NET Power

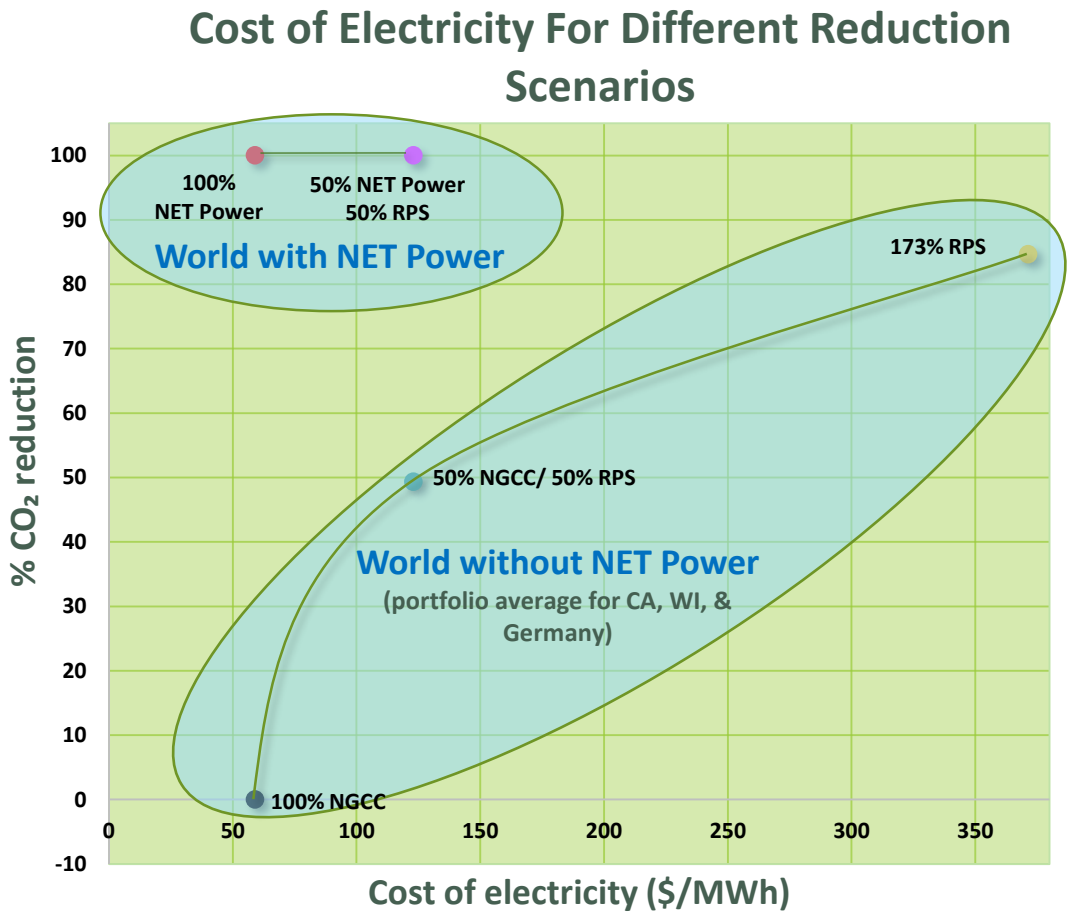
Truly Clean, Cheaper Energy

September 2016

NET Power allows the world to meet all climate targets without having to pay more for electricity.

Meets the World Economic Forum "Future of Electricity" call for "no regrets" investments that will be palatable in almost any economic climate.

NET Power compliments renewables, enabling deeper decarbonization



- **System level studies consistently show that high levels of renewable penetration (50-80%) result in greater system costs than balanced and "high CCS" scenarios even assuming *today's* high CCS costs.**
- **Fossil deployment remains roughly equal compared to reference or balanced scenarios; higher levels of renewable penetration do little to offset need for baseload generation.**

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

NET Power is a truly novel approach to power generation

- **NET Power makes low cost electricity from natural gas**
  - NET Power costs the **same as, or less than**, electricity from existing natural gas power plants
  - NET Power generates electricity at **high efficiency** (59% LHV)
- **NET Power will capture substantially all of the CO_2 and non-CO_2 atmospheric emissions without any additional cost**
  - The CO_2 is captured at **pipeline purity and pressure** ready for various industrial uses
- **NET Power does not need to use water (at a small reduction in efficiency)**

