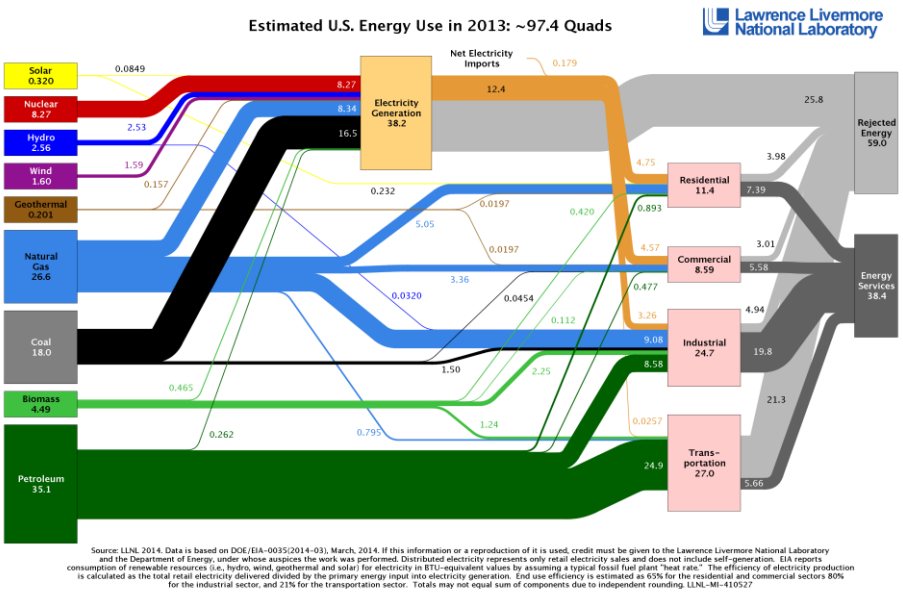
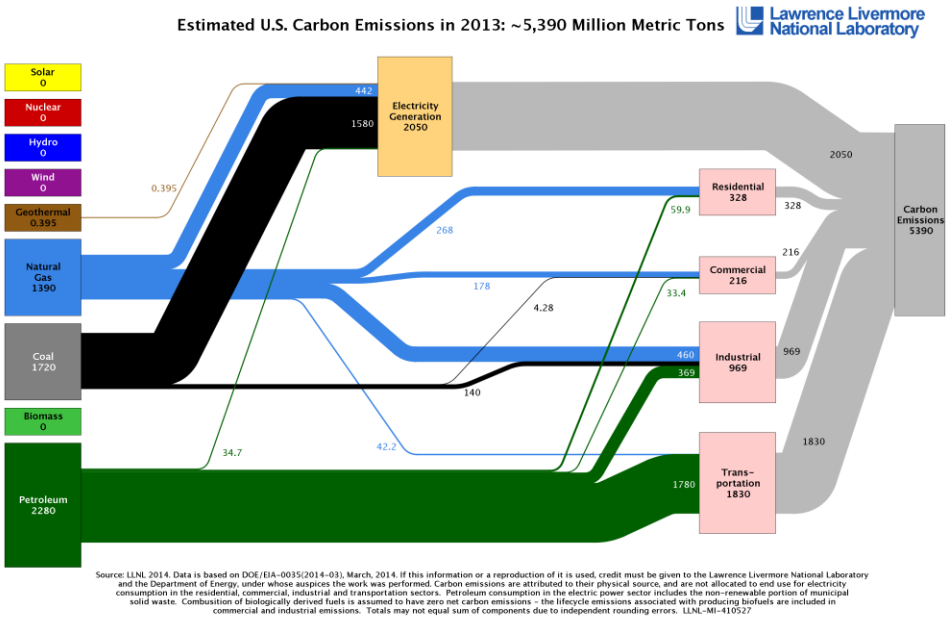
Insights into the Collaboration of Industry and Academia in the Energy Sector

April 29, 2016

Monty Alger
Director, Institute for Natural Gas Research
Penn State University

US Energy and Carbon Balances





Petroleum	**36.1%**	82%
Natural Gas	**27.4%**	
Coal	**18.5%**	
Nuclear	8.5%	
Biomass	4.6%	
Hydro	2.6%	
Wind	1.6%	
Solar	0.3%	
Geothermal	0.2%	
	100%	

