What Do Updated 45Q Tax Credits Mean for Carbon Capture?

Presentation to

NARUC Clean Coal Subcommittee

April 10, 2018
Today’s Topics

• Welcome & Introductions
• Technology Snapshots:
  • David Greeson, NRG
  • Walker Dimmig, NET Power
  • Ron Munson, Cogentiv Solutions
• Regional Carbon Capture Deployment Initiative
• Q & A
Carbon Capture with new 45Q

April 2018
Petra Nova – so far so good

Achieved COD on Dec. 29, 2016

- Captures approximately 1.6 million tons per year of carbon dioxide (CO₂)
  - CO₂ is used to enhance oil production at the West Ranch Oilfield
  - Sequestering 5,200 tons of CO₂ per day

Over 1.3 million tons of CO₂ captured

Producing more than 5,000 barrels of oil per day
Petra Nova Project Overview

Five Projects in One

1. **Diverting the flue gas** from an existing facility (Parish Unit 8)
2. **Processing flue gas** in a carbon capture system to strip out the CO₂
3. **Transport CO₂** to a nearby oil field.
4. **CO₂-EOR** operation to produce otherwise unrecoverable oil
5. **Transport and sell oil** – marketing, selling, and transporting the oil

Oil revenues pay for the entire project

No impact on power plant or its costs
Our Partners

JX Holdings is a leading integrated energy, resources, and materials company.

NRG Energy, Inc. is the largest independent power company in the US.

Hilcorp Energy is one of the largest privately-held oil and natural gas E&P companies in the US.

JBIC and NEXI combined on a $250 million project loan.

US DOE awarded $190 MM grant funded through Clean Coal Power Initiative.
Factors to consider for CCS

• Does the coal plant warrant the investment?
  - Cost of power vs. forward market
  - Will that be the case for the next 30 years

• Can you monetize the 45Q tax credit?
  - Tax Equity providers not currently in the space
  - There will be a cost

• Will CO2 off-takers commit?
  - Long term commitment required
  - Good credit quality needed

• Are commercial banks interested in financing?
  - Will need good answers to all the above
  - May be the same players as the Tax Equity crowd
Who will monetize 45Q tax credits?

- Only a tax payer can monetize
  - Public Power is not a tax payer
  - IOUs not consistently tax payers

- Transferable to CO2 off-taker or sequestration entities
  - Only helpful if the off-taker expects to be a consistent taxpayer over the next 10+ years

- Solar and Wind ITCs monetized by banks
  - Initial discussions have not yielded any interest
Is the new incentive enough?

- Depends on how much the capture technology improves
  - If costs are the same as Petra Nova – then answer is no
  - Upfront capital cost most significant hurdle
  - Energy penalty is a close second

- FOR EOR it’ll be close
  - 45Q improvements go a long way
  - But will need access to financing to get there
Thank you!

David Greeson
david.greeson@nrg.com
NET POWER

TRULY CLEAN, CHEAPER ENERGY

APRIL 2018
Using the Allam Cycle, NET Power:

- Produces **electricity from natural gas**
- Provides **superior economics than** existing natural gas power plants
- Captures or eliminates substantially all of the carbon and non-carbon atmospheric emissions without any additional cost
- **Does not require water** (at a small reduction in efficiency)
- Can use **inexpensive fuels** such as acid gas, sour gas, associated gas, and produced gas
- Produces **valuable gases**, including CO₂, N₂, O₂ and Ar
THE SUPercritical CO\textsubscript{2} ALLAM CYCLE IS SIMPLE

Historically, oxy-combustion has been too costly to employ.

The Allam Cycle makes oxy-combustion economic by pairing it with an sCO\textsubscript{2} cycle.
THE NET POWER ECONOMIC ECOSYSTEM

NET Power is targeting a cost of electricity that is competitive on electricity sales alone:

- 59% efficient (LHV)
- Comparable capital costs to NGCC

Co-produced industrial gases will help NET Power compete as it comes down the cost curve.

