Let’s Make A Deal!

• Welcome and safety
• Agenda and meeting rules
  – Meeting record
• “What Keeps Me Up at Night” submissions
### CEE 2015 in Review

<table>
<thead>
<tr>
<th>GOALS</th>
<th>RESULTS/OUTPUTS</th>
</tr>
</thead>
</table>
| Launch global gas deep dive | • China, India cases; China presented at WGC  
• Combined report in progress  
• LNG supply companion paper  
• **Next up?** Aggregated small markets?  
• Meanwhile, Asia/Europe gas for MEPR |
| Upstream – continue benchmarking, quality improvements | • U.S. producer snapshots, “look ahead” report in progress  
• Tax considerations (state level) still in development  
• NOCs/sovereigns, snapshots; “backcast” to 2013 paper and low oil price considerations |
| Midstream – short-mid term tracking, longer term views | • Industrial demand, eye to downstream monetization  
• LTO growth and “lightening” slate, USCG Proceedings |
## CEE 2015 in Review, cont.

<table>
<thead>
<tr>
<th>Goals</th>
<th>Results/Outputs</th>
</tr>
</thead>
</table>
| Electric power – continuous improvements and expanded scope | • Sustain AURORAxmp modeling  
• Coal fleet retirements, environmental rules, renewables, gas share  
• Nuclear energy – technology, economics, retirements, system impacts; *Roundtable III January 6, 2016*  
• UTEI full cost of electricity – LCOE, LACE, system costs  
• Price formation and uplift payments – LMP, ELMP, others |
| Energy storage and critical mineral resources | • Lithium and other critical minerals value chain economics, snapshots & forthcoming report  
• Resource access, commercial frameworks |
| State/ENR invitation for Government of Mexico | • *Launched:* technical assistance for upstream within context of overall sectoral integrity |
Gas: A Strong “Demand Stack” Scenario

- LNG Exports 2030 (FERC, External Sources)
- LNG exports CEE
- Pipeline exports CEE
- Power generation CEE
- Industrial CEE
- Other (Res, Comm, Trans, Other) EIA AEO 2015
- Total Demand CEE & EIA
- Total supply EIA AEO 2015

CEE analysis and modeling; *CEE outlook does not include growth in EIA industrial baseload; EIA AEO 2015 (reference case)
2015 – Wheeling and Dealing Through Cycles

• Business models and economics – what drives what, when, how, with what outcomes

• BEG/CEE analytics and modeling, mid-long term views
  – Accessible to public, deeper dives, deeper considerations for state of the industries and commercial frameworks

• External forces and disruptions
  – Environment and public perceptions/reactions

• CEE RESEARCH REFINEMENTS FOR 2016
Keynote – Peter Zeihan

BIG MOVING PARTS – DO ACCIDENTS “HAPPEN”?
Upstream Part I

UNCONVENTIONALLY CONVENTIONAL
Rule number 99, “never throw away a good forecast”……

**Humble Pie**

“I Was Like, Oh My God”*, Did I Really Say That? (August 2006)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Oil at $90, gas at $15: oil price pulls other costs, inflation, gas demand fundamentals</td>
</tr>
<tr>
<td>Medium (coin flip)</td>
<td>Oil at $48, gas at $8.28: approaching equilibrium and parity?</td>
</tr>
<tr>
<td>Higher</td>
<td>Oil $45-60, gas at $3-5: diverging fundamentals</td>
</tr>
</tbody>
</table>

* Tribute to Billy Collins
U.S. Speculative-Grade Corporate Rating Actions By Sector In November

Home/RE—Homebuilders/real estate companies. CP&ES—Chemicals, packaging, and environmental services. FP&BM—Forest products and building materials. Financial institutions include banks, brokerage companies, finance companies, mortgage institutions, and savings and loans. Rating changes exclude entities with no rated debt. Downgrades are shown as a negative number. Data as of Nov. 30, 2015. Source: Standard & Poor’s Global Fixed Income Research.