Electricity	**38%**	72%
Transportation	**34%**	
Industrial	18%	
Residential	6%	
Commercial	4%	
	100%	

Energy is “Big” – Global Scale

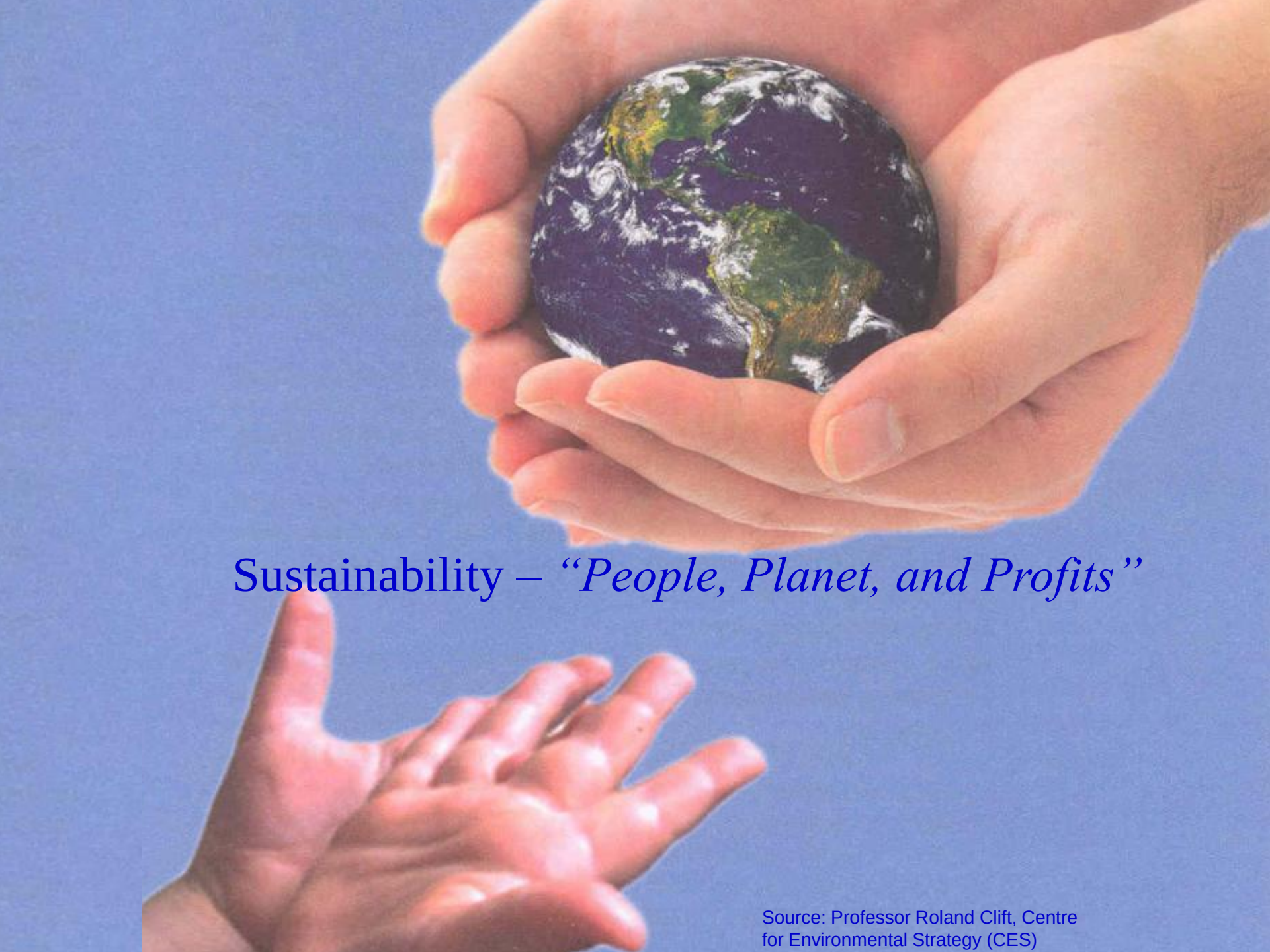
Global Energy Use = ~ 3 Cubic Miles of Oil

