# NARUC

*Summer Committee Meetings*

# Electricity Committee: Clean Coal & Carbon Management Subcommittee

# *Moderator*

Hon. Brian Kalk, North Dakota,

Chair of Clean Coal & Carbon Management Subcommittee

# *Panelists*

- Fred Eames, Hunton & Williams
- David Malkin, Drax Biomass
- Tom Clarke, Virginia Conservation Legacy Fund
- Evan Granite, NETL

# *Panelists*

Fred Eames, Hunton & Williams

# LEVELING THE PLAYING FIELD

## Policy Parity for Carbon Capture and Storage Technologies

**NARUC Summer Meeting**

**July 25, 2016**

# Introduction

**Hunton & Williams LLP**

- Founded in 1901, Richmond, VA; 750+ lawyers, 19 offices, 6 countries
- U.S. Offices – California, D.C, Florida, Georgia, New York, North Carolina, Texas, Virginia
- Strong focus on energy and environment, particularly air and water
- **Personal**
- Partner, Hunton & Williams LLP 2005 – present
- Represent utilities, oil and gas,  other energy clients on energy/environment; founded CCS Alliance in 2008
- Former Counsel, U.S. House of Representatives, Committee on Energy & Commerce
- Principal Author, NCC “Leveling the Playing Field”

# National Coal Council Charter

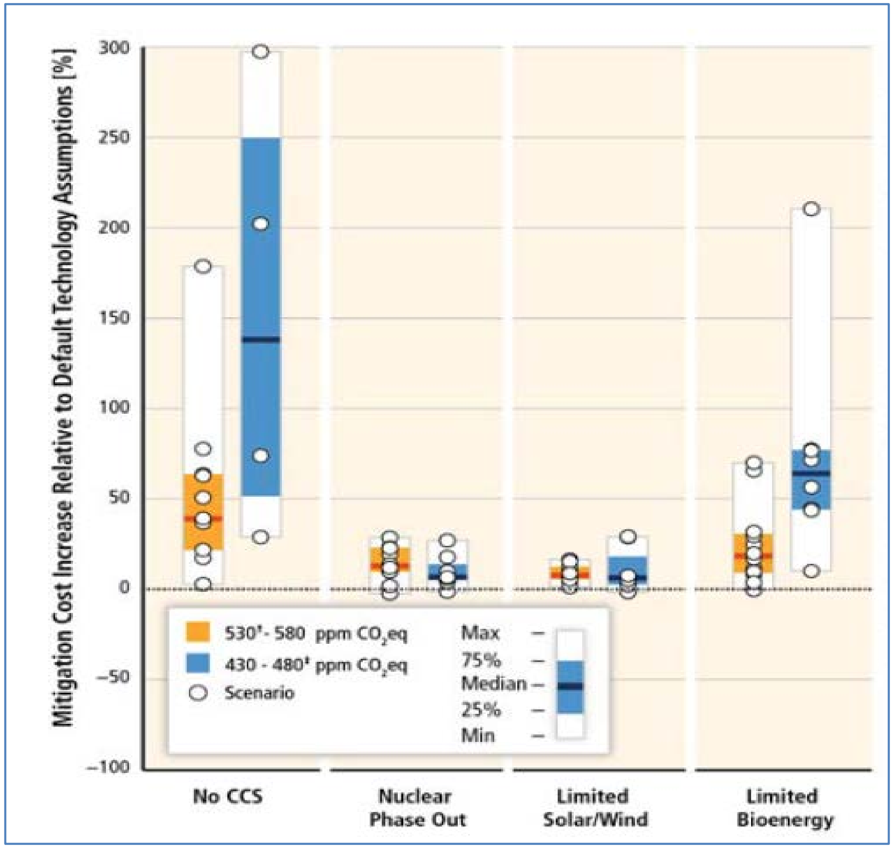
Celebrating 32 years ~ 1984|2016

**The National Coal Council**
**provides advice and recommendations**
**to the Secretary of Energy**
**on general policy matters**
**relating to coal and the coal industry.**

NCC is a Federal Advisory Committee
organized under FACA legislation

# The World Must Have CCS to Achieve $CO_2$ Emissions Goals

## Climate Change Mitigation Costs Without CCS and Other Technologies




**Not including CCS as a mitigation technology is projected to increase the overall costs of meeting $CO_2$ emission goals by 138% (and up to 250%).**

# Importance of CCS

## The Magnitude of the CO2 Management Challenge

- Current # of demonstration projects in operation or under construction globally = 22

  **Projected need by 2050 = 3,400**

- The current global CO2 storage rate = 40 million tons/year

  **Projected need = 10 billion tons/year**

- Cumulative total CO2 emissions 2050 ~ 2,000 billion tons

  **Projected "safe" level of emissions = 884 billion tons**

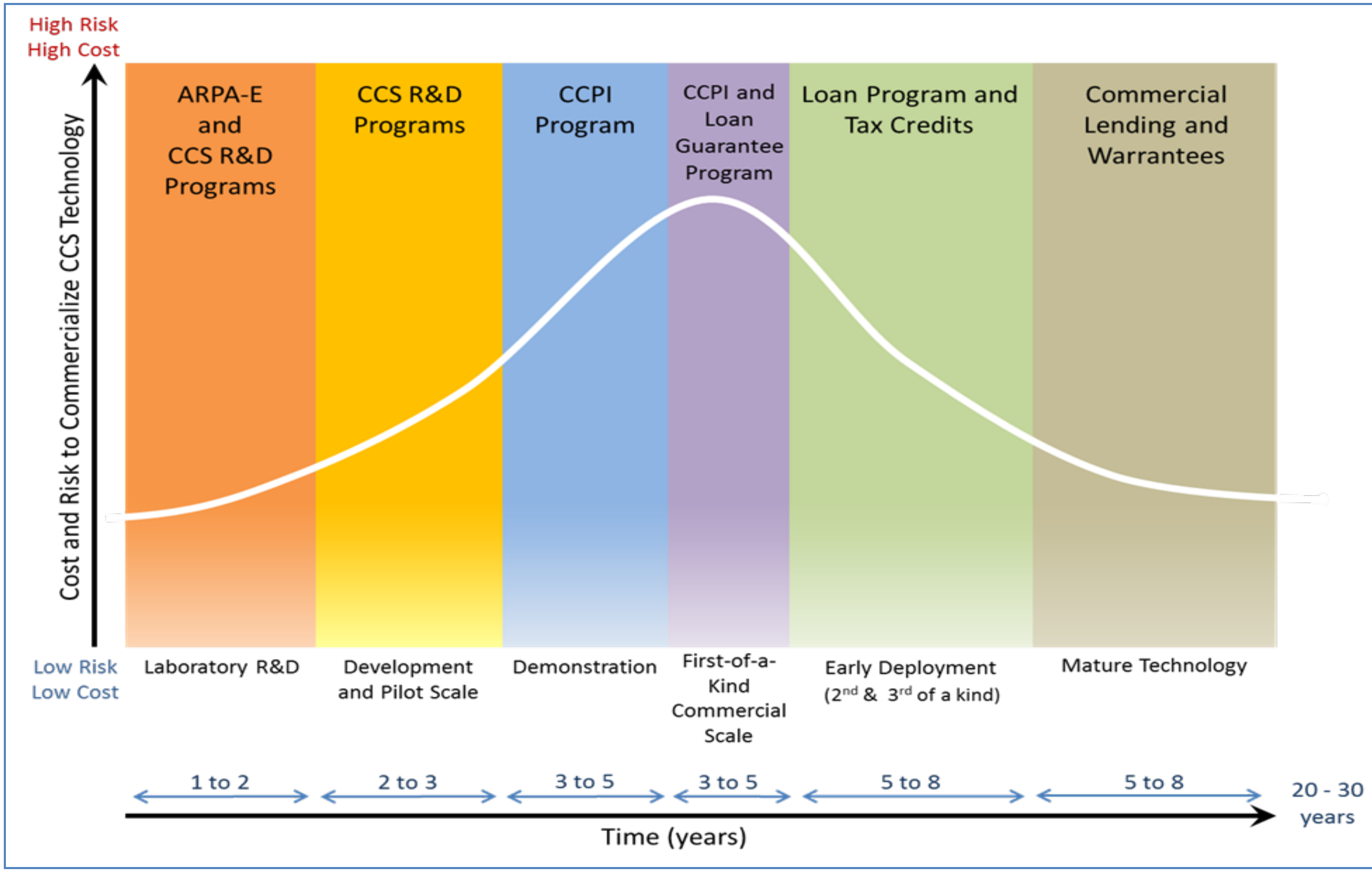
# >> Key Recommendation


**In order to achieve CCS at commercial scale, policy parity with other low/no carbon technologies is required . . .**

***The National Coal Council recommends that:***

- **DOE take a stronger position on the need for policy parity with respect to funding allocations**
- **DOE take a stronger position on the need for policy parity with respect to incentive mechanisms and subsidies applied to near zero emission energy technology**

