Insights into the Collaboration of Industry and Academia in the Energy Sector

April 29, 2016

Monty Alger
Director, Institute for Natural Gas Research
Penn State University
US Energy and Carbon Balances

Estimated U.S. Energy Use in 2013: ~97.4 Quads

- Petroleum: 36.1%
- Natural Gas: 27.4%
- Coal: 18.5%
- Nuclear: 8.5%
- Biomass: 4.6%
- Wind: 1.6%
- Solar: 0.3%
- Geothermal: 0.2%

100% = 82% + 36.1%

Estimated U.S. Carbon Emissions in 2013: ~5,390 Million Metric Tons

- Electricity Generation: 38%
- Transportation: 34%
- Industrial: 18%
- Residential: 6%
- Commercial: 4%

100% = 72% + 38%
Energy is “Big” – Global Scale

Global Energy Use = ~ 3 Cubic Miles of Oil

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Scale of Fossil Energy Supply (~82% Total Supply)

“A Cubic Mile of Oil: Realities and Options for Averting the Looming Global Energy Crisis“, Crane, Kinderman & Malhotra
Sustainability – “People, Planet, and Profits”

Source: Professor Roland Clift, Centre for Environmental Strategy (CES)
“Discovery”  ?  Sales
Institute for Natural Gas Research (INGaR)

Goals:

• Develop an Energy Transformation Process - establish role for natural gas
• Build collaboration practices to engage and reduce innovation cycle time
• Advance learning through application of best in class technology
• Education of the public, future scientists, engineers, policy-makers and leaders
Mission:

Build a new research, development and education collaboration among students, faculty and external partners for economic growth and transition to low-carbon energy supply through unconventional oil and gas.

Vision:

Enable the design, creation, development and commercialization of energy solutions integrating unconventional oil and gas energy.
Enabling Change: GE CCRINGSS Collaboration

GE to invest in Penn State center to study natural gas supply chains

September 24, 2014

UNIVERSITY PARK, Pa. -- GE announced that it will invest up to $10 million in Penn State to establish a new innovation center focused on driving cutting-edge advancements in the natural gas industry. The Center for Collaborative Research on Intelligent Natural Gas Supply Systems at Penn State (CCRINGSS) will engage Penn State researchers and students from many disciplines in collaborative work with various industry stakeholders. The center will seek to advance efficiency and environmental sustainability both through technological innovations and improved supply chain management.

"Natural gas is extremely important as a domestic energy source for the United States and continues to serve as a crucial element in revitalizing Pennsylvania's economy," said U.S. Congressman Glenn Thompson. "I fully support the work that Penn State and GE will be doing through CCRINGSS to support new research innovations and create real-world applications that will build upon existing partnerships led by the University to make a positive impact on the industry and the communities of Pennsylvania."

Thompson spoke at a luncheon Sept. 24, during which Penn State President Eric Barron outlined the creation of the center. GE Senior Vice President and Chief Technology Officer Mark Little, other representatives from GE, and several members of Penn State's academic leadership also attended.

GE / CCRINGSS Goals:

• Mission of CCRINGSS is to engage many disciplines, and stakeholders

• To create a deep understanding of natural gas supply chain systems - including technical innovation, design, investments, and operations

• Generation of new knowledge, dissemination of knowledge, engagement of stakeholders of the natural gas supply chain

• Education of current and future scientists, engineers, policy-makers and managers

• GE 5 Year Investment with Penn State
• Support New Collaboration Model – Natural Gas Supply Chain
Focus Areas - Institute for Natural Gas Research

Energy System Transformation

- Balance Innovation, Investment and Policy
- “Learn by Doing”, Penn State Operating Station
- Translate to any Energy System

Innovation

- Projects – Innovation Sessions
- Programs – Lean Start-up Model
- Full IP ownership option

Organization – All Penn State

Technology-Enabled Collaboration

- Use online platform for University and Business connections
- Priorities from external sponsors
- Existing best-in-class content
Energy System Transformation - Approach

**Policy**

- Energy System (University, City, State, …)
- Innovation
- Investment

**Output Measurements**
- Economic
- Sustainability
- Security

- Define an Energy System / Baseline & Goals
- Options for system improvement
- Evaluate innovation, investment and policy
- Priorities, Plans and Projects
- Local Implementation / Global Reporting
Energy System Transformation - Example

Energy System
Penn State University Park
- 290,000,000 kwhr / year
- 33.1 MW average
- 160,818 mton CO$_2$ (Natural Gas basis)

Policy
$180/mton CO$_2$

Innovation
100% Solar with Storage

Investment
$281 MM 1X

Output Measurements
Zero Carbon Electricity

Order of Magnitude: Solar $2/watt; 2X capacity; 1.5 Tracking; Storage $3/watt; 1.22 lb. CO$_2$/kwhr

http://www.opp.psu.edu/services/energy/energy-usage
Beyond 2020

Penn State GHG Emissions
80% below 1990 levels to 2050

Penn State Operating Station

- Penn State Emissions Strategic Plan
- “Learn by Doing” - 24 campuses, $6B Assets, Platform Research
- Engagement - OPP, students, suppliers, community
- Develop, translate and benchmark externally