*Source	Number	Cost (US$ trillion’s)	Area	
			(km^2)	(sq mi)
Three Gorges Dam, China	496	15	3,135,712	1,210,736
Nuclear plants	6,448	32	25,792	9,920
Coal plants	12,896	8	25,792	9,920
Wind turbines	4,072,160	8	678,694	262,044
Rooftop photovoltaics	11,315,000,000	169	158,410	61,162

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

https://en.wikipedia.org/wiki/Cubic_mile_of_oil

“A Cubic Mile of Oil : Realities and Options for Averting the Looming Global Energy Crisis “, Crane, Kinderman & Malhotra

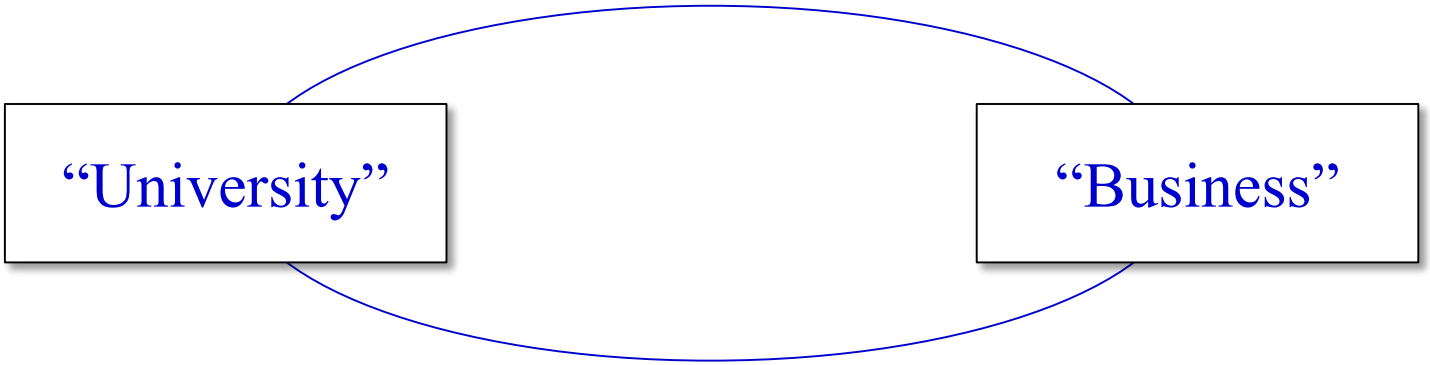


Sustainability – *"People, Planet, and Profits"*

Source: Professor Roland Clift, Centre for Environmental Strategy (CES)


“Discovery”
?
Sales

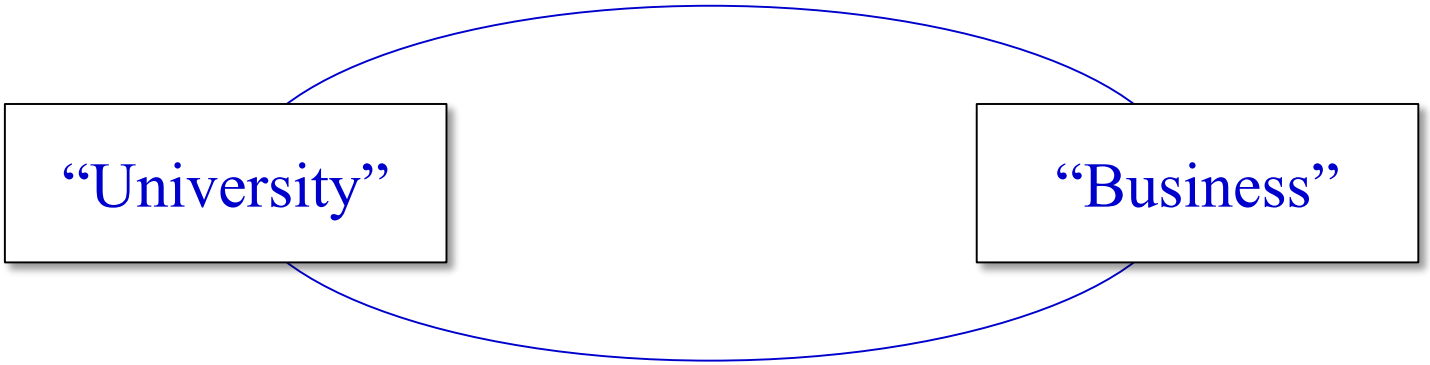
Institute for Natural Gas Research (INGaR)



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

Institute for Natural Gas Research (INGaR)



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.

