb costs and volumes needed for carbon capture and storage from power plants.
- Clarity is needed on CCS liability to close financing – perhaps a “showstopper”.
- Increases in coal prices or interest rates were not rated high risks.
- Lower NGas prices (<$5) would pose competitive problems; not seen as likely.
### Summary: Risk Ratings for Coal Gasification (2005-06)

#### Highest Risks

<table>
<thead>
<tr>
<th>Q#</th>
<th>Risk Area for IGCC</th>
<th>Co-Prod'n 2005</th>
<th>Co-Prod'n 2006</th>
<th>2050 Rs</th>
<th>IGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High capital cost</td>
<td>3.6</td>
<td>4.5</td>
<td>16.0</td>
<td>14.9</td>
</tr>
<tr>
<td>3*</td>
<td>Excessive downtime</td>
<td>2.5</td>
<td>3.7</td>
<td>8.9</td>
<td>13.1</td>
</tr>
<tr>
<td>6</td>
<td>Lack of EPC capacity to build</td>
<td>3.6</td>
<td>3.7</td>
<td>13.1</td>
<td>6.5</td>
</tr>
<tr>
<td>8</td>
<td>Materials &amp; budget overruns</td>
<td>3.6</td>
<td>4.0</td>
<td>14.2</td>
<td>10.9</td>
</tr>
<tr>
<td>10</td>
<td>Thin EPC / vendor wrap</td>
<td>3.4</td>
<td>3.5</td>
<td>11.7</td>
<td>9.5</td>
</tr>
<tr>
<td>12*</td>
<td>State air permitting delays</td>
<td>2.2</td>
<td>3.4</td>
<td>7.2</td>
<td>13.0</td>
</tr>
<tr>
<td>18*</td>
<td>Regional policy on sequest lag</td>
<td>3.0</td>
<td>2.7</td>
<td>7.8</td>
<td>11.4</td>
</tr>
<tr>
<td>19</td>
<td>Nat'l incentives on plants lag</td>
<td>3.3</td>
<td>4.2</td>
<td>13.7</td>
<td>11.8</td>
</tr>
<tr>
<td>28</td>
<td>Financing difficult (equity, terms)</td>
<td>3.0</td>
<td>4.2</td>
<td>12.4</td>
<td>13.0</td>
</tr>
<tr>
<td>29</td>
<td>DOD purchase agreement thin</td>
<td>4.0</td>
<td>3.9</td>
<td>15.2</td>
<td>NR</td>
</tr>
<tr>
<td>30</td>
<td>Long-term off-take inadequate</td>
<td>3.4</td>
<td>4.1</td>
<td>13.9</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Overall Average</td>
<td>2.6</td>
<td>3.3</td>
<td>8.7</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- Concerns about high capital cost rate highest for co-production plants.
- Concerns about cost overruns and tight EPC capacity also are elevated.
- Uncertainties about off-take and incentives add to financing challenges.
- Combined, these risks explain why plants are not being built, unaided.

Source: Scully Capital, also David Berg
Plot of Risks Based on their Attributes (Likelihood, Severity of Impact)

Lower Likelihood
Higher Impact

Accidents
(Insurance, long-term or futures contracts, backup supplies, spare subsystems, site surveys)

“Show-Stoppers”
(Requires government subsidies, risk-sharing, credit support, rate-based or long-term off-take agreement)

Higher Likelihood
Low Impact

Marketing and Operations
(Well-grounded management practice, internal audits, training)

Externalities (e.g., pollution)
(Regulatory clarity, system standards – like EPRI CoalFleet UDBS)

Low Likelihood
Low Impact

Higher Likelihood
Lower Impact
First of a Kind Systems: High Risk Early

1. Not enough coverage of operating risks and performance at startup.
2. Too much risk coverage after successful operations: Buydown of costs reduces generation cost over life of the plant. Cost to government unnecessarily high.

More “lift” (grants, subsidies) needed early on, rather than over life of plant after proven. Risk-based policies allow tapering of tax credits.

Plant Project Timeline

Source: Scully Capital, also David Berg
Different Risks Require Different Approaches

Risk-based approaches are more complex, require more work, but cost less and/or spread benefits to more states more regions, more projects with broader impact for the same budget cost. Policy mechanisms overlap, but a risk-based negotiation spreads the benefits.