© Standard & Poor’s 2015.
Subsector Distribution Of Weakest Links By Number Of Issuers


© Standard & Poor’s 2015.
Speculative-Grade Corporate Composite Total Returns By Sector

- Year-to-date 2015 return (through November)
- Monthly return (November)

Metals
Oil and Gas
Utilities
Telecommunications
CP&ES
Aerospace/defense
Bank and brokerage
Automotive
Capital goods
Financial institutions
High technology
FP&BM
Media and entertainment
Health care
Insurance
Transportation
Retail/restaurants
Consumer products
Home/RE

(25) (20) (15) (10) (5) 0 5 10


© Standard & Poor's 2015.
U.S. Speculative-Grade Rating Bias By Sector (as of 11/30/2015)


© Standard & Poor's 2015.
Cumulative U.S. Oil & Gas Production, 1900-2014

- Oil discovered in Titusville, Pennsylvania, 1859; natural gas replaces town gas in U.S., 1870s
- Advances in drilling, early seismic, shallow offshore E&P
- Oil discovered at Spindletop (Texas), 1901

**Offshore water depths (feet):**

<table>
<thead>
<tr>
<th></th>
<th>0-25</th>
<th>250</th>
<th>1,000</th>
<th>5,000</th>
<th>10,000+</th>
</tr>
</thead>
</table>

**Porosity, permeability:**
- Conventional
- Unconventional
- "Nano"

**IT Pathway:**
- Slide Rule
- Mainframes
- Minis/Micros/Workstations/Networks
- "Standalone"
- Data Integration

- Arctic?
- Hydrates?
- Multistage hydraulic fracturing
- 4-d seismic
- 3-d seismic, horizontal drilling, measurement while drilling
- Directional drilling; pipeline trenching and welding, compression, pressure control, metering
- Long-line pipeline transmission
- Advances in drilling, early seismic, shallow offshore E&P
- Oil discovered at Spindletop (Texas), 1901
- Oil discovered in Titusville, Pennsylvania, 1859; natural gas replaces town gas in U.S., 1870s
NOC Upstream Costs and Leverage

<table>
<thead>
<tr>
<th>LTD/Equity %</th>
<th>2013</th>
<th>2014</th>
<th>Moody’s Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statoil</td>
<td>46%</td>
<td>54%</td>
<td>Aa2-S</td>
</tr>
<tr>
<td>CNOOC</td>
<td>24%</td>
<td>28%</td>
<td>Aa3-S</td>
</tr>
<tr>
<td>PetroChina</td>
<td>24%</td>
<td>28%</td>
<td>Aa3-S</td>
</tr>
<tr>
<td>Sinopec</td>
<td>28%</td>
<td>28%</td>
<td>Aa3-S</td>
</tr>
<tr>
<td>Petronas</td>
<td>11%</td>
<td>9%</td>
<td>A1-S</td>
</tr>
<tr>
<td>Pemex</td>
<td>Negative Equity</td>
<td>Negative Equity</td>
<td>Baa1-S</td>
</tr>
<tr>
<td>Ecopetrol</td>
<td>30%</td>
<td>49%</td>
<td>Baa2-S</td>
</tr>
<tr>
<td>ONGC</td>
<td>7%</td>
<td>27%</td>
<td>Baa2-S</td>
</tr>
<tr>
<td><strong>Speculative Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosneft</td>
<td>53%</td>
<td>76%</td>
<td>Ba1-N</td>
</tr>
<tr>
<td>Petrobras</td>
<td>71%</td>
<td>103%</td>
<td>Ba2-S</td>
</tr>
<tr>
<td>PdVSA</td>
<td>53%</td>
<td>53%</td>
<td>Caa3-S</td>
</tr>
<tr>
<td><strong>Simple Average</strong></td>
<td>35%</td>
<td>46%</td>
<td></td>
</tr>
</tbody>
</table>
Day One Luncheon Keynote – Mark Houser

ENERGY OPPORTUNITIES
Upstream Part II

NAVIGATING THE MIDSTREAM RAPIDS
What We Said in June 2013

• MLPs in the midstream are abandoning less profitable basins with more dry or non-associated gas and shifting their production/capital to basins with more profitable hydrocarbons such oil and liquids