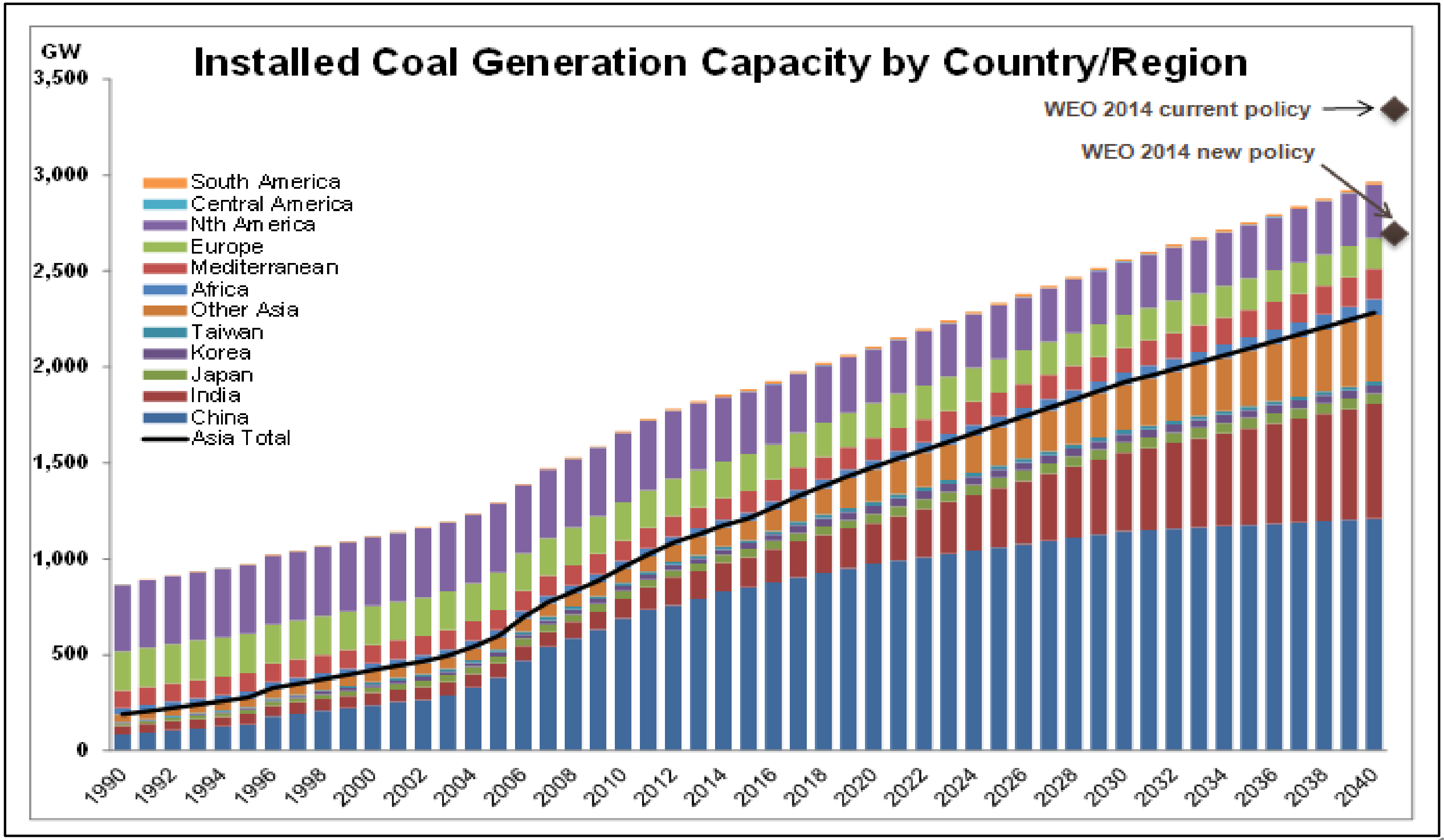
# Energy Technology Development Spectrum To Commercialize CCS




**Capital and operating costs for projects with CCS are more expensive than conventional technologies, carrying greater commercial risk.**

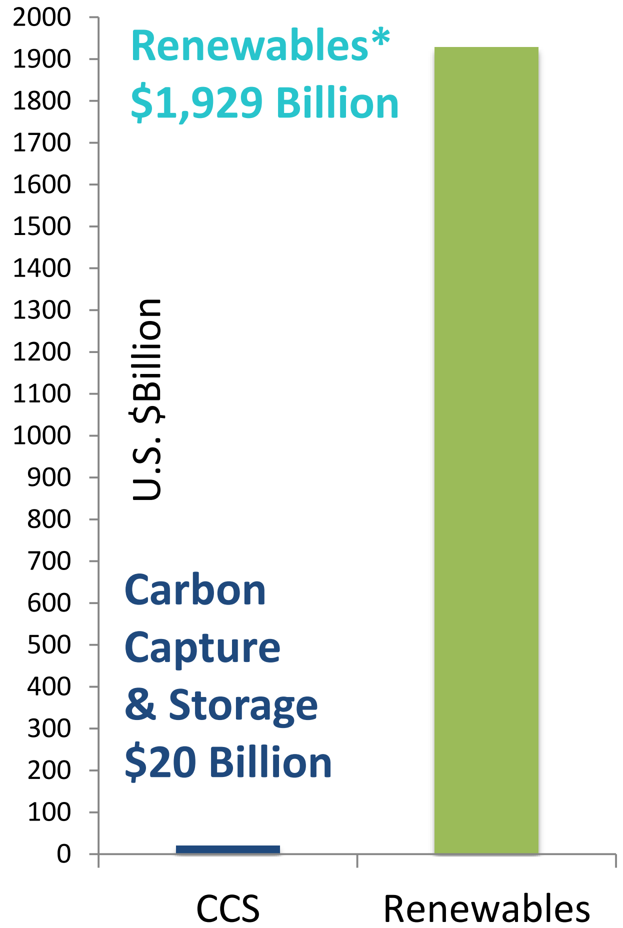
# Importance of CCS

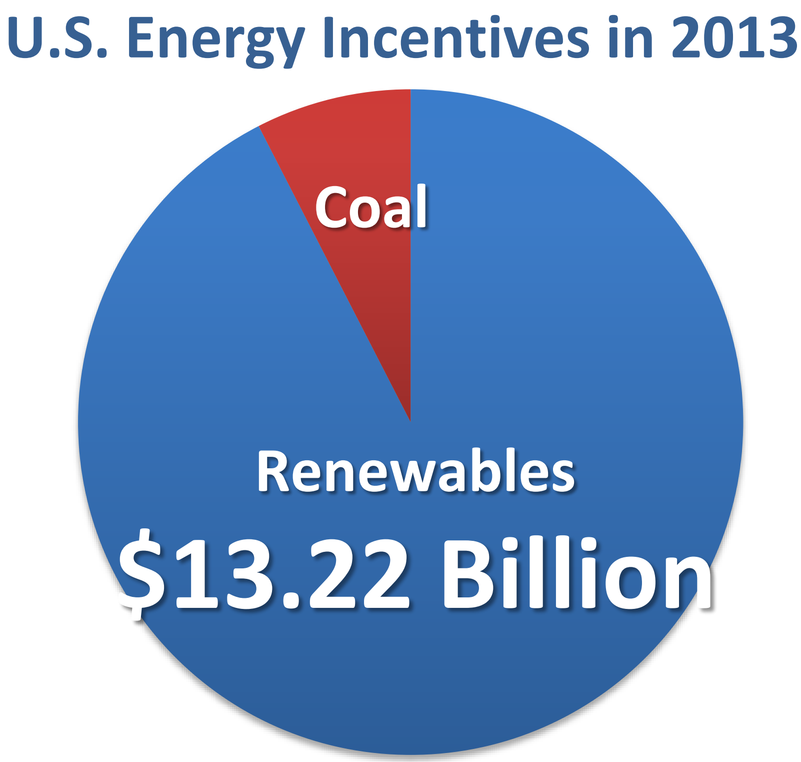
## 2,200+ Coal Units in Construction and Planned Globally