<table>
<thead>
<tr>
<th>Key risks</th>
<th>Cost-based Policies</th>
<th>Risk-based Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>High plant capital costs for CCS</td>
<td>Grants, ITCs (tax credits)</td>
<td>Loans, preferred equity</td>
</tr>
<tr>
<td>“First of a kind” plant costs</td>
<td>Federal RD&amp;D, grants</td>
<td>Loan guarantees, preferred equity</td>
</tr>
<tr>
<td>Excessive downtime</td>
<td>Federal RD&amp;D, grants</td>
<td>Standby credit, backup systems</td>
</tr>
<tr>
<td>Feedstock shortages, poor quality</td>
<td>Capacity payments</td>
<td>More storage, alternative supply</td>
</tr>
<tr>
<td>Shifting regulations on feedstocks</td>
<td>Grants, waivers</td>
<td>Alternative supply, waivers</td>
</tr>
<tr>
<td>Higher transport costs of feedstock</td>
<td>Subsidies</td>
<td>Infrastructure investment</td>
</tr>
<tr>
<td>High processing / operating costs</td>
<td>Property tax relief, PTCs</td>
<td>Engineering, demonstrations</td>
</tr>
<tr>
<td>EPC contractor constraints</td>
<td>Educational programs (engrs)</td>
<td>RD&amp;D, feasibility study grants</td>
</tr>
<tr>
<td>Revenue uncertainty, price flux</td>
<td>Government off-take</td>
<td>Financing more storage</td>
</tr>
<tr>
<td>Lagging private investment</td>
<td>Grants, ITCs, early PTCs</td>
<td>Loans, preferred equity</td>
</tr>
<tr>
<td>Revenue and off-take uncertainty</td>
<td>Purchase agreements by gov’t</td>
<td>Standby (step-in) agreements</td>
</tr>
<tr>
<td>Uncertain CCS regulatory regime</td>
<td>Prescribed rules (e.g., EPA UIC)</td>
<td>Private insurance + gov’t backstop</td>
</tr>
<tr>
<td>Carbon emission policy uncertainty</td>
<td>Cap with safety valve</td>
<td>Long-term capital subsidies (ITCs)</td>
</tr>
</tbody>
</table>
Wrap-up Points for CCS Deployment

- With dependence in U.S. on coal-based electricity for 12 hours a day (50% of supply), CCS is vital for progress on carbon emissions.
- The current pace of electricity demand and the sharp rise in natural gas prices require that advanced coal plants be built now.
- If risks are addressed through a mix of policies and demos, early plants can be built with CCS to demonstrate feasibility.
- CCS is not economic and subsidies will be needed for first plants.
- Grants and tax credits are easy for industry to ask for, but are difficult for Congress to fully fund. Levies on coal may be needed; but those funds would need to be sequestered for coal projects.
- Risk-based policies (such as loan guarantees, capacity payments) can help stretch limited government funds across more projects.
- Utility bond holders require certainty on CCS liability with no indefinite, long-term exposure. Private owners and insurance can manage first losses, states may want to play to encourage plants.
- Some tools are in place, but legislation is needed to resolve uncertainties. Financing is key: No financing = no CCS deployment.
Path Forward Must Mobilize **Debt** Capital

- Set a long-term cap (2040), economically and physically feasible
- Use “output-based” regulatory performance standards for fossil use
- Provide capital incentives for GHG emission mitigation
- Use fees on fossil use to fund capital incentives via dedicated trust
  - Fees would be geared to carbon emitted (Ed Rubin et. al., CMI)
  - Trust fund prevents governments from misusing receipts (prevents earmarking)
  - Some receipts could be used to support low income households
- Use the bond market to finance infrastructure with carbon mitigation
- Lenders / bond holders demand “predictable, steady cash flow” with strong, creditworthy off-takers
- WBCSD: Forge an international trading market built on national policies among top 10-12 “Major Emitters”. Use treaties (vs. U.N.)
  - Allow carbon offsets in developing countries to be traded among the Major Emitters (Maintain CDM / JI process in growing nations)
  [Curbing consumption for growing nations is a form of oppression]
Insurance / bond can transfer CCS Risk Over Time

Insurance or bonding enacted regionally and chartered by state can be utilized to spread risk and negotiate the cost and liability for carbon leakage over time. Bonding (cash + carbon offsets) can be transferred over time.