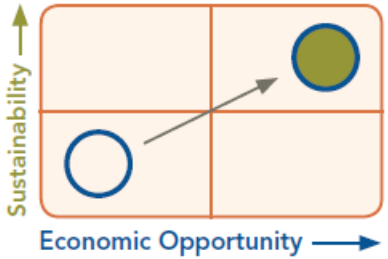
GE / CCRINGSS Goals:

- 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

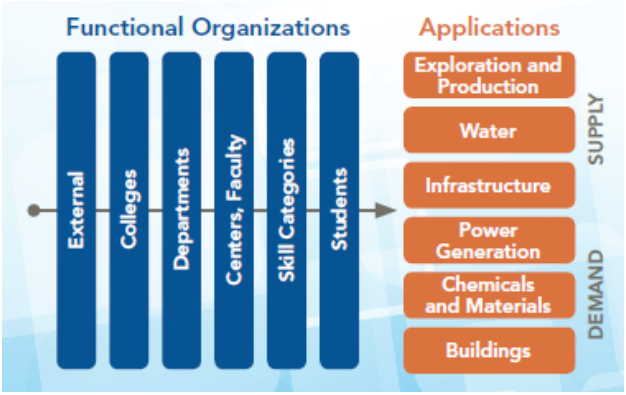


- Balance Innovation, Investment and Policy
- "Learn by Doing", Penn State Operating Station
- Translate to any Energy System

Innovation

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

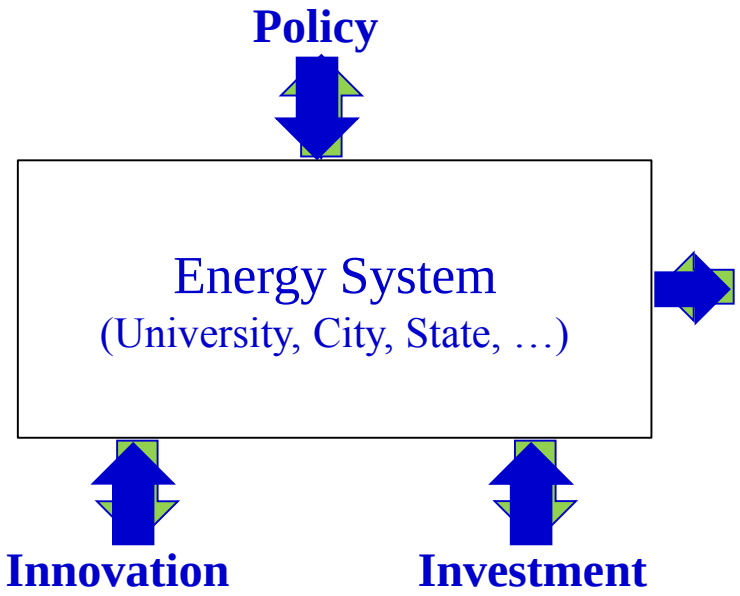
Organization – All Penn State



Technology-Enabled Collaboration

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

Energy System Transformation - Approach



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

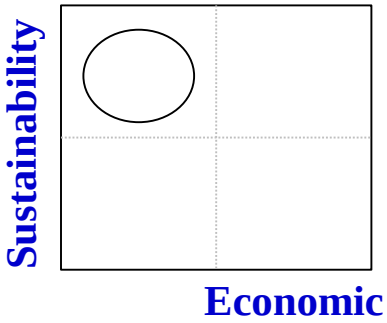
Policy **$180/mton CO_2**

Energy System
Penn State University Park

- 290,000,000 kwhr / year
- 33.1 MW average
- 160,818 mton CO_2 (Natural Gas basis)