# Dis-Parity
# CCS vis-a-vis Renewables

## Global/U.S. Clean Energy Investments
*2004 - 2013*

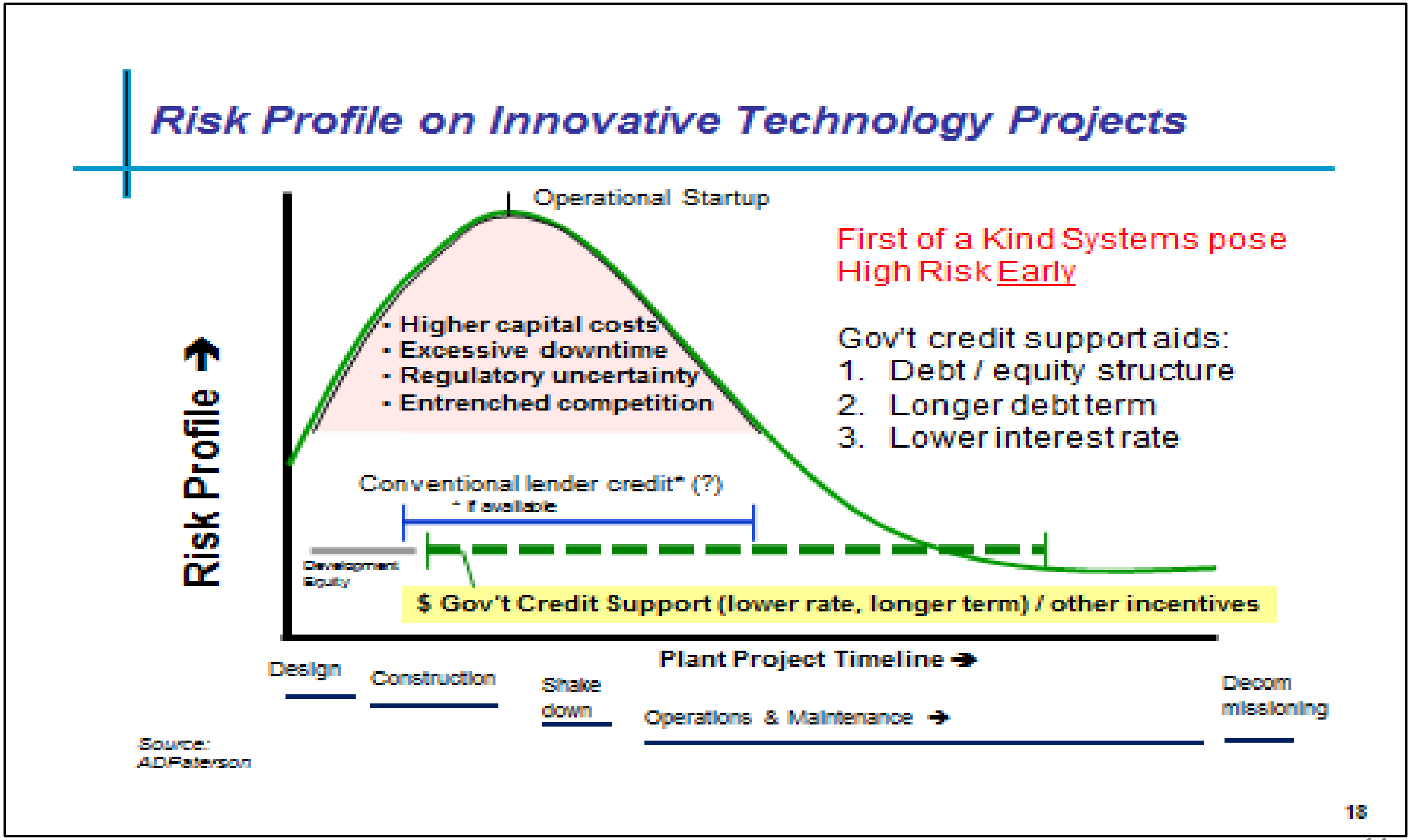



Source for international spending: International Energy Agency. *Includes technology development , projects, M&A. Source: BNEF.
Source for U.S. incentives: Energy Information Administration, March 2015.

# The Development Cost Challenge Facing CCS Projects

## Policies Must Address Investment Costs to Deploy CCS




Source: Andrew Paterson, CCS Alliance.

# Renewable Energy Incentives

| Development | Getting Financing | Borrowing Cost | Revenue Stream |
|---|---|---|---|
| R&D funding | PURPA mandatory purchase requirement<br><br>State RPS requirements (29 States/D.C.)<br><br>Section 45 production tax credit – $23/MWh<br><br>Loan guarantees | Section 48 investment tax credit<br><br>Loan guarantees | PURPA mandatory purchase requirement<br><br>State RPS requirements (29 States/D.C.)<br><br>Section 45 production tax credit - $23/MWh<br><br>Clean energy credits |

# Recommendations for Leveling the Playing Field

## Key Financial Incentives Recommendations

- **"Contracts for differences" structure:** For first 5-10 GW of projects, awarded competitively, allow developers to choose from a menu of incentives – grants, loan guarantees, tax incentives – to close the cost gap
- **Limited Guaranteed Purchase Agreements**: Offer a limited number of pioneering CCS facilities to receive a guarantee that their output will be purchased in order to obtain financing
- **Market Set Aside**: Establish a market set-aside to provide parity with state RES requirements
- **Clean Energy Credits**: Allow CCS projects to receive credit under applicable programs for $CO_2$ emissions avoided

# Recommendations for Leveling the Playing Field

NATIONAL COAL COUNCIL

## Financial Incentives

- **Tax Credits and Price Interventions**: In addition to guaranteed purchase agreements and the ability to attract financing, offer other support through:
  - Production Tax Credit
  - Revised $CO_2$ Injection Credit
  - Electricity Price Stabilization
  - $CO_2$ Price Stabilization
- **Tax-Preferred Bonds**: Provide financing with tax-preferred and tax exempt bonds under Section 54 or Section 142 of Internal Revenue Code
- **Master Limited Partnerships**: Provide MLP structure for projects with CCS so qualifying income is taxed at the individual level
- **Loan Guarantees**: Put in place a mechanism to pay the credit subsidy cost of loan guarantees similar to the Section 1705 program that helped renewables

# Recommendations for Leveling the Playing Field

NATIONAL COALCOUNCIL

## Regulatory Improvements

- **Regulatory Blueprint**: U.S. Dept. of Energy must take the lead in developing a regulatory blueprint to identify and remove barriers to construction and development of CCS projects
- **Remove Injection Barriers**: Eliminate barriers in EPA's Clean Power Plan and 111(b) rule to facilitate beneficial reuse of $CO_2$ from regulated carbon capture facilities (Subpart RR GHG reporting requirements)
- **New Source Review:** Eliminate uncertainty under NSR to encourage installation of $CO_2$ emission controls

## Regulatory Improvements

- **Infrastructure Siting**: Congress should consider providing backstop federal eminent domain authority for siting and construction of $CO_2$ pipelines, similar to authority provided under the Natural Gas act for gas pipelines
- **Storage Siting:** U.S. Dept. of Energy should identify at least one reservoir capable of storing at least 100 million tons of $CO_2$ at a cost of less than \$10 per ton in each of the seven RCSP regions

# Recommendations for Leveling the Playing Field

**Research, Development and Demonstration**

- **Align RD&D Funding with Other Fuels:**
  - Substantially increase RD&D budget
  - Fully fund CCS RD&D recommended in CURC-EPRI Roadmap
  - Fund an 80% federal cost share for early stage RD&D
  - Fund 100% federal cost share for large-scale pilots
  - Fund 50% cost share for commercial demonstrations

**Communications and Collaboration**

- **Initiate Projects Immediately**: In addition to initiating 5 to 10 gigawatts of U.S. projects, DOE should advance collaboration of 5 to 10 gigawatts of global demonstration projects in the next year, which will promote energy, environmental, and foreign policy objectives
- **Vigorously Explain Reality**: DOE must assure U.S. and global policymakers and other stakeholders that fossil fuels will be used to an even greater extent today, and there is a resulting need for CCS