- 4 Learning Factory Projects Spring 2016
- Real time LCA measurement of CO2-e
Energy System Transformation - Penn State Operating Station

Measurements

Cloud Based Data Layer (http://Measurabl.com)

- Company N
- City A
- Penn State
- University B
- University A

Analysis

- Benchmarking / Sharing of Practices
- Long-term Globally Consistent Reporting

Benchmarking

- Sustainability
- Economics

- Transformation Plan for Any Organization
- Benchmarking / Sharing of Practices
- Long-term Globally Consistent Reporting

https://lucidconnects.com/
http://www.energycap.com/
http://energyhippo.com/
Organization - Institute for Natural Gas Research

Penn State

Functional Organizations

- External
- Colleges
- Departments
- Centers, Faculty
- Skill Categories
- Students

Applications

- Exploration and Production
- Water
- Infrastructure
- Power Generation
- Chemicals and Materials
- Buildings
... 

Stakeholders

- Public
- Private
- NGOs

Shared Practices – Collaboration, Knowledge Management and Education

$800 MM Year
Penn State Sponsored Research
## Organization – Institute for Natural Gas Research

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<tr>
<th>Theme</th>
<th>Application</th>
<th>Champion</th>
<th># of Projects</th>
<th># Concepts</th>
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Innovation – External Engagement

**Strategic**
- Sponsor Needs & Solutions
- Agreements, Terms
- Sponsor Commitment
  - Engagement Proposal
  - Approved Projects

**Collaboration**
- Program / Project Concepts
- Joint Innovation Sessions
- Prioritized Projects
  - Integration
  - Prioritization
  - Project Execution

**Research**
- Penn State Sponsored Research
- $800 MM/year

- VC’s
- Ben Franklin
- Small Companies
Innovation Sessions
Innovation – Projects

- Growing Library of 1 Page Project Concepts
- Sharing & Translating Practices Across Penn State
- Developing Sponsored Research Programs

Horizontal

- Oil and Gas Exploration and Production: 65
- Water Processing: 30
- Collaboration: 14
- Education: 10
- Infrastructure: 8
- Supply Chain Energy: 7
- Innovation: 6
- Power Systems: 5
- Chemicals and Materials: 5
- Products and Processes: 5
- Transportation Fuels and Advanced Vehicles: 3

Penn State Sponsored Research

$800 MM/year

Strategic

Sponsor Needs & Solutions

Collaboration

Program / Project Concepts

Research

• Growing Library of 1 Page Project Concepts
• Sharing & Translating Practices Across Penn State
• Developing Sponsored Research Programs
Innovation – Programs

Program:

- Integrate Multiple Faculty and Disciplines
- Translate External Need into University Projects
- Same Challenges Exist in Business
Innovation – Program Design Example

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<th>Project Concepts</th>
<th>Program</th>
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<td>Long-term Oil/Gas/Water Recovery in Unconventional and Conventional Reservoirs</td>
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<td>Fracturing fluid loss and retention by reservoir formation – implications on productivity</td>
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<td>Innovating Decline Curve Analysis for Unconventional Reservoirs with Spatial and Temporal Statistics</td>
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Initial Program Concept:

Develop a Tool to predict well behavior based on range of re-stimulation designs

- Discussions – Opportunity to Connect Multiple Project Concepts
- Need a Method to Design Program Tied to Market Need
Innovation – Developing New Programs

Steve Blank
www.SteveBlank.com

Lean Start-Up

Business Idea
(Program Concept)

Lean Program Design
Program Proposal

Lean Start-up Methodology

Market (Customers)

“Start-Up”

- “Reverse” Lean Start-up Model – Connect Research to Market Need
- Value Proposition, Customer Discovery, Pivoting, Lean Start-up Canvases
- Program Development Course Pilot Spring 2016 – 4 Project Teams
Technology-Enabled Education
“How Do I ... Fix a Leaky Faucet”
“How Do I …” Energy Examples

How Do I Site a Well

How Do I Create a New Program

How do I Transform an Energy System

How Do I Balance a Reformer
Technology-Enabled Collaboration

Penn State

Start Here

Business

How do I …

Site a Well

Develop a New Program

Transform an Energy System

…

External Public Content
(YouTube, Vimeo, etc.)

Use Online Technology to Build a New Integrated Collaboration Model

• Needs
• Best Practices
• Engagement
Focus Areas - Institute for Natural Gas Research

Energy System Transformation

- Balance Innovation, Investment and Policy
- “Learn by Doing”, Penn State Operating Station
- Translate to any Energy System

Innovation

- Projects – Innovation Sessions
- Programs – Lean Start-up Model
- Full IP ownership option

Organization – All Penn State

- Functional Organizations
- Applications
  - Exploration and Production
  - Water
  - Infrastructure
  - Power Generation
  - Chemicals and Materials
  - Buildings

Technology-Enabled Collaboration

- Use online platform for University and Business connections
- Priorities from external sponsors
- Existing best-in-class content
Summary

- Building New Practices to Connect University and Business
- Reduce Innovation Cycle-time, Connection of Market with Research
- Use Technology to Enable an Integrated Learning Model
- Business Partnership Needed for Design, Iteration and Deployment
Thank You!