Output Measurements

Zero Carbon Electricity



Innovation

100% Solar with Storage

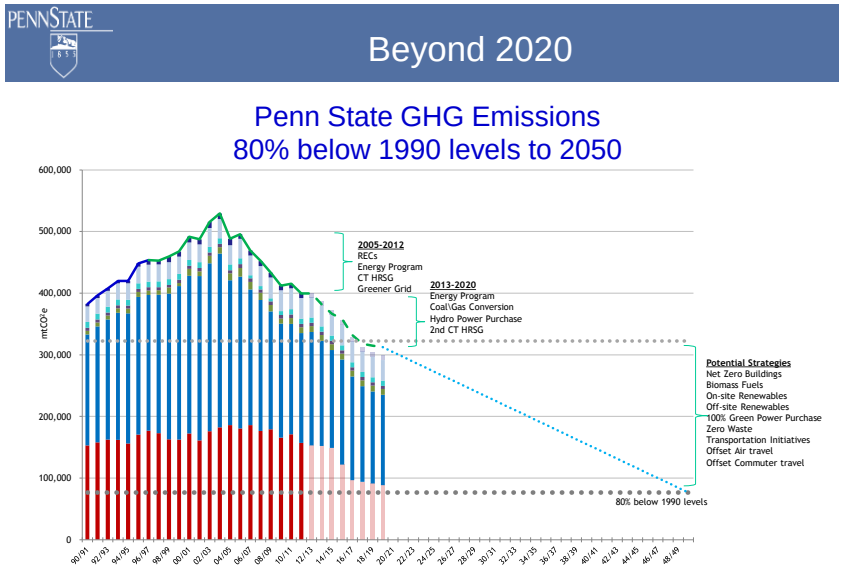
Investment

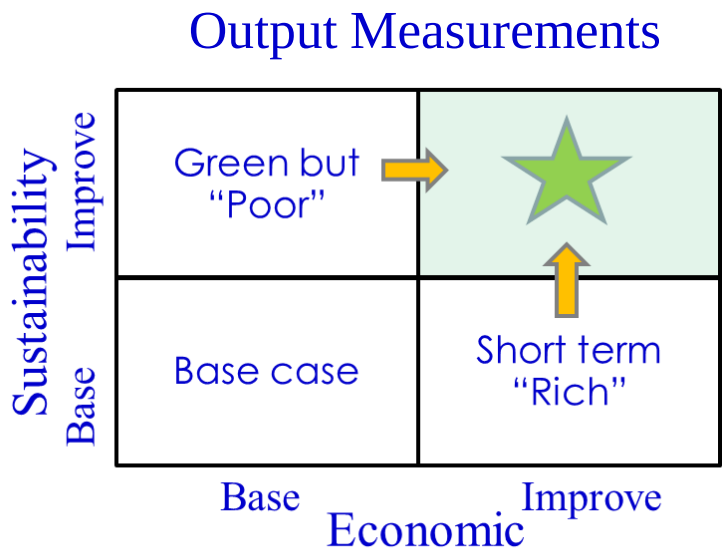
$281 MM 1X

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

Energy System Transformation – Penn State





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Penn State Operating Station

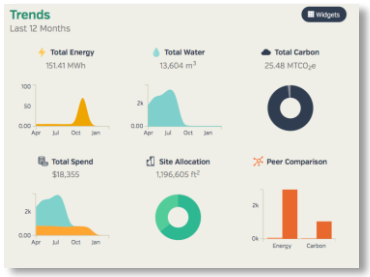
- Penn State Emissions Strategic Plan
- "Learn by Doing" - 24 campuses, $6B Assets, Platform Research
- Engagement - OPP, students, suppliers, community
- Develop, translate and benchmark externally

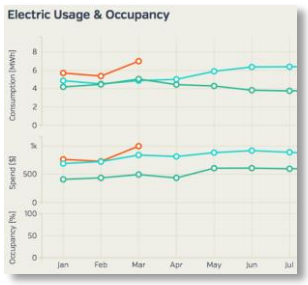
- 4 Learning Factory Projects Spring 2016
- Real time LCA measurement of CO2-e