# Carbon Advance Centre

**Carbon Advance Centre will advocate for CCUS**

- **No existing national group dedicated to advocating for CCUS**
- **The Carbon Advance Centre will:**
  – Develop advocacy agenda to support development and deployment of CCUS, consistent with policy parity
  – Prepare legislative proposals and background materials supporting CCUS
  – Address federal regulatory issues through rulemaking comments and engagement with regulatory agencies
  – Work to redirect fossil divestment efforts toward emphasis on clean fossil investment
  – Primarily oriented toward federal policy, but available to support CCUS policy development at the State level
  – Connect CCUS supporters from fossil and non-fossil industries, risk management entities, financial entities, supportive NGOs, and concerned governmental entities

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# *Panelists*

David Malkin, Drax Biomass

# Biomass co-firing and conversion

## *New opportunities for the US coal fleet*

# Drax Group – a vertically integrated biomass energy co.

drax

## Source

drax biomass
A Drax Group company

## Generate

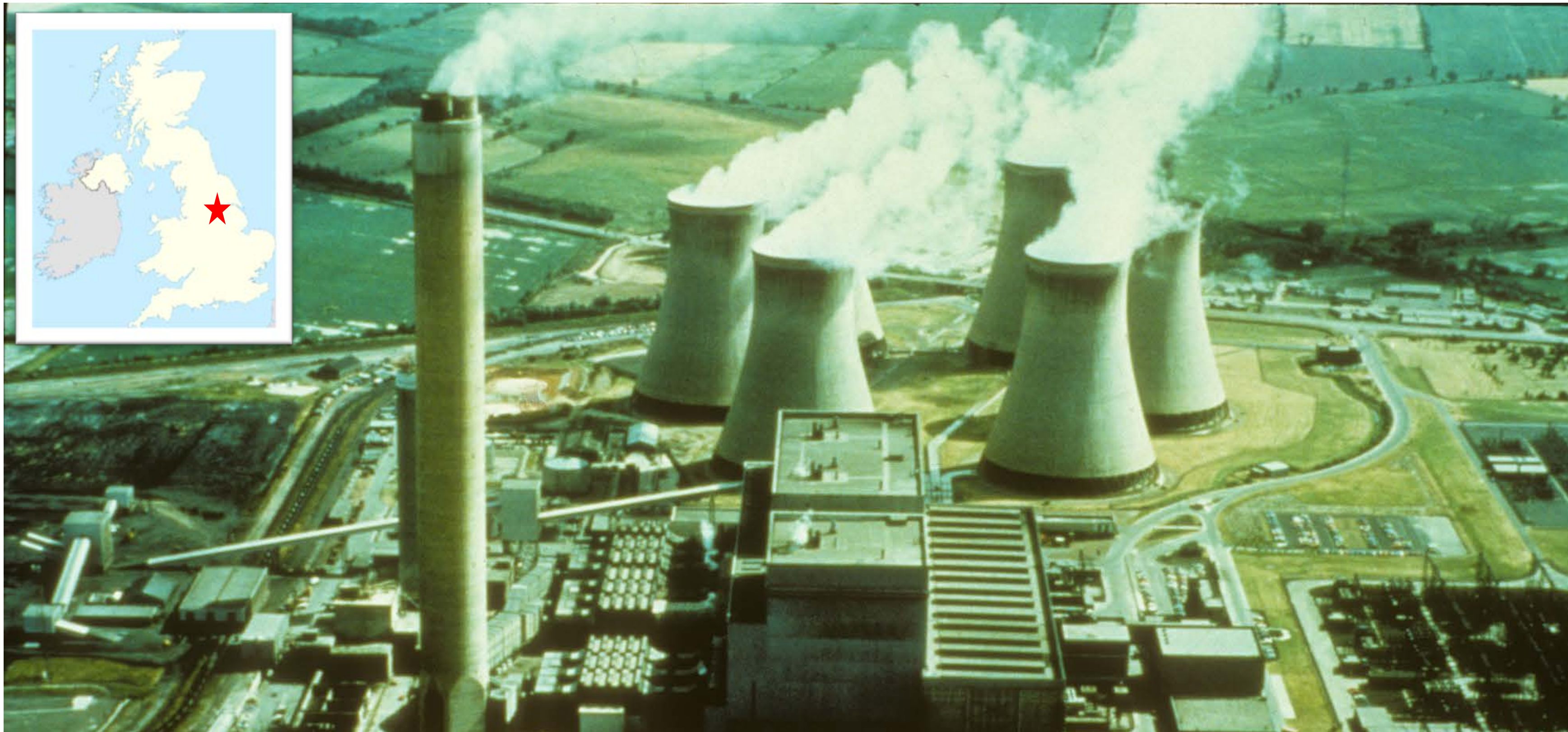
drax power
A Drax Group company

## Supply

haven power
A Drax Group company

BILLINGTON bioenergy
A Drax Group company

# Drax Power Station then (1975)



UK’s largest power station… 4 GW (6 x 645 MW units)

Major emitter of $CO_2$… 22 MM MT/yr at peak

Critical asset… 7-8% of total supply

# Drax Power Station now

2 of 6 units fully converted to biomass, 3rd unit at 90% biomass

No loss of output, negligible impact on efficiency

12% of UK renewable generation, largest decarbonisation project in W. Eur

# Wood pellets key to Drax’s


**Why forest-derived biomass?**

- Plentiful, renewable resource
- Mature industry supply chains
- Requires minimal irrigation and fertilization
- Ideal combustion characteristics

**Why pellets?**

- Efficient, cost-effective bulk transport
- Low moisture content = higher BTU value
- Adaptable for use at coal-fired facilities
- Stringent specs = reliable plant operations

# Coal-to-biomass: good for the environment

| $SO_x$ emissions | $NO_x$ emissions | $CO_2$ emissions |
|---|---|---|
| 85%[1,2] | 50%[3,4] | 80%[5,6] |

[1]FGD-abated coal versus unabated biomass
[2]Abated sulfur content of coal = 200-300 mg/$m^3$

[3]Unabated coal versus unabated biomass
[4]Normal operating conditions - Boosted Overfire Air system and low-NOx coal

[5]Fossil (geologic) emissions versus lifecycle (biogenic) emissions
[6]Includes emissions from production and transportation of biomass fuel

# Coal-to-biomass:  good for the grid

# Coal-to-biomass: good for ratepayers

- ✓ Utilizes existing grid infrastructure
- ✓ Reduces risk of stranded assets
- ✓ Offers alternative to costly pollution control upgrades
- ✓ Provides cost-competitive complement to wind and solar

| Technology | Levelized Cost of Elec. (DECC 2013) | System Integration Costs[1] (Average 2020-2030) | Whole System Cost (WSC = LCOE + SIC) |
|---|---|---|---|
| | £/MWh (2012)[2] | | |
| Onshore Wind | 100 | 10-14 | 110-114 |
| Offshore Wind | 132 | 10 | 142 |
| Solar PV | 123 | 12 | 135 |
| Biomass Conversion | 108 | -1 | 107 |

**[1]Includes costs of backing up intermittent generation and making the system flexible enough to adapt to fluctuations in demand; estimated relative to a benchmark technology (assumed nuclear power)**

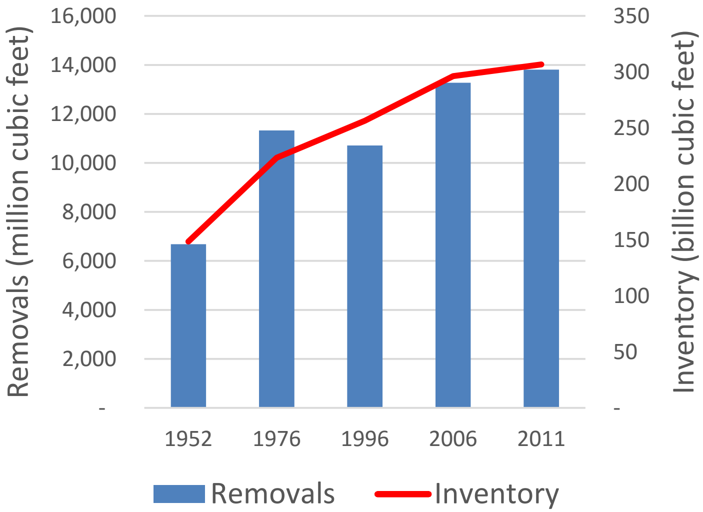
**[2]Costs denominated in real 2012 prices for ease of comparison to the DECC (2013) levelised cost of energy**