• Those shale plays richer in crude oil and liquids such as Eagle Ford, Marcellus, and Permian will benefit from this shift
Conclusions/Concerns from June 2013 Meeting

1. Vicious cycle: need more DCF to pay unit holders requiring more capital to build or buy assets that create more DCF.

2. Assets can become overvalued due to increased competition among MLPs to increase DCF.

3. Oil and NGL prices could weaken with increased production thereby pressuring DCF of the MLPs?

4. Could credit metrics weaken or MLPs become overleveraged in quest for DCF?

5. Is a Bubble forming?

Implications for CEE research
Teeing Up the Issues

• In what way is Midstream different than the rest of the petroleum industry? Regulatory? Economics? Business/Financial model?
• Are there drivers or indicators that are different for Midstream than for other oil patch industries?
• Anything happening today in the Midstream that is not happening to other petroleum industry sectors?
• Is there likely to be any actionable results from further Midstream study? For example:
  – Are producers and customers being well served by the current business/financial structure?
  – Does the Midstream business model fit the underlying economics?
  – Is there a more efficient business model?
  – Is the current round of consolidation leading to too much market power?
  – Where is FERC on changes in Midstream?
  – Implications of current trends in the U.S. petroleum industry?
  – What changes are needed?
Midstream – What’s the economic Rationale?

1. Majors vs. Independents
2. Economies of Scale
3. Appropriate risk-reward ratio between business and customer
4. Is this a competitive industry?
5. Focus on Core Competencies
6. Regulatory incentives/barriers
7. Cost of Capital
8. Financial Vehicles
9. Sources of Capital
10. Investor Risk Profiles
11. Tax incentives/Disincentives
12. Market-based rates versus Fixed ROI
13. Geographic scope
14. Others?
Size of the Midstream

In Billions of Dollars; Apple based on 11/20/15 market close

Source: AMZI Fact Sheet
Infrastructure in the Midstream

AMZI based on 22 MLPs with total Market Cap of $213 billion

Composition

- Pipeline Transportation/Nat Gas: 42.5%
- Gathering & Processing: 31.6%
- Pipeline Transportation/Petroleum: 25.9%

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S&P ratings of Midstream

- CCC
- BBB
- A
- BB
- B
S&P Ratings of Midstream Co’s

Two Notable Downgrades: DCP from BB to BB from BBB- and Enbridge from A- to BBB+
How Bad is Bad? Financial Optics

- S&P reports 11 downgrades as of Oct, 2015 as compared to 11 for all of 2014. 13 companies are on negative watch.
- DCP and Enbridge were 2 large downgrades in 2015 by S&P.
- Moody’s lowers midstream outlook as a result of cuts in capex by E&P companies that funded infrastructure projects.
- Continued low NGL prices.
- Alerian Index (ETF for MLPs) is down 30% as of Oct.
- Cost of capital is increasing (e.g. KMI paying 9.75% on mandatory preferred shares).
- Unit prices of MLPs are down as investors flee the sector.
How Bad is Bad?

• Proportion of defaults by E&P companies has risen to 42% in North America so far this year

• The sector leads in the weakest links (issuers Standard & Poor's rates 'B-' or lower with negative outlooks or on CreditWatch with negative implications) and is considered the sector to be among the most vulnerable to defaults in the coming months

• According to S&P, the oil and gas sector accounted for the largest number of distressed borrowers, 95 out of 270
How Bad is Bad?

• Moody’s analysts downgraded their outlook for global midstream on Aug 17\textsuperscript{th}
• From “Positive” to “Stable”
• Project that EBITDA growth will slow to 3% to 5% in 2015 and slower growth in 2016
• Deep spending cuts in E&P have reduced midstream spending that underpinned their previous positive outlook which peaked at 15% in 2013 and 2014
• Moody’s does project that Marcellus and Utica plays are still in need of additional infrastructure investment
• Gathering and Processing segments are feeling pressure of low prices
• Moody’s held out possibility of further downgrade if EBITDA slows more than 5% as projected
Negative Trends for Midstream

• Lower energy prices
• Hedges are rolling off and being renewed at lower levels
• DCF (Distribution Coverage Ratio) is decreasing
• Lower production volumes are hitting their revenues
• Margins being squeezed by producers reaching for more margin (e.g. Chesapeake/Williams deal)
MLP is Dominant Business Structure in the Midstream

What are MLPs?