NET Power's first plant is under construction

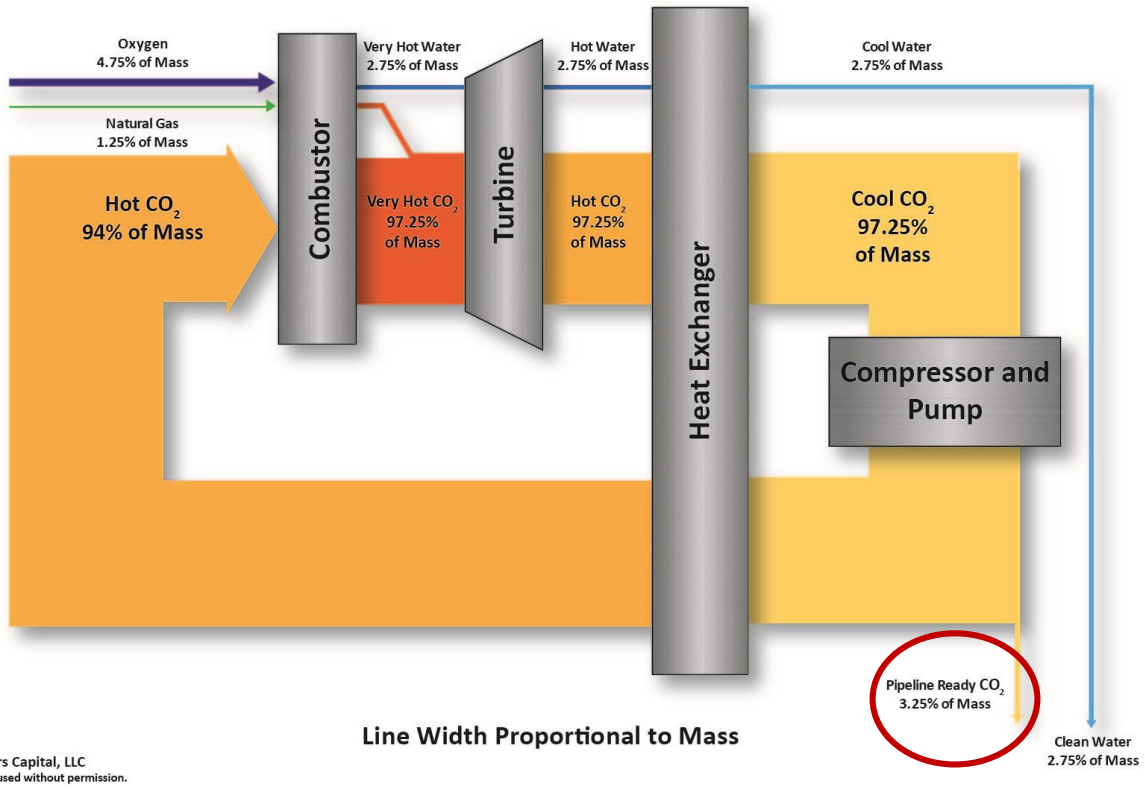
50 MWth Plant in LaPorte, TX, on track for commissioning later this year