First Stage
Formation, Permitting & Operation

Years 40 to 60 - 70, negotiated term

Second Stage
Capping, Closure & Monitoring

Third Stage
Post-closure, Stewardship, & Transfer

Beyond 60-80 years, set by federal regulation

Risk profile of CCS changes over time with rising storage volume then capping and sequestration.

Private

State

Federal

Privately managed
Insurance or bonding
Mitigation of CCS risks

“State chartered” bonding, regulated by state insurance commissioners, with site monitoring, annual fiscal reporting
- Capitalized by private sector as a “first loss reserve” for CCS leakage or damages; multiple plants/sites could capitalize same bond or risk pool.
- Each site brings multiple policy holders
- Federal backstop helps provide finite risk level for initial financing of plant

Optional: State Supervision
Insurance or bonding
Mitigation of CCS risks

States supervise permitting of capping and closure
- To encourage initial financing states can negotiate eventual transfer terms
- Trust assets are available for transfer with the potential liability
- Gathering assets and liabilities from multiple projects with CCS helps diversify risk across multiple sites

Federal Repository
Assumption or bonding
Mitigation of CCS risks

Federal backstop beyond first reserve handles long-term major uncertainties
- Long term assumption by a federal agency (or Treasury) boosts financing for new energy infrastructure with CCS
- Shared risk avoids the “moral hazard” of dumping all liability to a federal agency.
And, the long-term risk is manageable for the federal government with bond assets.

Risk Rating on CCS for WCI – May2008 ADPaterson
IOGCC CCS Legal Framework (State-based)

**September 2007:**
The thirty member states and four Canadian affiliate member provinces of the IOGCC are well suited for regulation of CO2 because of their jurisdiction, experience, and expertise in the regulation of oil and natural gas production, particularly in the use of enhanced oil recovery (EOR), which uses carbon storage.

Scott Anderson, an Energy Policy Specialist for Environmental Defense and an observer to the Task Force deliberations, said that state oil and gas regulators have developed a set of model carbon storage requirements that are thoughtful, rigorous and not a walk in the park for industry.

"The IOGCC model rules will certainly be subject to revision as they are reviewed by more people and as more knowledge about geological sequestration is made. IOGCC’s work, however, is a strong, major step forward in the ongoing conversation about how to do carbon sequestration right," said Anderson.

The report recommends that states and provinces actively solicit public involvement in the process as early as possible and that the process is as transparent as possible. In addition the report stresses that CO2, which is generally considered safe and non-toxic, be viewed in a manner that allows beneficial uses of CO2 following removal from regulated emission streams. Contaminants and pollutants such as hydrogen sulfide, NOx and SOx should remain regulated for public health and safety and other environmental concerns, the report says.

Additionally, the Task Force has proposed a two-stage Closure Period and Post-Closure Period to deal with long-term monitoring and liability issues. The operator of the storage site would be liable for a period of ten years after the injection site is plugged, unless otherwise designated by the state regulatory agency. At the end of the Closure Period, the liability for ensuring that the site remains a secure storage site during the Post-Closure Period would transfer to the state. A [bonding instrument] that is industry-funded and state administered would provide the necessary oversight during the Post-Closure Period. The bonding could be funded by an injection fee assessed to the Carbon Storage Project operator and calculated on a per ton basis.
Wrap-up: Capital Incentives First, with Long-term Cap

- The fundamental issue is accelerating the turnover of “High Carbon” energy infrastructure to low-carbon, efficient systems:
  - Renewables, Power generation with CCS and grid upgrades are all needed
  - End-use efficiency in buildings extends time to turnover capital stock
  - Regulation for CCS is critical to mobilizing debt capital in the bond market
- Large energy infrastructure is built with debt, not risk-oriented capital
- Capital incentives promote economic growth, which is needed to fund innovation and regional infrastructure, and change demand
- Capital incentives foster engineering and innovative technology
- OECD capital markets are large, liquid, and efficient
- Short-term cap & trade can create bureaucratic inefficiencies and incentives for “gaming” and is very difficult to monitor and enforce
  - Economy-wide reporting and monitoring costs are extensive – what to do with cheaters
  - Uneven impact creates large scale winners and losers by region and sector
- Natural sources of carbon are vast and not “capped”
- Incentives engage big developing economies (China, India, etc.)
- A long-term cap (2040) with stable prices mobilizes the bond market
Background References