MLPs, or Master Limited Partnerships, are publicly traded limited partnerships traded on stock exchanges. A share of an MLP is a unit, and all unitholders are limited partners. They are a popular energy-industry investment vehicle.

MLP History

First MLP, launched in 1981, was Apache Oil Co., and the number grew through the ‘80s.

1981

1987

Congress passed legislation to define publicly traded partnerships in 1987, requiring them to earn more than 90% of their income from specific sources, causing many MLPs to lose their status.

Qualified earnings are:
- Interest, dividends and capital gains;
- Rental income and capital gains from real estate;
- Income from natural resource activities;
- Income from commodity investments; and
- Capital gains from asset sales of all of the income types.

2015

Today, most MLPs are in the energy industry, with most in the midstream—gathering, processing, transportation and storage—sector. Some upstream—oil and gas production—and downstream—refining and marketing—are MLPs.

2000

1990

During the ‘90s, energy companies began dropping down midstream assets to partnerships that
MLP vs C Corps

**MLPs vs. Traditional Corporations**

**What's the difference?**

**MLPs**

- **Pay no taxes**
  If at least 90% of its income is from qualifying sources as defined by the Internal Revenue Code 247A—most of which are within the energy industry.

- **Two classes of owners**
  - General partner (GP)
  - Limited partner (LP)

- **The GP interest of an MLP is**
  Usually owned by a major company, an investment fund or the MLP’s management.

- **The GP controls operation and management**
  For the MLP and usually owns a small portion of the operating LP.

- **People who own units, called limited partners,**
  own the rest of the partnership but usually aren’t involved in operations or management.

**Corporations**

- **Pay federal income taxes of up to**
  35% and any applicable state and local taxes.

- **Owned**
  100% by shareholders

- **Decisions are made by management teams**
  as well as shareholders at annual meetings where shareholders vote on important issues.
Current Financial Stress on MLPs

• One problem cited is lack of “MLP quality” assets for drop downs
• Cost of capital could limit ability to fund acquisitions or make the more expensive
• Lack of upstream development continues to limit need for infrastructure which will limit future drop downs
• More M&A as a result?
Can MLPs Survive?

• Many are already predicting the demise of the MLP. If it doesn’t survive, what does this do to the energy value chain? Winners and losers?

• Will midstream start to segregate into two classes: major non-MLP companies (KMI ETE, etc) versus the smaller MLPs? Is there a comparative advantage?

• If MLPs do survive, what changes will the business model have going forward as a result of low energy prices and what impact on value chain?

• How is midstream responding to current financial stresses and what is the impact on the industry?
Will Higher Prices Reverse the Declines?
More Light Less Heavy Means?

Crude Price Delta to WTI

Source: EIA
Are Many Other Basins Overbuilt?

* Basin, Centurion, West Texas Gulf, Longhorn pipelines
Proposed Crude Pipelines
Did New Pipe Raise Realizations?

Crude Price Differential to WTI

Source: EIA
Bakken Crude Squeeze

• Region is still dependent on rail takeaway with limited pipeline capacity
• Higher cost of rail vs pipe now causing east coast refiners to move to foreign crudes instead
• Producers can’t afford the discounts to move by rail and abandoning the region
• Occidental Petroleum sold its ND assets to undisclosed buyer for $600 million
• Two other Bakken players: American Eagle and Samson Resources are in bankruptcy  (WSJ: 11/23/15)
Estimated ND Rail Export Volumes

Source: ND Pipeline Authority
Gas Production: Not Much Change Since April

Lower 48 Wellhead Production Growth (Bcf/d)

Source: PointLogic Gross Processing Plant Database
Will 2014 Ever Be Repeated?