Technology Overview

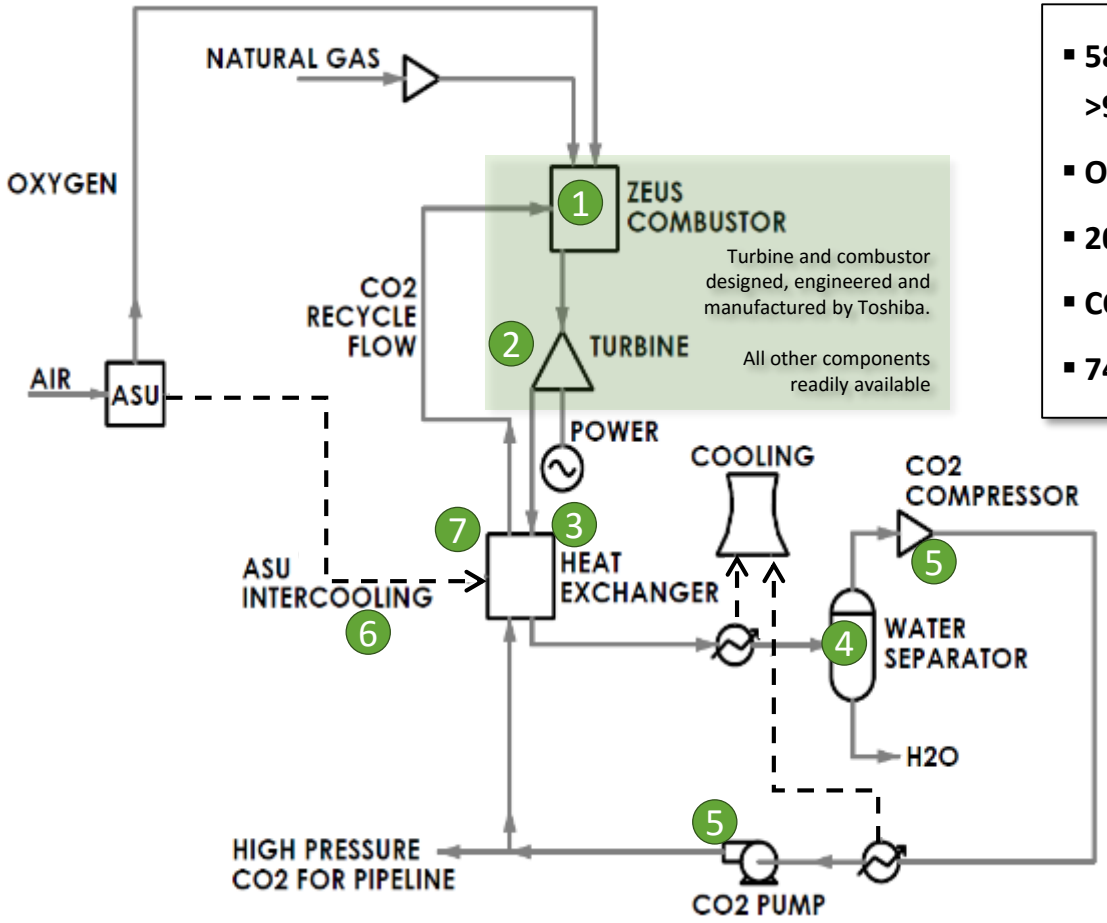
The Supercritical CO_2 Allam Cycle

The supercritical CO_2 Allam Cycle is simple

- **Historically, CO_2 capture has been expensive, whether using air to combust or oxy-combustion**
  - Air combustion
    - $\underbrace{8N_2 + 2O_2}_{air} + CH_4 \rightarrow \underbrace{8N_2 + CO_2}_{expensive\ to\ separate} + 2H_2O$
  - Oxy-combustion
    - $\underbrace{2O_2}_{expensive\ to\ produce} + CH_4 \rightarrow CO_2 + 2H_2O$
- **The Allam Cycle makes oxy-combustion economic by:**
  - Relying on a more efficient core power cycle
  - Recycling heat within the system to reduce O_2 and CH_4 consumption, and associated costs of the ASU



NET Power is Based on the Allam Cycle Platform



- 58.9% (LHV) net efficiency, with capture of >97% of carbon
- Oxy-fuel, closed-loop, CO_2 working fluid
- 200-400 bar; 6-12 pressure ratio
- CO_2 and water are the only byproducts
- 740H now in commercial use at two facilities

1. Fuel Combustion
2. CO_2 Turbine
3. Heat Rejection
4. Water Separation
5. Compression and Pumping
6. Additional Heat Input
7. Heat Recuperation

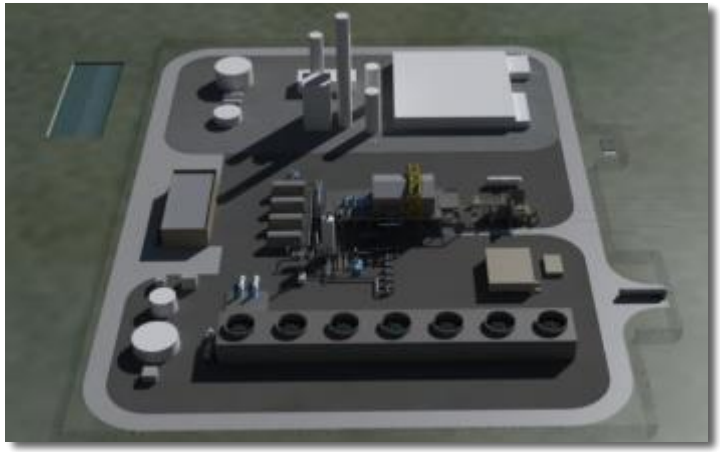
NET Power's Development Program

NET Power's Demonstration Plant is under construction

- **50MWth natural gas plant**
  - Scaled down from 500 MWth pre-FEED design to ensure scalability
  - Site is in La Porte, TX
  - First fire: Early 2017
- **Includes all core Allam Cycle components**
  - Combustor/turbine, heat exchangers, pumps/compressors, controls, etc.
  - Full operation tests (startup, shutdown, ramping, hot/warm/cold starts)
  - Oxygen will be pulled from a pipeline as opposed to a dedicated ASU
  - CO_2 quality will be confirmed for off-take viability
- **$140 million (USD) program funded**
  - Includes first of a kind engineering, all construction, and testing period
  - Partners include Exelon Generation, CB&I, 8 Rivers and Toshiba