**Source: UK Renewables Subsidies and Whole System Costs; NERA Economic Consulting/Imperial College London – Feb 2016**

# Coal-to-biomass: good for our forests

## Healthy markets = healthy forests

US South inventory and removals
*(1952-2011)*

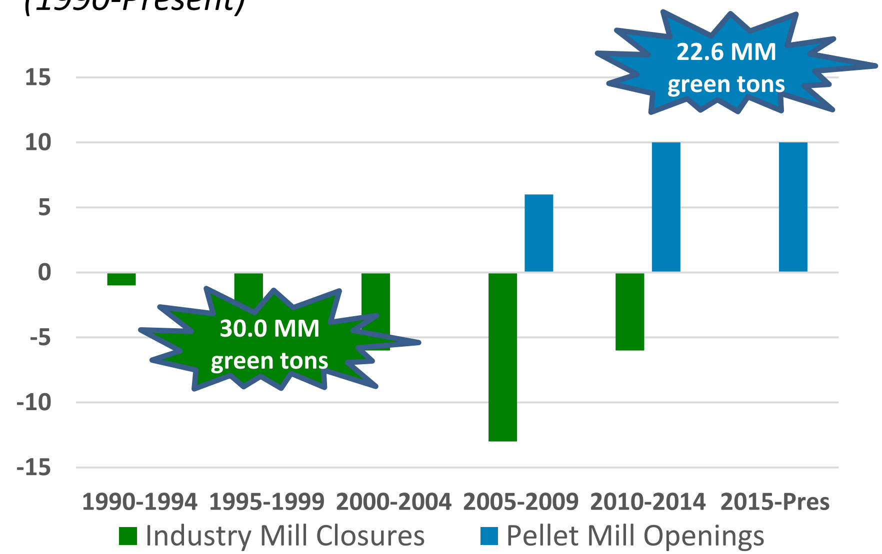



- ✓ Promotes adoption of land management techniques to increase yield + economic return
- ✓ Supports investment in R&D regeneration
- ✓ Discourages land conversion

Source: Forest Resources of the US, 2012: A Technical Document Supporting the Forest Service Update of the 2010 RPA Assessment

## Pellet mills replacing lost demand

US South mill closures[1] and openings[2]
*(1990-Present)*




- ✓ Provides markets for low-value material (thinnings, residues, diseased trees)
- ✓ Sustains local forest-based economy
- ✓ Encourages adoption of sustainable land mgmt practices among small landowners

[1]Includes pulp, paper and OSB mill closures
[2]Includes pellet mills under construction or in permitting
Sources: FORISK Consulting; F2M, *Wood Supply Market Trends in the US South, 1995-2015*, Nov. 2015

# Pellet co-firing/conversion: opportunities in the US

## Value proposition

- Compliance option for many state RPS programs
- Resource diversification in IRPs and state energy policies
- Potential state compliance mechanism for EPA CPP
  - Co-firing = flexible compliance option for achieving coal heat rate performance standard
  - Conversion = non-zero emitting renewable generation source

## Target facilities

- Pulverized coal boiler technology
- Proximity to healthy wood baskets and road/rail infrastructure
- Marginal/unfavorable business case for pollution control CAPEX
- Access to REC markets

# Questions?

# *Panelists*

Tom Clarke, Virginia Conservation Legacy Fund

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# Offsetting $CO_2$ Emissions with Reforestation

Tom Clark, Virginia Conservation Legacy Fund

# *Panelists*

Evan Granite, NETL

# NARUC

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# Recovering Rare Earth Metals from Coal and Coal Ash

Evan Granite, NETL

# NETL RIC Rare Earth Element Research

**Evan Granite, Elliot Roth**
**Mary Anne Alvin**

**2016 Summer NARUC Meeting**
**Nashville, Tennessee**

**July 25, 2016**

# Domestic Coal – A Precious Resource

- 250 Year Supply
- 30 - 40% of our Electricity from Coal
- Utilize Abundant Domestic Coal
- Clean and Environmentally Friendly Manner

# Positive Impact on Many Industries

- Mining, Power, Transportation, Manufacturing
- Chemical, Steel, Activated Carbon, Fuel
- Promote Economic Growth and Security

# Retirement of US Coal-Fired Power Plants

## Current Domestic Coal-Fired Fleet ~ 310 GW

- **Stringent Regulations, Many Older Plants**
- **Forecast of 50 – 70 GW Retirements by 2020**

- **Energy Information Administration**
- **Edison Electric Institute**

- **Future US Coal-Fired Fleet ~ 250 GW in 2020**

# What is Coal-Derived Flue Gas?

## Composition Untreated Flue Gas

| | |
|---|---|
| $CO_2$ | 13 – 16% |
| $O_2$ | 3 – 4% |
| $H_2O$ | 5 - 7% |
| $N_2$ | balance – approximately 73% |
| HCl | 10 – 100 ppm |
| $SO_2$ | 100 – 2000 ppm |
| $SO_3$ | 1 – 40 ppm |
| $NO_x$ | 100 – 500 ppm |
| CO | 20 ppm |
| HC | 10 ppm |
| Hg | 1 ppb |
| Fly ash | entrained particulates |

# What is Fuel Gas?

- Carbon-Steam Reaction
- Pyrolysis
- Combustion
- Elevated Pressure

## Major Products

- $CO$, $H_2$, $CO_2$, $H_2O$, Tars & HCs

## Minor Products

- $NH_3$ , HCl, $Cl_2$ and particulates
- $H_2S$, COS, $CS_2$
- Trace Contaminants: Hg, $AsH_3$, $H_2Se$, and $PH_3$

# Clean Power Plan - Carbon Dioxide

- **USEPA**
- **Announced August 3, 2015**
- **Fully Implemented in 2030, Power Plant Carbon Emissions Will Be 32% Lower than 2005 Levels**

**Details**

- **http://www2.epa.gov/sites/production/files/2015-08/documents/fs-cpp-overview.pdf**

# Traditional Research at NETL

## Flue Gas and Syngas Clean-up (Gas Separations)

- *$SO_2$, $H_2S$, NO, $NH_3$, particulates, Hg*, $CO_2$
- **Proposed Carbon Dioxide Regulation**
- **Mass Retirement of Older Coal-Burning Power Plants**