2014 Wellhead Production Growth by Region

Source: PointLogic Gross Processing Plant Database
Will Declines Overtake Growth in 2016?

2015 Year-to-Date Production Growth by Region

Source: PointLogic Gross Processing Plant Database
Pipeline Logistics Forever Altered?

Throughput Louisiana North - MMcf/d (TETCO)
Capital’s Been Focused on the Northeast

**Escape Routes from the Northeast**

- Leach Xpress, Nexus
- NED, Atlantic Coast, App. Connector
- REX Clarington West, Rover Phase II, Atlantic Sunrise
- Rover Phase I
- REX Z3 E2W

Source: PointLogic Energy

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Are 2017-18 Projects in Jeopardy?

Northeast Infrastructure Expenditures

Source: EIA, PointLogic Energy
Any Issues to be Addressed in the Rockies?

![Rocky Mountain Supply/Demand Graph](image)

**Source:** PointLogic Energy
Some RM Basins Still Show Growth

![Rocky Mountain Dry Gas Production Graph](image-url)

- Rig Count

Source: PointLogic Energy

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Is the Rockies Over/Underbuilt?

Rocky Mountains Oil Production

- Rig Count

Source: PointLogic Energy
Most of the Rockies Gas Gets Dumped Early

Rockies Eastbound Outflows (Jan.-Oct.)

Source: PointLogic Energy
* excludes Bakken outflows.
Big Ticket Projects

SPECIAL ECONOMICS, SPECIAL REGIONS AND VERY SPECIAL FRAMEWORKS
CEE Global Gas Demand

Some Ideas/Concerns From 2014 Workshops

• What is the global market for US LNG?
• Could China’s natural gas demand decline? Could LNG be replaced by piped gas or nukes?
• Is competition from coal and renewables still an issue for natural gas?
• Are natural gas prices delinked from oil prices?
• Are big potential natural gas importers developing substitutes for natural gas/LNG?
• Status of global natural gas infrastructure development
CEE Global Gas Demand

Insights from China and India Natural Gas Demand Research

• 43% of gas consumption in China is from industrials-fertilizer, glass, paper, steel and petrochemicals-experiencing overcapacity and weak profitability. Transitioning economy away from these industries.

• Power accounts for 18% of China’s gas consumption primarily for peaking in coastal areas. Power consumption growth rates are declining. Base load power generation expected to come from coal (9 new clean coal power bases in West) and nuclear (25 units under construction). Gas relegated to peaking?

• Residential gas consumption in China (20% of gas consumption) is growing-only 16% of population has access to piped gas. Growth potential in North. Big enough to offset potential declines in industrial gas consumption?

• Industrial and power gas prices linked to fuel oil and LPG prices. Historically substantial price subsidies. Coal generation about 25% cheaper than gas generation.
82% of India’s gas consumption is from power and industries.

Power sector gas consumption has been declining since 2010 constrained by lack of supply and inadequate infrastructure. In early 2015 53% of gas generation capacity had zero supply and 36% operated at 30-40% load factors.

Power sector renewables consumption about equal to gas consumption in 2013. India recently announced aggressive solar development program targeting mainly rural areas where about 300 million are without electricity.

Gas-fired generation (7% of total) is expensive relative to coal-fired generation (71% of total) at domestic prices of about $5.00/MMBtu. 84% of supply is from less expensive domestic sources. Power sector is financially weak and heavily subsidized.

Industrial gas demand has been flat since 2010. About 50% of non-fertilizer industrial gas consumption comes from LNG.