Commercial plants are under development

- **Initial 295MWe pre-FEED completed**
  - Currently undergoing a “refresh” following learnings from demo plant detailed design
  - Pursing several advanced design concepts
- **Power generation, oil & gas, and other companies engaged in plant development**
  - Includes 11 of the 14 largest utilities in the US
  - Major and independent oil & gas firms involved for CO_2-EOR and power purposes
  - Several sites have been purchased by customers
- **Moving towards delivery of first commercial plant in Q2 2020**
  - Seeking to issue a notice to proceed following successful demonstration plant operation in 2017



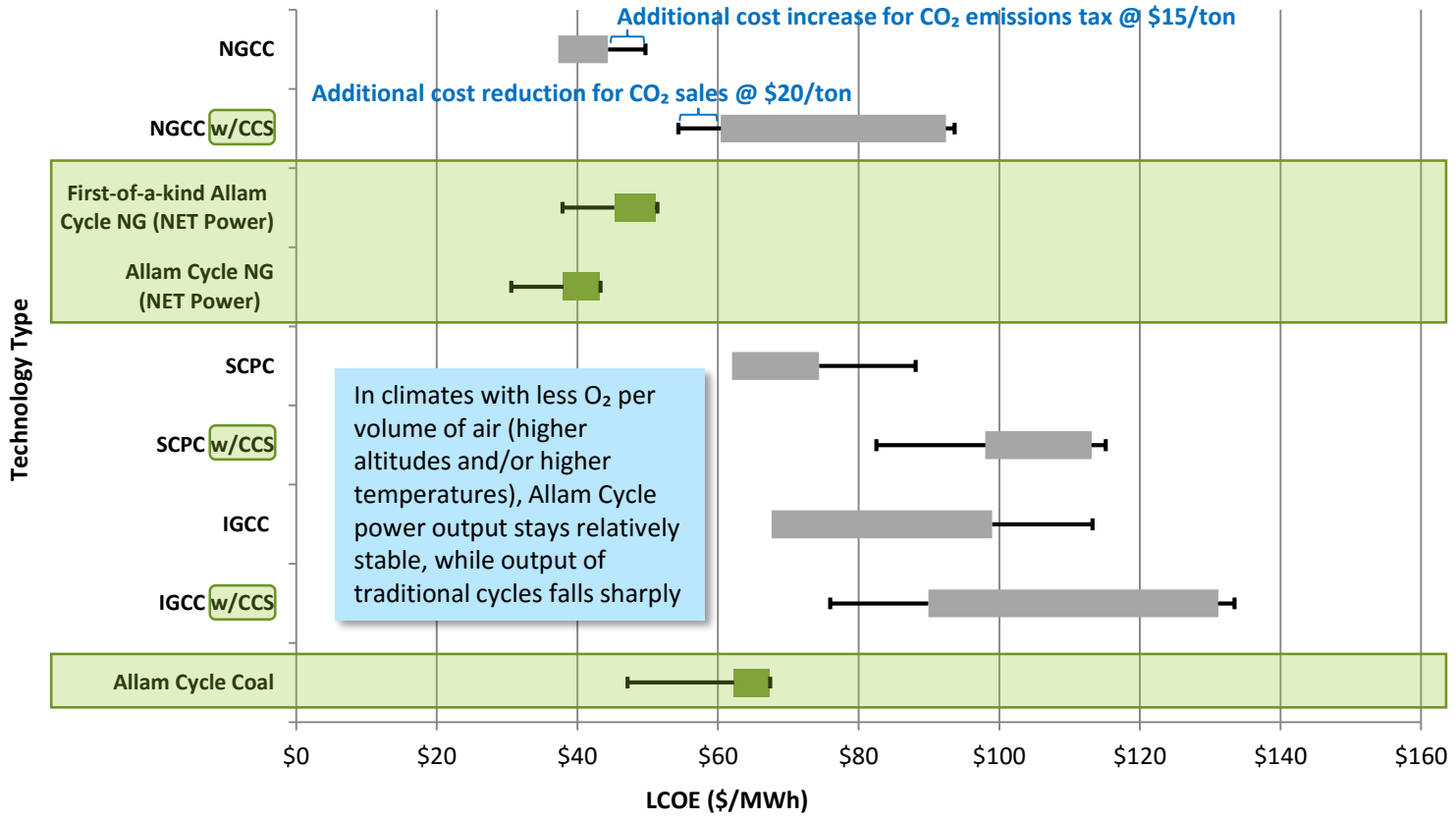
NET Power Commercial Natural Gas Plant	
Electric Output	295MW
CO_2 Output	804,000 ton/year at 120 bar pressure
N_2 Output	4.2 MM ton/year
ASU Output Demand	3,500 ton/day
Site Area	13 acres