- Coal plants under construction by type (ENR)
- IPCC Technical Risk Framework for CCS
- GCEP Technical Mitigation Framework (Stanford)
- Carbon Price Volatility
- Utility Cap Ex 2006 – 2008
Despite numerous cancellations, some plants are underway, but CCS is seen as too costly.

<table>
<thead>
<tr>
<th>Bitum.</th>
<th>Sub-bitum</th>
<th>Lignite</th>
<th>Pet coke</th>
<th>Total MW (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supercritical PC</td>
<td>4,150</td>
<td>2,100</td>
<td>1,600</td>
<td>-</td>
</tr>
<tr>
<td>Subcritical PC</td>
<td>1,620</td>
<td>4,040 (1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CFB</td>
<td>850 (2)</td>
<td>40</td>
<td>630</td>
<td>600</td>
</tr>
<tr>
<td>Total, MW (% of total)</td>
<td>6,620 (42.4)</td>
<td>6,180 (39.5)</td>
<td>2,230 (14.3)</td>
<td>600 (3.8)</td>
</tr>
</tbody>
</table>

(1) Includes 280 MW of sub-bituminous waste
(2) Includes 290 MW of bituminous waste

Table 1-6 Net Power Output of Combustion Projects with Permits

<table>
<thead>
<tr>
<th>Bitum.</th>
<th>Sub-bitum</th>
<th>Bitum waste</th>
<th>Pet coke</th>
<th>Total MW (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supercritical PC</td>
<td>338</td>
<td>1,987</td>
<td>2,325 (43.5)</td>
<td></td>
</tr>
<tr>
<td>Subcritical PC</td>
<td>600</td>
<td>600</td>
<td>1,200 (22.5)</td>
<td></td>
</tr>
<tr>
<td>CFB</td>
<td>270</td>
<td>250</td>
<td>465</td>
<td>830</td>
</tr>
<tr>
<td>Total, MW (% of total)</td>
<td>1,208 (22.6)</td>
<td>2,837 (53.1)</td>
<td>465 (8.7)</td>
<td>830 (15.6)</td>
</tr>
</tbody>
</table>

Source: NETL, EPRI
IPCC Overview of CCS Risks

The risks due to leakage from storage of CO2 in geological reservoirs fall into two broad categories: global risks and local risks. Global risks involve the release of CO2 that may contribute significantly to climate change if some fraction leaks from the storage formation to the atmosphere. In addition, if CO2 leaks out of a storage formation, local hazards may exist for humans, ecosystems and groundwater. These are the local risks. With regard to global risks, based on observations and analysis of current CO2 storage sites, natural systems, engineering systems and models, the fraction retained in appropriately selected and managed reservoirs is very likely to exceed 99% over 100 years, and is likely to exceed 99% over 1000 years. Similar fractions retained are likely for even longer periods of time, as the risk of leakage is expected to decrease over time as other mechanisms provide additional trapping.

Figure T.S.8. Potential leakage routes and remediation techniques for CO2 injected into saline formations. The remediation technique would depend on the potential leakage routes identified in a reservoir (Courtesy CO2CRC).
Mitigation Built on Science, Industrial Experience

A sound risk mitigation strategy can be built on scientific methodologies and industrial experience.

Geological Storage Safety and Security Pyramid

“With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods…”

IPCC, 2005

“…the fraction retained in appropriately selected and managed geological reservoirs is likely to exceed 99% over 1,000 years.”