## New Research Thrust (Separations)

- **Fossil Energy/Coal Mission**
- **Rare Earths**

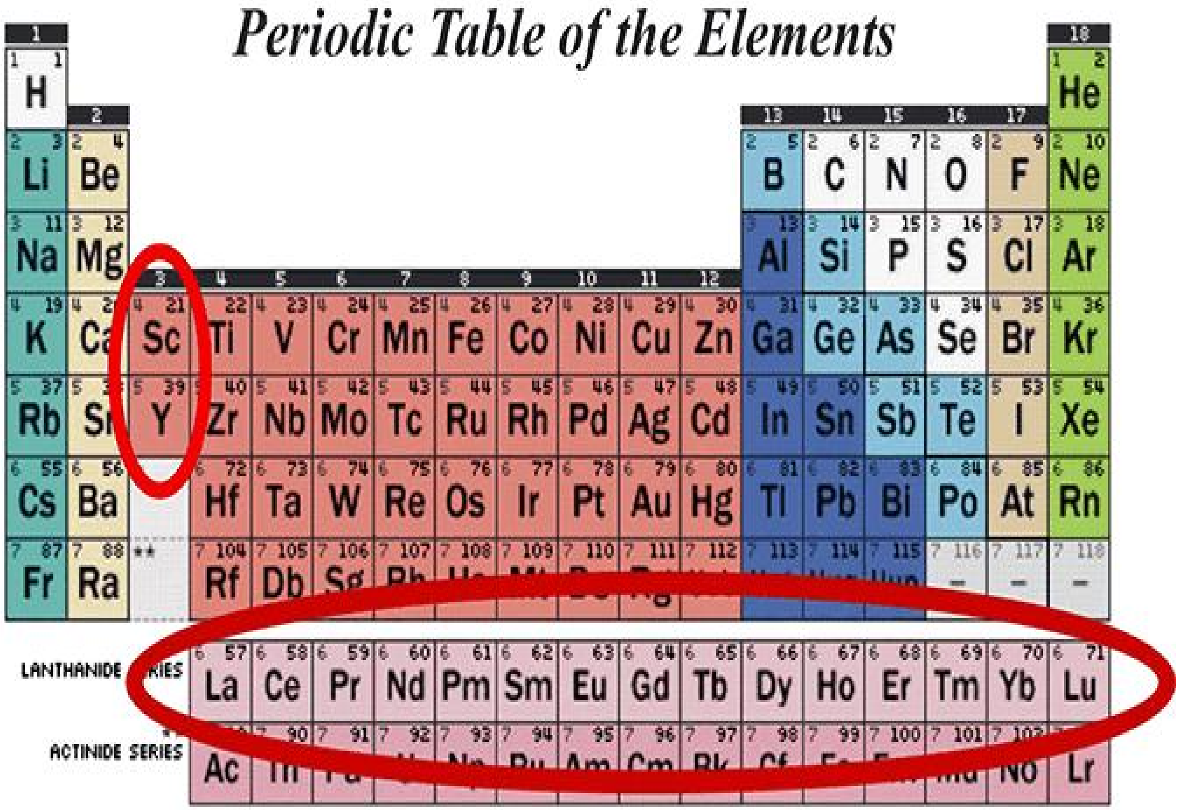
# Rare Earths

- **A Once-in-a-Lifetime Opportunity**

## Characterization and Separations

- **Different Matrices**
- **Typically Solids**
- **Liquids**

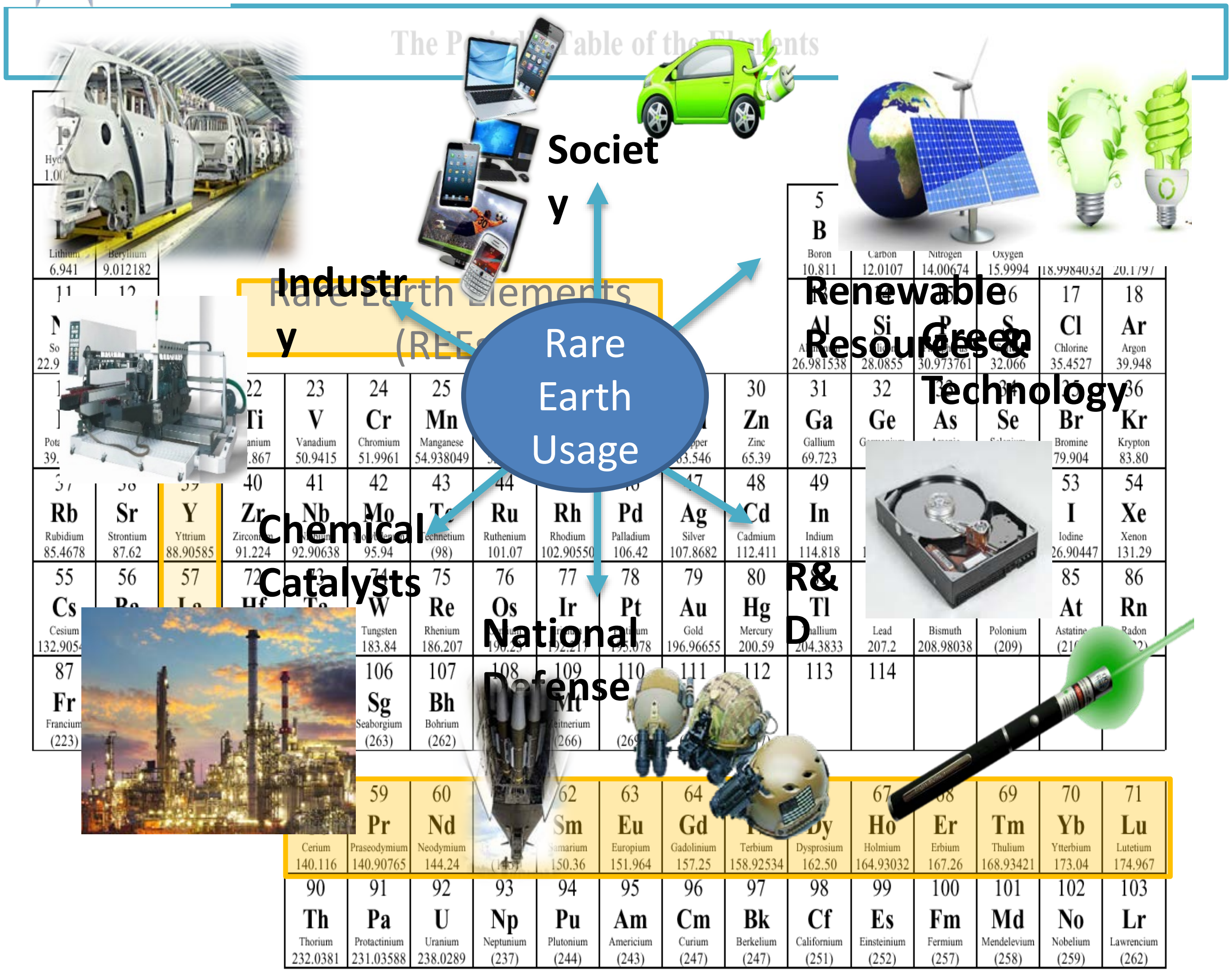
# What are Rare Earth Elements?




*Average total crustal concentration = 184 ppm*

**Wedephol, 1995*

# What are Rare Earth Elements (REEs)?






1. genius.com 2. Mos-Tech.co.uk 3. greenliving4live.com 4. cleantechica.com 5.ishareimage.com 6. USGS Rare Earth Fact Sheet (2014) 7. lowereasternshorenews.com 8. osa.opn.org 9. army-technology.com 10. oilinvestigatingnews.com 11. alibaba.com 12. cardvice.com.au

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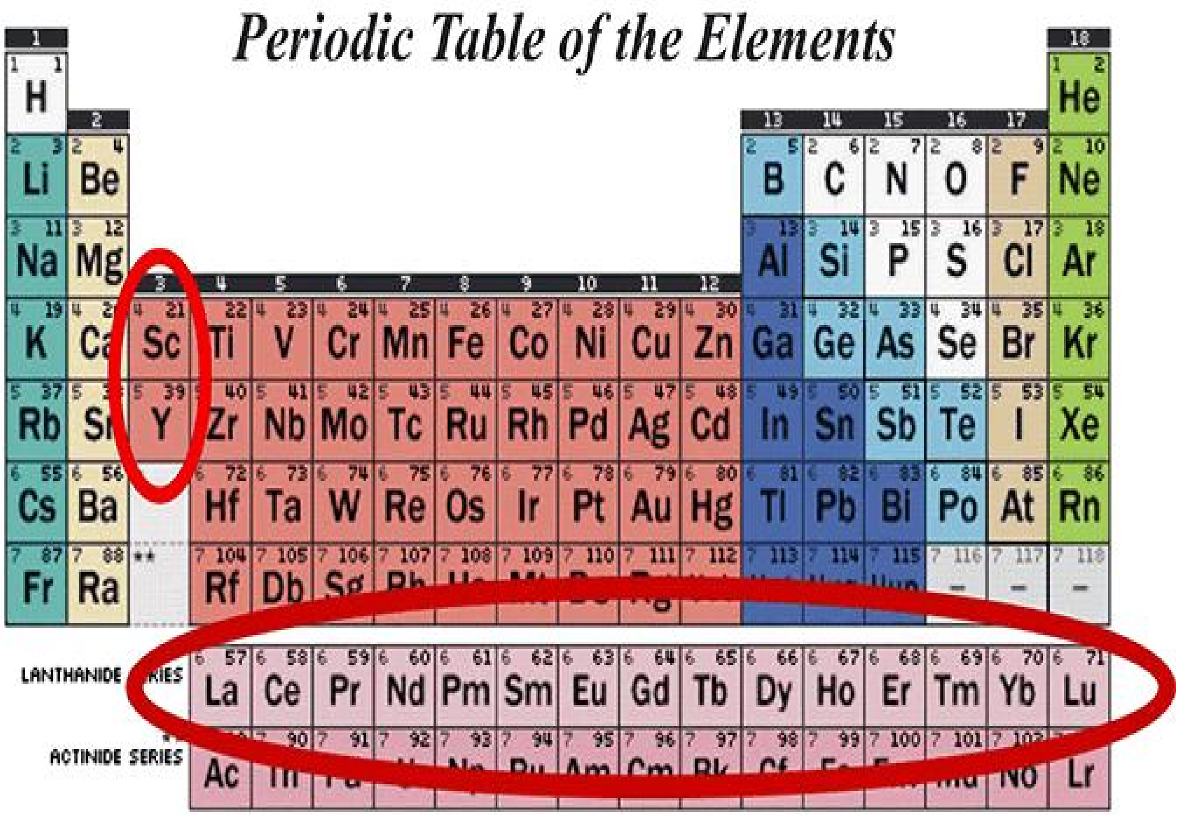