NET Power’s Benefits

Benefits Summary

1. **Low Cost: Competes head-to-head with combined cycle on cost of electricity**, without assuming additional value for CO_2
2. **Capture-Ready**: Enables CCS to be implemented in stages; plants can vent CO_2, **but can begin capturing for no retro-fit cost or efficiency penalty**
3. **Operational flexibility:** turndown capabilities **beyond combined cycle** and **comparable ramping** ability
4. **Siting flexibility**: performance is **resistant to ambient condition changes**, such as altitude; **water not required**; no NOx and CO_2 enable **new siting opportunities** (e.g. non-attainment zones)
5. **Regulatory Support**: can **support Clean Power Plan compliance for low cost;** provides **regulatory certainty** as CO_2 and other emissions limits continue to ratchet down

NET Power Economics



- LCOE calculated using EPRI methodology
- Assumes natural gas at $2.85/MMBTU and coal at $1.73/MMBTU
- Every move of $1 in natural gas moves LCOE $6
- Cost ranges represent range of data combined from: EIA (2013), Parsons Brinkerhoff (2013); Black & Veatch (2012); DOE NETL (2012)

NET Power, EOR and Other Industries

Most Importantly, NET Power's Low Cost-of-Capture Solves the CO_2 Supply and Demand Problem

- **CO_2 capture**
  - at no extra cost
  - already at pressure (available from 30 bar/450 psi to 300 bar/4500 psi)
  - already high purity
- **Scalable CO_2 uses**
  - Enhanced oil recovery (EOR)
    - Cheaper than geologic CO_2 used for (no associated lifting costs, mineral lease costs or pressurization costs)
    - Current CO_2 use in US would take the CO_2 from over 110 Allam Cycle turbines (500 MWth)
  - Additional CO_2 utilization opportunities
    - Building materials
    - Chemical processes
    - Artificial photosynthesis

NET Power is not limited in siting or CO_2 demand by EOR industry

- **EOR demand for CO_2 would absorb over 100% of projected new gas builds in US to 2040**
- **Each NET Power turbine produces enough CO_2 to justify a 57 mile pipeline**
- **New gas demand to 2040 in US supports enough NET Power turbines to justify 4100 miles of pipelines, on top of 5100 miles existing today**
- **NET Power accesses EOR opportunities exist outside of current network**
  - Michigan, Illinois, Indiana, Ohio, West Virginia, Pennsylvania, California

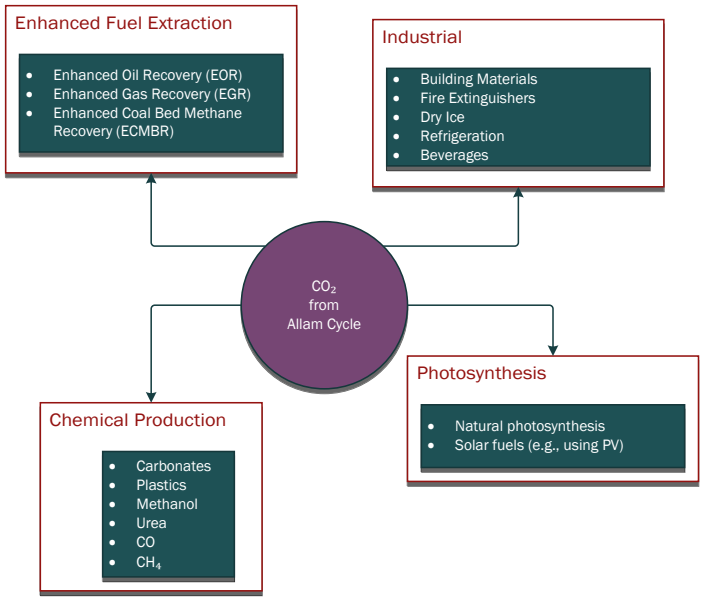
Remaining Oil in Place and Technically Recoverable Oil (billion bbls)

Region	Remaining Oil in Place	Technically Recover-able
Alaska	45.0	12.4
California	57.3	6.3
Mid-Cont.	65.6	10.6
IL and MI	11.5	1.2
Rocky Mts.	22.6	3.9
Permian Basin	61.7	15.8
East/Cent. Texas	73.6	17.6
Williston Basin	9.4	2.5
Gulf Coast	27.5	7.0
LA Offshore	15.7	5.8
Appalachia	10.1	1.6
Total	400	84.8