IPCC, 2005

Source: Dr. Sally Benson, GCEP at Stanford, in WRI Workshop June 5, 2007
Recent (Apr 2008) Phase II EU Carbon Prices

Note: A short-term cap-and-trade (i.e., geared to 2020 vs. 2040) without a safety valve will not generate a stable price for carbon emissions, but volatile prices instead – particularly because consumers cannot easily switch away from current consumption and new supply takes a long time to come online. This creates MORE uncertainty for bond investors seeking to evaluate investments in long-lived coal-fired power plants with CCS. A long-term cap-and-trade (2040) regime is better geared to the capital markets and thus will mobilize more debt capital for low-carbon systems.
### Utility CapEx Forecast: 2006 – 2008

*Source: Lehman Brothers*

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>States</th>
<th>NERC area</th>
<th>Building Coal?</th>
<th>2006 ($Mil)</th>
<th>2007E ($Mil)</th>
<th>2008E ($Mil)</th>
<th>Sum ($Mil)</th>
<th>Growth %</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dominion Resources</td>
<td>VA</td>
<td>SERC</td>
<td>Yes</td>
<td>$4,052</td>
<td>$4,400</td>
<td>$4,600</td>
<td>$13,052</td>
<td>$548</td>
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<tr>
<td>2</td>
<td>American Electric Power</td>
<td>OH, TX</td>
<td>RFC</td>
<td>Yes</td>
<td>3,528</td>
<td>3,867</td>
<td>3,026</td>
<td>10,421</td>
<td>-502</td>
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<tr>
<td>3</td>
<td>FPL Group, Inc.</td>
<td>FL, SC</td>
<td>FRCC</td>
<td>No (was)</td>
<td>3,507</td>
<td>5,198</td>
<td>4,258</td>
<td>12,963</td>
<td>$751</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Duke Energy</td>
<td>IN, OH, NC</td>
<td>SERC, RFC</td>
<td>Yes</td>
<td>3,381</td>
<td>3,500</td>
<td>3,500</td>
<td>10,381</td>
<td>$119</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Southern Company</td>
<td>GA, MS</td>
<td>SERC</td>
<td>Yes</td>
<td>2,994</td>
<td>3,911</td>
<td>4,525</td>
<td>11,430</td>
<td>$1,531</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Edison International</td>
<td>CA</td>
<td>WECC</td>
<td>No (but BP)</td>
<td>2,536</td>
<td>3,161</td>
<td>2,951</td>
<td>8,648</td>
<td>$415</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Exelon Corp.</td>
<td>PA, IL</td>
<td>RFC</td>
<td>No</td>
<td>2,418</td>
<td>2,801</td>
<td>2,801</td>
<td>8,020</td>
<td>$383</td>
<td></td>
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<tr>
<td>8</td>
<td>PG&amp;E</td>
<td>CA</td>
<td>WECC</td>
<td>No</td>
<td>2,402</td>
<td>3,200</td>
<td>2,800</td>
<td>8,402</td>
<td>$398</td>
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<tr>
<td>9</td>
<td>TXU Corp.</td>
<td>TX</td>
<td>ERCOT</td>
<td>Yes</td>
<td>2,180</td>
<td>2,870</td>
<td>3,400</td>
<td>8,450</td>
<td>$1,220</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Consolidated Edison</td>
<td>NY</td>
<td>NPCC</td>
<td>No</td>
<td>1,921</td>
<td>1,800</td>
<td>1,800</td>
<td>5,521</td>
<td>-$121</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Xcel Energy</td>
<td>MN, CO</td>
<td>MRO, WECC</td>
<td>Yes</td>
<td>1,626</td>
<td>1,900</td>
<td>1,900</td>
<td>5,426</td>
<td>$274</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Entergy Corp.</td>
<td>AL, AR, LA</td>
<td>SERC</td>
<td>No?</td>
<td>1,614</td>
<td>1,738</td>
<td>2,001</td>
<td>5,353</td>
<td>$387</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Progress Energy</td>
<td>NC, SC</td>
<td>SERC</td>
<td>Yes?</td>
<td>1,425</td>
<td>2,400</td>
<td>2,500</td>
<td>6,325</td>
<td>$1,075</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>DTE Energy</td>
<td>MI</td>
<td>RFC</td>
<td>Yes?</td>
<td>1,403</td>
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**Totals ($millions)**

- Growth 21.5% 1.0%

- Top 10

- Top 20

- $51,148 $62,126 $62,722 $175,996 $11,574