45Q increases the value of NET Power’s CO₂ significantly

Commodity pricing:
- Natural Gas - $2.85/MMBtu
- Electricity - $0.04/kWh
- Ar - $300/ton
- O₂ - $35/ton
- N₂ - $8/ton
- CO₂ - $15/ton
- CO₂ (45Q) - $40.19/ton

(tax credit of $35 per metric tonne converted to short ton and grossed up at 21% rate to represent a pretax revenue stream)
NET POWER PARTNERS WELL WITH RENEWABLES

NET Power’s cost, reliability, and flexibility make it a critical component of any clean energy portfolio.

Allows deep decarbonization, without diminishing returns.

COST OF ELECTRICITY WITH DIFFERENT LOW-CARBON TECHNOLOGY MIXES

To achieve deep CO₂ reductions with high renewable penetration and NGCC, the electricity system must be “overbuilt” to address renewable intermittency. NET Power enables deeper reductions for far lower costs.

Data obtained from: Brick, S., and Thernstrom, S., Renewables and decarbonization: Studies of California, Wisconsin, and Germany, The Electricity Journal, 2016, 29, 6-12.
DEVELOPMENT STATUS

50 MWth Demonstration Plant in Start-up and Testing

- Plant scaled down from 300MWe commercial design
- Full, grid-connected Allam Cycle facility
- $160M+ design, construction, and testing program

300MWe Commercial Plants Under Development

- Detailed Pre-FEED completed
- Sites and development opportunities identified
- Targeting COD in 2021

La Porte, TX Demonstration Plant
45Q TAX CREDIT CONSIDERATIONS

 PROVIDES SIGNIFICANT VALUE TO NET POWER PROJECTS

- CO\textsubscript{2} revenue stream approximately $49M/year
  - NET Power projects offer a very strong economic case
- Creates opportunity for CCS projects that are not tied to EOR
- Provides pathway to move down cost curve towards nth-of-a-kind targets
- Siting less dependent on CO\textsubscript{2} network and maximizing sales of produced gases
- Should lead to an acceleration of orders to meet the 2024 eligibility deadline

QUESTIONS AND UNCERTAINTY WILL STILL NEED TO BE ADDRESSED

- IRS guidance will be key
  - Big Issues: secure geologic storage requirements (permitting); recapture; commence construction definition
- Project structuring
  - EOR aspect of the project helpfully brings another tax-payer into the mix, but there will be added project structuring complexity
  - Role and appetite for financial institutions and tax equity players?
Carbon Capture in Industrial Systems

NARUC Carbon Capture Technologies Webinar

Cogentiv Solutions

April 10, 2018
Cogentiv Solutions
Carbon Energy and Environmental Management

- Carbon Management
  - Carbon Capture
  - Carbon Utilization/Re-use
  - Research Programs
  - Project Development
Projected Carbon Management Contributions

IEA 2°C Scenario

CCS contributes 12% of cumulative reductions required through 2050 in a 2DS world compared to ‘business as usual’

Source: IEA, Energy Technology Perspectives (2016)
# Cost Impacts of Mitigation Technology Choices

What happens if some technologies are not included

## Percentage increase in total discounted mitigation costs (2015-2100) relative to default technology assumptions – median estimate

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<th>2100 concentrations (ppm CO₂eq)</th>
<th>no CCS</th>
<th>nuclear phase out</th>
<th>limited solar/wind</th>
<th>limited bioenergy</th>
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<td>450</td>
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<td>7%</td>
<td>6%</td>
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Symbol legend – fraction of models successful in producing scenarios (numbers indicate number of successful models)

- **All models successful**
- **Between 80 and 100% of models successful**
- **Between 50 and 80% of models successful**
- **Less than 50% of models successful**