Beyond EOR is Only Opportunity to Monetize and Utilize NET Power's Clean CO_2

- **Regulatory opportunities and incentives exist that enhance NET Power's economics**
  - The federal 45Q Tax Credit is applicable to NET Power anywhere it sequesters CO_2 ($20/ton) or utilizes it for EOR ($10/ton)
  - 21 states have incentives and policies in place the provide value or preferential treatment to NET Power for capturing CO_2

- **Availability of CO_2 utilization opportunities not driven by potential uses, but by cost of anthropogenic CO_2.**
- **NET Power effectively lowers that cost to zero, enabling a massive CO_2 economy.**



Appendix

NET Power's economics enable CCS to be implemented in stages

- **NET Power is economically competitive with NGCC even when not capturing CO_2**
  - If CO_2 transportation infrastructure is not available when plant operation commences, CO_2 capture can be enabled *later* in the plant's life
- **While awaiting transportation and storage to be developed:**
  - NET Power plants would vent CO_2, increasing plant efficiency by 1-2% while remaining competitive with conventional power plants
  - The plant would still be cleaner than NGCC: plant emissions would be almost entirely pure CO_2, with virtually no NO_X emissions
  - No further investment is required to begin commence CO_2 capture
- **This allows deployment of CCS to be implemented in stages**
  - Power infrastructure developed today is fully CO_2 capture ready
  - CO_2 transportation, utilization and storage infrastructure can be developed on its heels

"NET Power does not make natural gas a bridge—or a pier.
It makes it a destination."
-Senior DOE official

NET Power Plants are Flexible

- **Large amount of operational flexibility and reliability, with zero emissions, provides needed support to growing renewables (and decreasing coal)**
  - **Large amount of operational flexibility**
    - Electrical turndown not limited by air permit constraints
    - Enables rapid responsiveness to load requirements
    - Ramp-rate expected to be 2-5% per minute from warm/hot start
  - **Large amount of siting flexibility**
    - Ability to site in low air density locations, such as at high altitude, w/out requiring major nameplate de-rating
    - Ability to cool with hybrid or air cooling configurations, eliminating water needs (no make-up water required), with minimal (2-3%) efficiency impact
    - Elimination of air emissions enables siting in non-attainment zones without requiring purchase of offsets

NET Power enables customers to meet increasingly stringent environmental regulations

- **NET Power can help customers comply with the EPA's new Clean Power Plan**
  - Under mass-based + new source compliment standard, NET Power enables existing assets to be run longer while meeting CPP targets
  - Potential to be included in Clean Energy Incentive Program (final rule under development)
  - Potential creation of carbon markets in most (if not all) of the US creates large value opportunity
- **New source standards likely to move towards NET Power**
  - New EPA standards for new power plants regulate carbon emissions to the lowest limit that can be achieved while remaining economically competitive
  - As efficiencies increase and costs come down, standard likely to be tightened
  - NET Power ensures customers are able to meet any future CO_2 standard
- **Elimination of NOx emissions enables siting in ozone non-attainment areas without requiring offsets**

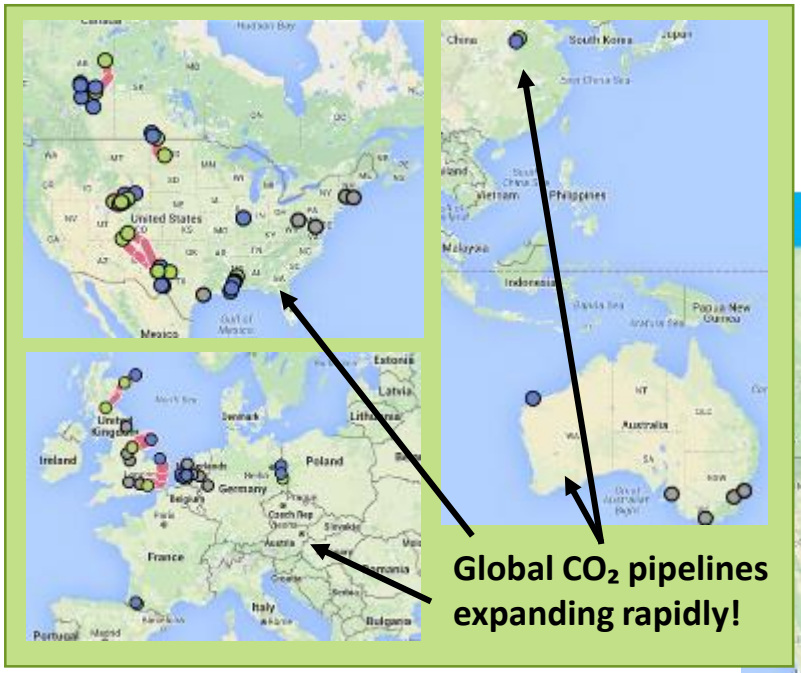
EOR demand for CO_2 will not be saturated by NET Power, even with a 100% share of new gas capacity