Indian gas midstream infrastructure is inadequate to move supply to demand centers. Infrastructure expansion impeded by land acquisition policies.
CEE Global Gas Demand

Some Ideas/Concerns From 2014 Workshops

• What is the global market for US LNG? WEAK AT PRESENT
• Could China’s natural gas demand decline? YES Could LNG be replaced by piped gas or nukes? NUCLEAR AND CLEAN COAL FOR BASELOAD
• Is competition from coal and renewables still an issue for natural gas? YES
• Are natural gas prices delinked from oil prices? STILL LINKAGES WITH OIL BASED SUBSTITUTES
• Are big potential natural gas importers developing substitutes for natural gas/LNG? YES ESPECIALLY FOR POWER
• Status of natural gas infrastructure development  MORE DEVELOPED IN COASTAL CHINA. INDIA HAS MAJOR DEFICIT.
CEE Nuclear Energy Research – Timelines and Project Costs

Vogtle Unit 3&4
- Southern Company (Georgia Power)
- 2 * Westinghouse 1,250MW AP1000 Reactor

Georgia PUC Approval
March 2009
Total Cost ~ $ 14.3 Billion


Georgia PUC Approval
March 2009
Unit 3&4 COD

12th VCM Report
Feb. 2015
Unit 3&4 COD

Cost overrun ~ Total $ 17+ Billion

Schedule delay
CEE Advisors Panel

CLOSING THOUGHTS FOR DAY 1, LOOK AHEAD TO DAY 2
Invited Dinner Keynote – Sheila Hollis

WHEELING AND DEALING IN WASHINGTON IN 2016
Power and Utilities Part I

FUZZY LOGIC?
ERCOT Resource Adequacy: Higher Price Cap Should Increase Reserve Margin

- ERCOT is an energy-only market (i.e., no capacity markets)
- Marginal fuel is natural gas + >10 GW of wind ➞ low electricity prices since 2010 (except for August 2011)
- Price cap increase should help but
- Reserve margins also depend on environmental regulations, share of renewables, price of natural gas

Natural Gas Consumption Increases Significantly Even With More Renewables

• The model builds CT primarily, partially because natural gas price remains low.
• ~12 GW of CC under construction or in advanced development were added for all scenarios as well as 5.5 GW of nuclear.
• The renewables case is aggressive, including ~58 GW of wind and ~27 GW of solar, including “announced” projects.
But, What Future do you Expect?

Consumption of Natural Gas in Power Generation
(Index, 2010 = 1)

- More energy efficiency and conservation (AEO reference scenario 0.8% annual growth in electricity use)
- More renewables
- More generation from nuclear

Based on data from EIA AEO 2013* & IHS Global Insight

* AEO 2014 and AEO 2015 are similar.
Also, What Cost of Generation?

LCOE is imperfect but used a lot!

LCOEs on this map
- Cover capital, operating, fuel and emissions costs, including social cost of carbon of $63/ton.
- Do not cover T&D costs.
- Do not consider access to cooling water.
- Do not consider local constraints.
- Regional variation due to differences in overnight capital and fuel costs, and capacity factors.
Potentially Major Game Changer: Utility-Scale Solar PV Cost Declines to $/1 W Installed

Reference case with low solar CAPEX ($1/W)

• Used $2.7/W in the Reference Case, which is based on 2013-14 engineering design studies
• Solar industry already claims <$2/W but reported installed costs have been higher
• Without storage, solar expansion will be curtailed
• Power purchase agreements signed by utilities offer prices as low as $40-50/MWh, competitive with cheap gas-fired power (e.g., Austin Energy and CPS in Texas)
LACE Incorporates Portfolio Mix (If LACE > LCOE, “economic”) – ERCOT Scenarios (2014-2030)

<table>
<thead>
<tr>
<th>$2014/MWh</th>
<th>Current Trends</th>
<th>CT with High NG Price</th>
<th>Aggressive Renewables</th>
<th>AR with High NG Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>31.8</td>
<td>61.7</td>
<td>30.4</td>
<td>54.8</td>
</tr>
<tr>
<td>Solar</td>
<td>36.8</td>
<td>70.5</td>
<td>36.1</td>
<td>67.5</td>
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<tr>
<td>Gas – Non-Cycling</td>
<td>39.9</td>
<td>85.8</td>
<td>40.6</td>
<td>86.1</td>
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<tr>
<td>Gas – Peaking</td>
<td>80.9</td>
<td>162.1</td>
<td>88.6</td>
<td>168.7</td>
</tr>
<tr>
<td>Coal</td>
<td>45.5</td>
<td>65.4</td>
<td>46.3</td>
<td>63.1</td>
</tr>
</tbody>
</table>

- Low NG prices ($3-4 through 2030): LACE < LCOE with the possible exception of gas units.
- High NG prices ($8 by 2027): LACE > LCOE with the possible exception of solar under most assumptions.