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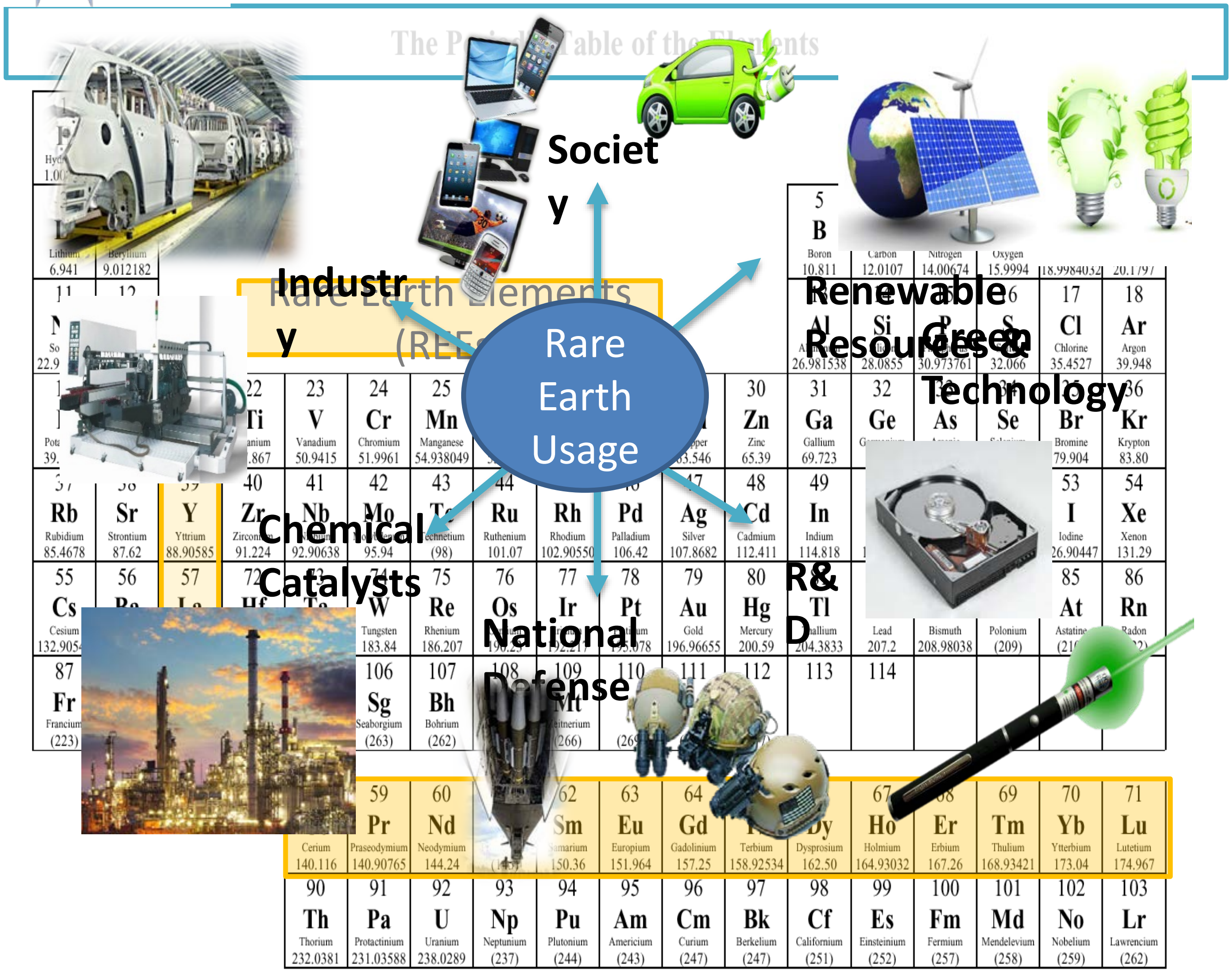




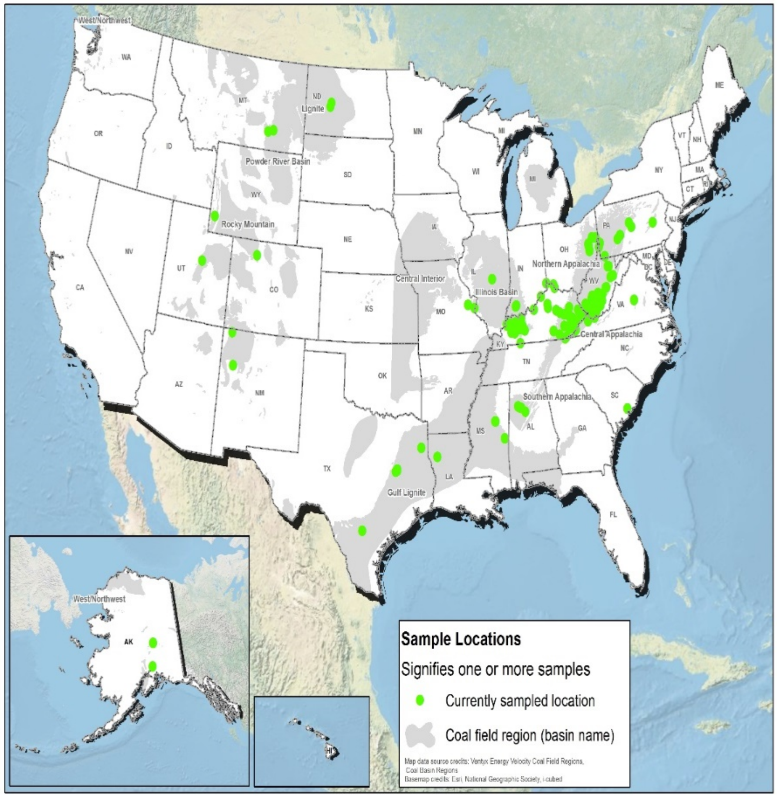
1. genius.com 2. Mos-Tech.co.uk 3. greenliving4live.com 4. cleantechica.com 5.ishareimage.com 6. USGS Rare Earth Fact Sheet (2014) 7. lowereasternshorenews.com 8. osa.opn.org 9. army-technology.com 10. oilinvestigatingnews.com 11. alibaba.com 12. cardvice.com.au

## REE Extraction Opportunities for Coal and Coal By-Products

- Everything in the earth's crust, good and bad, is found to some extent in coal and coal by-products
- The US burns almost 1 Billion tons of coal a year
  - Producing 100-150 million tons of coal ash with an average concentration of ~470ppm REE+Y
  - Coal ash produced yearly based on average concentrations contains ~47,000-70,500 tons of REE+Y or 2 - 4 times the US consumption
  - Coal mining and coal prep by-products could provide additional opportunities for REE extraction and recovery.
  - Other critical or valuable elements could also be extracted from coal and coal by-products during the extraction of REEs
  - Extraction of REEs from coal and coal by-products could provide a stable source of REEs and other critical metals
  - Extraction of REEs could also be environmentally friendly by utilizing already mined materials and potentially treating and utilizing by-product materials