Definition of Carbon Capture

Separation of the CO$_2$ from a gas stream produced in a power station or an industrial process to obtain pure CO$_2$ for geological storage or further use.
CO₂ Concentrations: Select Sources
Large-Scale Projects

- Power generation
  - Boundary Dam
  - Petra Nova
- Coal-to-liquids
- Chemical production
- Iron and steel production
- Synthetic natural gas
  - Great Plains
  - Enid Fertilizer
- Fertiliser production
  - Century Plant
  - Coffeyville
  - Uthmaniyah
- Oil refining
  - Shute Creek
  - Selwyn
  - Air Products
- Natural gas processing
  - Terrell (formerly Val Verde)
  - Lost Cabin
  - Lula
- Hydrogen production
  - EOR
  - Dedicated Geological

= 1Mtpa of CO₂ (area of circles proportional to capacity)
Large-Scale Projects

Cost/Complexity of Removing CO₂ from Selected Sources
Cost Analysis for Industrial Carbon Capture

The graph illustrates the break-even selling price of CO2 in dollars per tonne as a function of the potential CO2 available in the U.S. from existing sources in million tonnes per year. Different industries are represented by different colors and markers:

- **CTL** (black circle)
- **GTL** (orange square)
- **NGP** (brown triangle)
- **Ethylene Oxide** (blue diamond)
- **Ammonia** (red square)
- **Ethanol** (green square)
- **Steel** (purple rhombus)
- **Cement** (light blue triangle)
- **Ref H2** (yellow square)
- **PC Reference** (purple diamond)

The graph shows the cost implications for various industries depending on the availability of CO2.
Cost Reductions Through Learning-By-Doing and R&D

Relative to Supercritical PC Plant w/o Capture (39.3% HHV efficiency)

$100+/Tonne (FOAK)

~ $60/Tonne (NOAK)

< $40/Tonne (NOAK)

Energy Penalty Reductions Enable Cost Reductions

Power Generation Penalty [% of Plant Output]

2005 2012 2020
Implications in Light of 45Q

• **Industrial Sources**
  • 80 million tonnes/year with breakeven costs of $35/tonne or less
  • Hydrogen production is a potential source of additional 50+ million tonnes/year; requires additional analysis
  • Challenge comes with accessing EOR or storage
  • Low costs mean these sources are likely to be used before power

• **Power Sector Sources**
  • Higher costs make the business case challenging
  • **Clean Air Task Force Analysis**
    — Assumes industrial sources used first
    — Takes into account CO2-EOR supply curves
    — 45Q alone incentivizes approximately a dozen power plants
    — Number goes to 80+ with additional incentives; PAB/MLP
    — Full study results in 3-4 weeks
Ron Munson
Ron.munson@cogentivsolutions.com
www.cogentivsolutions.com
Regional Carbon Capture Deployment Initiatives

- Development of two regional deployment initiatives to capitalize on the passage of 45Q: Northern Plains/Rockies and Midwest regions
  - Governor Mead has sent a letter to 17 governors, inviting their states’ participation.
  - Scoping effort underway, with launch of regional initiatives planned for June.

- Three-phased approach
  - **Phase I** scoping underway under auspices of 14-state Work Group (Q1-2 2018):
    - Baseline mapping of CO\(_2\) sources and oilfield and saline reservoir sinks;
    - Cost analysis to identify early mover carbon capture project opportunities;
    - Pipeline modeling based on source mapping and cost analysis;
    - Direct outreach to governors staff and state officials in ~17 states; and
    - Identification of state, industry, and other stakeholder participation.
  - **Phase II** (Q3 2018)
    - Convene regional deployment initiatives, drawing on baseline analyses and modeling.
  - **Phase III** (Q4 2018 and beyond)
    - Modeling and planning support of project deployment (deeper analysis and public-private engagement around specific project opportunities identified); and
    - Identification of federal and state policy options for closing remaining cost gaps for specific capture and pipeline projects after accounting for the 45Q tax credit.
Thank you!
Questions?