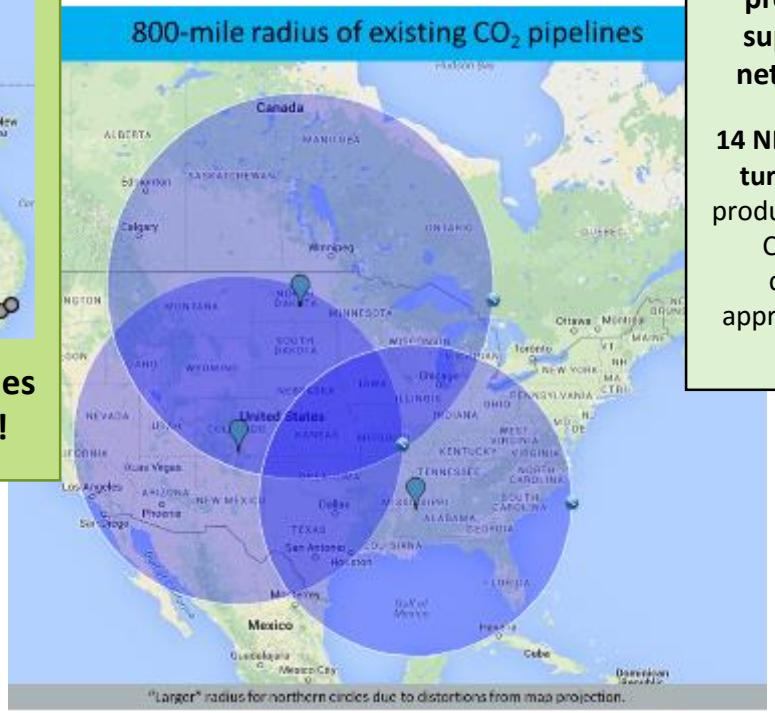
- **In Canada and the US, the EOR market could absorb CO_2 emissions from more than double the capacity projected to 2040.**
- **Globally, 100% of new build can be absorbed by either EOR or enhanced coal bed methane recovery (ECBMR).**

	Gross Fossil Capacity Builds to 2040 (IEA)	Fraction of Gross Build That Would Be Justified by EOR Demand*	Fraction of Gross Build That Would Be Justified by ECBM Demand*	500MWt/295MWe Trains justified by EOR and ECBM demand for CO_2	
				Low	High
Europe	158 GW	39-61%	109%	793	913
Former Soviet Union	149 GW	189-313%	576%	3,865	4,489
Asia Pacific/Oceana	477 GW	14-23%	698%	11,514	11,661
Middle East	150 GW	611-911%	254%	4,399	5,928
Latin America	83 GW	159-226%	148%	865	1,054
United States and Canada	277 GW	109-168%	544%	6,130	6,679
Total	**2,403 GW**			**27,565**	**30,725**

*A value greater than 100% indicates that EOR/ECBM demands exceed CO2 supply from gross capacity builds between now and 2035.
Sources: Godec et al. Potential global implications of gas production from shales and coal for geological CO2 storage. Energy Procedia. GHGT-11 (2013)