Sponsored by UT Energy Institute as part of the Full Cost of Electricity (FCe) research program.
Even LACE Does Not Tell the Whole Story – How About Total System Costs

- Aggressive Renewables (AR) scenario costs ~$20 billion more in overnight capital costs than the Current Trends scenario
- AR saves ~$630 million in fuel and operating costs in 2030
- Assuming the same savings every year (2014-2030), AR can save ~$10 billion, half of the capital investment
- Assuming emissions savings are as high every year as 2030 and $100/tCO2, savings from emission costs can be ~$36 million, minimal as compared to other costs

Sponsored by UT Energy Institute as part of the Full Cost of Electricity (FCe) research program.
CEERT Low Carbon Grid Study
Towards 2050:
CA Carbon Emission Trajectories

Electric Sector Emissions (MMT)

Year

2010 2015 2020 2025 2030 2035 2040 2045 2050

CARB Emission Trajectory to 2050
Baseline Case
High Solar- Conventional
Target-Enhanced
Accelerated Case (Phase I)
Path to 2050
Gradual interest rate increases unlikely to cause a financing crisis
Existing central station power is subject to tightening pollution rules
Oversupply in power portfolio hasn’t been rationalized
“Big” transmission is not actually happening
Energy efficiency a legacy of California Energy Crisis prices
Economies of scale hard to sell in an smart phone world?
Average retail net metering divides customers
Push to empower consumers’ ability to manage energy consumption
Resiliency starts at home?
The morality of buying groceries locally…
**Clean Power Plan** structure creates opportunity to use options beyond utility scale renewables and natural gas for compliance

**Distribution level investment empowers state regulators**
- Energy efficiency reduces demand
- Demand response and storage flatten the load curve
- Retail self-supply pushes back on distrusted centralized wholesale markets
- Distribution level investment implies improved reliability/resiliency
- Cost of capital advantage via utility balance sheet finances

**Public utilities have called the bluff on average retail rate net metering**
- Little wisdom in abandoning the existing system before it is paid for
- Have no profits to use to fund overpayment of solar DG
- Could help drive constructive changes in rate design (moving to fixed charges and time of use, fees for services)
TRANSMISSION AND STORAGE
Roadmap

Raw Material Demand for Lithium-ion Batteries

- Specific energy (Wh/kg)
- Specific power (W/kg)
- Safety
- Performance
- Life Span
- Cost of production

Cathode Chemistry

- Raw Material Demand
- Raw Material Price
- Raw Material share in manufacturing cost

Demand for Batteries

Energy & Environmental Policy

Geopolitical risk of mining
Environmental impact of mining
Market transparency
Transportation and storage of batteries

Geothermal brine
Geothermal brine

Recycling

Substitution in markets other than batteries

New Process Capacity

Existing Process Capacity

Raw Material Supply

- Capacity Utilization
- Recycling
- Substitution in markets other than batteries

New Resources

Resources

Reserves

- New Resources
- Continental brine
- Hectorite clay
- Oil field brine

Pegmatite

Raw Material Price

Raw Material share in manufacturing cost

Manufacturing cost

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The data and end use information for calculation of this lithium flow diagram is derived primarily from USGS (2013), Yaksic (2009), Gruber (2012), Peiro (2013), Evans (2014) and Deutsche Bank (2011) and from information published by major manufacturers like Albermarle Corporation and FMC.
CEE Advisors Panel

CLOSING THOUGHTS DAY 2, COMMENTS ON/RECOMMENDATIONS FOR CEE RESEARCH
TECHNOLOGY DISRUPTIONS – GAS AND POWER “DEEP DIVE”

Day 2 Luncheon Keynote – Ed Kelly