# US Mines ~ 1 Billion tons of Coal/Year

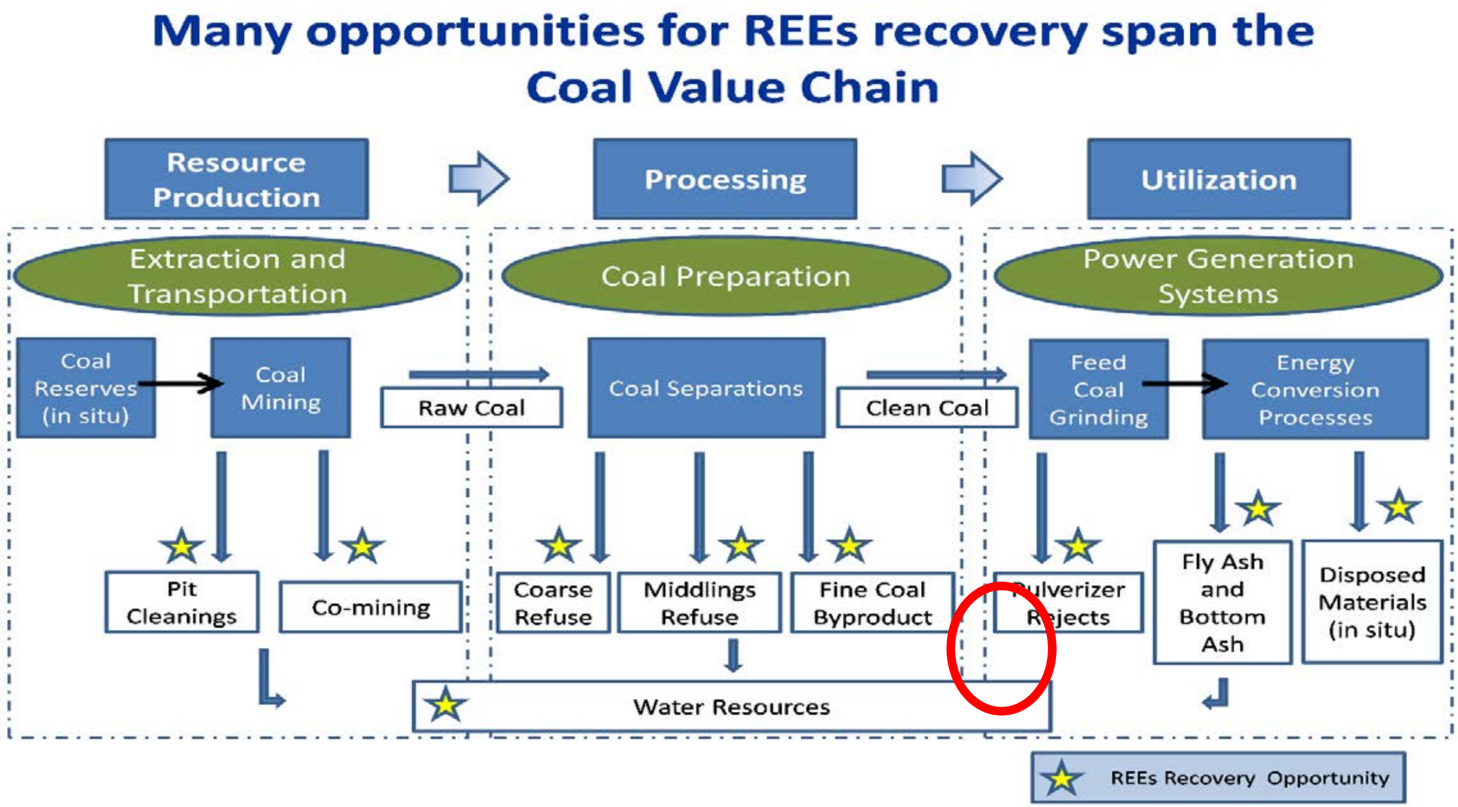
- **Large amounts of mine wastes, coals, coal prep wastes, ashes**
- **Potential as REE sources**
- **These vastly different samples make accurate and consistent measurements of REE concentrations challenging**




*https://edx.netl.doe.gov/ree/?page_id=1002*

# Recovery of REE from Coal and Coal By-Products

- ~ 100 - 150 million tons of coal ash produced annually
- Some coals and coal byproducts have been shown to contain elevated concentrations of REE




https://edx.netl.doe.gov/ree/

# Research Thrusts

- **Characterization**

- **Separation**

- **Program Goal**
  - Develop technologies for cost effective and environmentally friendly recovery of the rare earths and critical elements from abundant coal byproducts

- **Technology Specific Goals and Priorities:**
  - Determination of rare earth contents of coal byproducts (lab and field)
  - Identification of rare earth species
  - Finding easily measured marker elements suggesting presence of rare earths
  - Determining most promising byproducts for recovery of elements
  - Produce a ≥ 2% rare earth concentrate

## RIC Research

- R&IC conducts field and laboratory-scale research to identify/collect/archive promising samples; and to measure and recover rare earths and critical elements from abundant coal byproducts.

- Rare Earth Program will identify the most promising coal byproducts for recovery of rare earths and critical elements; and develop technologies for commercial recovery.

# Rare Earth Elements – Capabilities & Challenges

## Capabilities being developed

- ***Rare Earth Element Characterization*** *down to sub ppm levels in solids, and sub ppb levels in aqueous matrices.*
- ***Rare Earth Element Separation*** *from complex coal byproduct solid and liquid matrices.*
- ***Modeling*** *– Any extraction, sorbent, or catalytic process involving shrinking core model*
- ***Advanced Sensors*** *– for in situ determination of trace metals in aqueous solutions*
- ***Novel Sorbents*** *– for capture of rare earths and heavy metals from liquid matrices*
- ***Geochemical Mechanisms –*** *identified for mobilization of rare earths*

## Technical Challenges

- ***The low concentration of the rare earths:*** The **typical** total rare earth contents of coals are 70 ppm; for fly ash, 400 ppm; coal mining overburden, 180 ppm; and acid mine drainage, 5 ppb. For comparison, a commercial rare earth ore often will contain 2 – 10 weight percent total rare earths.

- ***Complex byproduct matrices***: The coal and coal byproduct solids contain virtually every element in the earth's crust, with the rare earths often present as small (micron size) monazite crystals. The aqueous byproducts contain numerous unwanted particulates and salts. Low concentration and complex matrices hinder both characterization and recovery.

# Technology Transfer, and Making DOE Results Available to the Public

- 24 Presentations to date
- At least 15 Presentations at upcoming meetings
- 8 Publications to date, with many in preparation
- 4 Reports of Invention
- Collaborations with many organizations
- Sessions Organized on Rare Earths at 3 International Conferences
- EDX Web Site Updated Regularly, more than ten thousand site visits
- https://edx.netl.doe.gov/ree/
- Many Visitors to Our RIC Labs and Media Interviews
- 2015 GSA Energy Division Best Paper Award
- Several Awards of Beam time at Stanford Synchrotron
- Featured in Upcoming Fall Issue of NAE publication The Bridge

# FY 16 Field Sampling Efforts – Accomplishments - Deliverables

- Identification of Promising By-Products for Rare Earths
- Rare Earth Archive houses over 1,000 samples
- Collected over 700 samples in the past year
- Sample analyses being uploaded onto EDX website
- Promising Materials identified with over 500 ppm RE+Y on dry whole basis
- Geochemistry
- Marker Elements and Element Associations
- MOUs for Sampling and Collaborations
- Peer-Reviewed Publications
- Commercial and Media Interest Based Upon RIC Sampling Efforts

# FY 16 Characterization Efforts – Accomplishments - Deliverables

- Over 1,000 assays – bulk elemental analyses
- Approximately 40 SEM-EDX, 90 XRD
- ICP-MS – best in class - digestion, uncertainty, publications (Topical Report April 14, 2016)
- ICP-OES – bulk multi-elemental analysis (supplementary)
- C, H, N, S, Ash, and Moisture
- SEM-EDX – identified phosphates in by-products, possible Ca-association in ash
- XRD – determine minerology of the sample
- LA-ICP-MS – Spot and Depth Analyses; State-of-the-Art Mass Spectrometer to Resolve Overlapping Peaks (Publication)
- Ion Exchange Capacities and pH – novel technique developed
- Stanford Synchrotron – several awards of beam time – identified sulfates, oxides, phosphates in ash – now focusing on mine by-products (Best Paper Award 2015)
- Sequential Extractions – current – form of RE in coal and by-products
- LIBS: Laser Induced Breakdown Spectroscopy (Publication)
- Sensitized Fluorescence (Report of Invention)
- Portable XRF
- Gamma Detection
- SHRIMP-RG

# FY 16 Separation Efforts – Accomplishments - Deliverables

- Mineral Processing and Physical Beneficiation – Paper Completed
- Density Float-Sink
- Magnetic
- Size
- Froth Flotation – Shakedown and commercial interest
- Bench/Pilot Scale Process Design – Report Completed
- Ammonium Sulfate
- Deep Eutectic Solvents/Ionic Liquids
- Acid dissolution
- High Temperature Phase Separations (Confocal Microscope, TGA)
- REE Selective Sorbents – Aqueous Feeds (Two Reports of Invention)
- Photophoresis (Paper Published)
- In-situ $CO_2$ Brine injection and extraction
- Reactive Grinding

# FY 16 Modeling Efforts – Accomplishments - Deliverables

- Extraction of REEs from clays and other coal and coal by-products
- CFD Modeling
- Mass/Heat Transfer
- Kinetic/Reaction Modeling
- Modeling Physio-Chemical properties and REE Extraction Simulations
- Paper in Preparation

# The NETL Rare Earth EDX Database

# The NETL Rare Earth EDX Database

## Resource for Rare Earth Information

- **Coal Materials**
- **Rare Earth Content - DOE's Coal-Based Rare Earth Element (REE) Data Bank**
- **Reports**
- **Presentations**
- **Upcoming Meetings**
- **Receive E-Mail Updates**
- **Submit Questions to NETL Experts**
- https://edx.netl.doe.gov/ree/

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