NET Power Accelerates the Already Rapidly Growing CO_2 Pipeline Networks

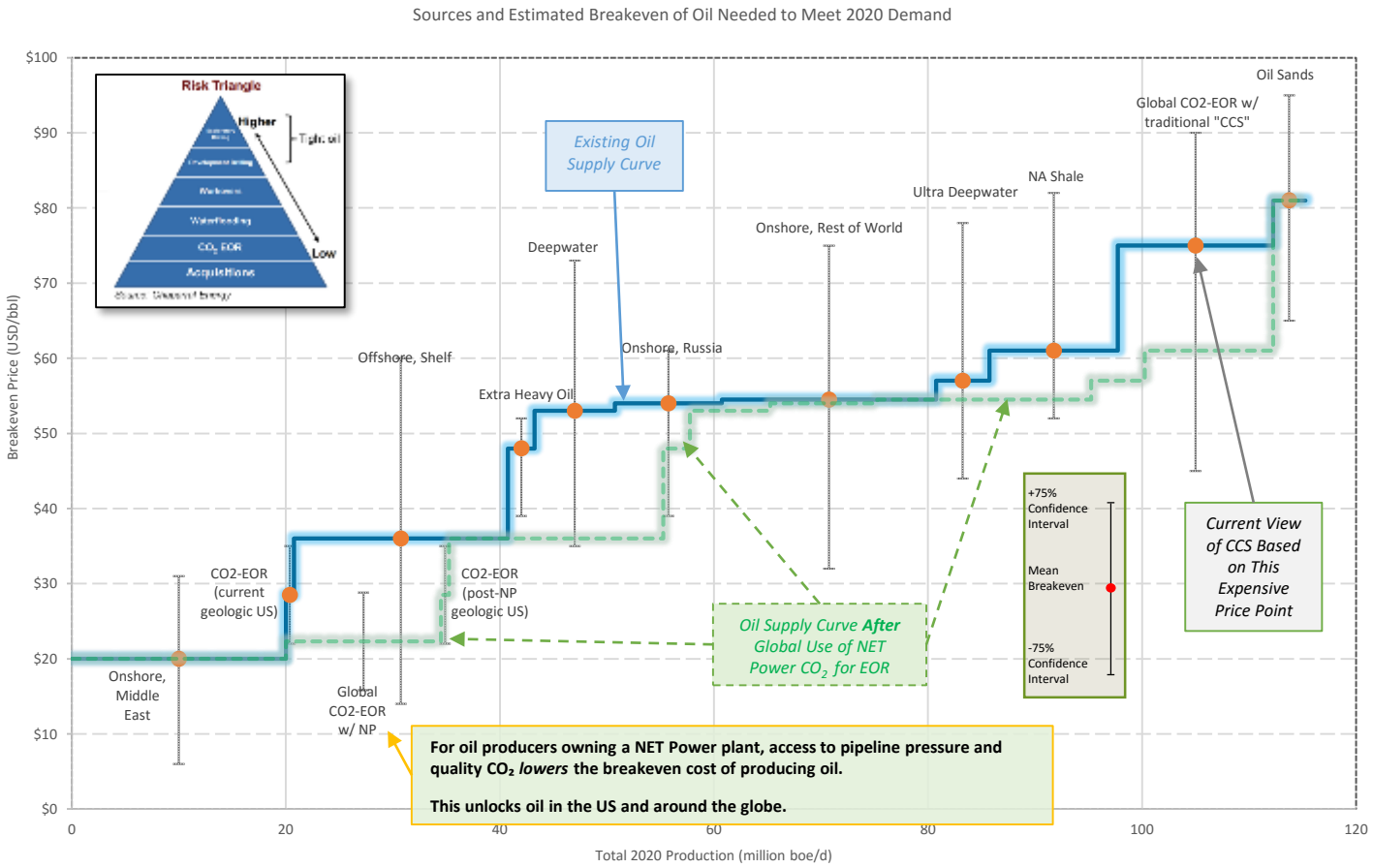




Low-Cost CO_2 production would support a massive network expansion

14 NET Power 295 MWe turbine trains would produce enough low-cost CO_2 to justify the development of approximately **800 mile CO_2 pipeline**

NET Power Transforms the Global Oil Stack



- **Shutdown of tight oil/high cost plays highlights EOR as a low-cost opportunity for growth from existing fields**
- **NET Power further improves the economics of EOR and will significantly expand CO_2 supplies for producers**
- **NET Power solves the challenge of carbon capture adoption by achieving lower cost and higher efficiency than current non-carbon capture power generation options**

Source: Rystad Energy (2014): 8

NET Power provides growth opportunities to industries outside of electricity generation

- **NET Power co-produces gases that are synergistic with chemicals and oil & gas industries**
  - For each turbine train (operating at an estimated 85% capacity factor for power, 98% for ASU)
    - 13.9 million MMBTU per year NG use
    - 800,000 tons per year CO_2 production
    - 4.8 MM tons per year N_2 production
    - 166,000 tons per year O_2 production (during planned outages for electricity part of plant)
  - Capability of delivering syngas (H_2 and CO)
- **Significant flexibility to site where resources exist**
  - Option for zero water usage
  - Insensitive to changes in ambient conditions (altitude, temperature, etc.)
  - CO_2 production constant as long as plant is operating, not interrupted by plant cycling
- **Reduces the CO_2 intensity of the oil & gas industry, making it greener at lower cost**
  - Can utilize flare and waste gases (associated, acid, sour) that would otherwise be emitted
  - Integrates directly with operations of oil producers, simplifying operations and reducing costs
  - Integration with LNG-regasification terminals provides high efficiency power generation (67% LHV) and eliminates the need for gas-fired regasification

NET Power

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