Energy System Transformation - Penn State Operating Station

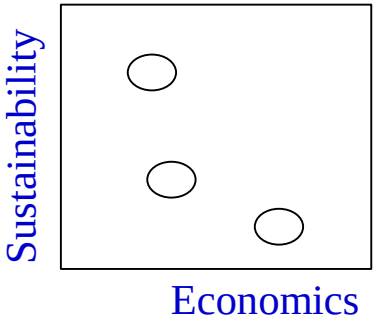
Measurements

Analysis





Benchmarking



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

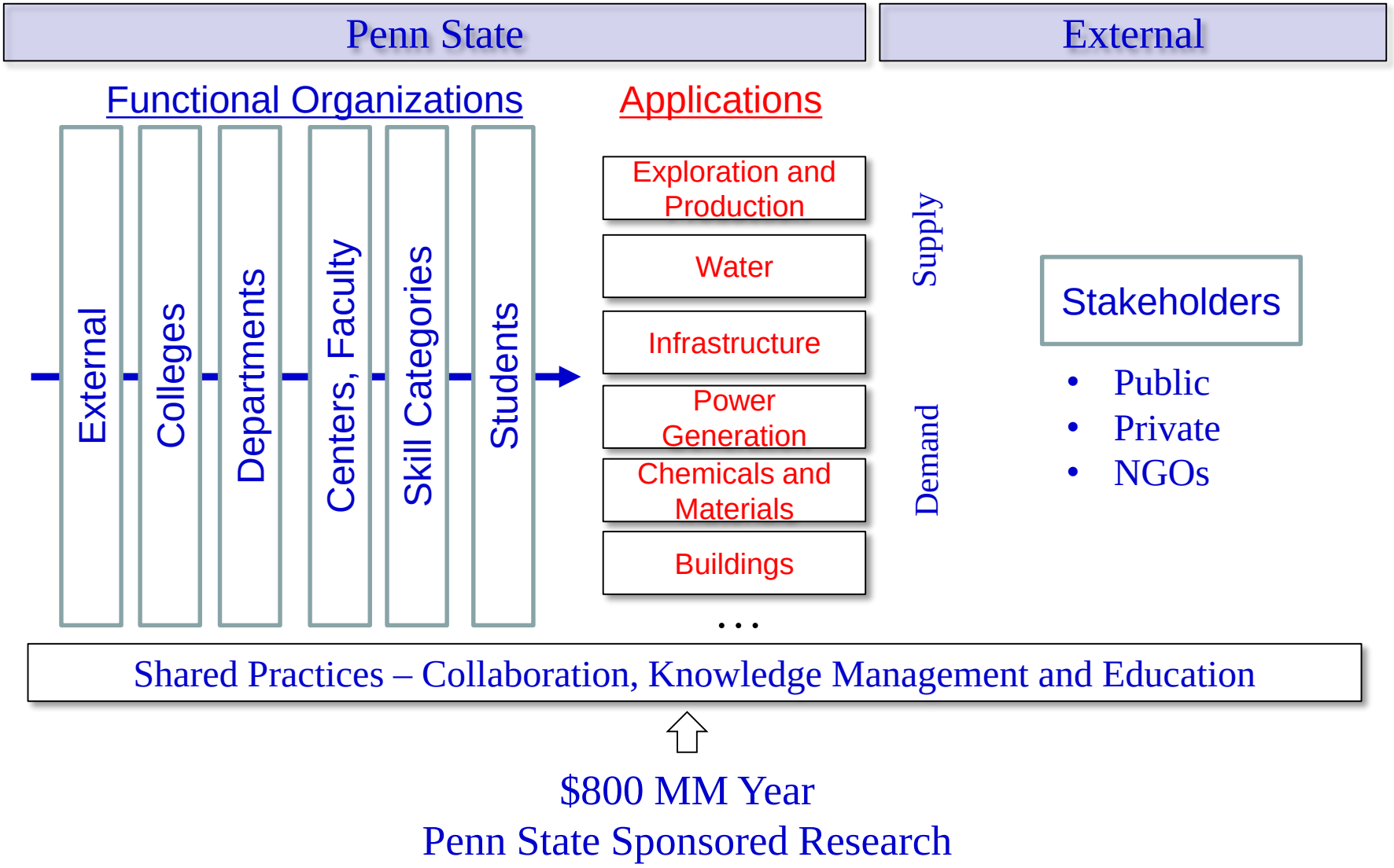
Company N | City A | Penn State | University B | University A

. . .

- 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



$800 MM Year
Penn State Sponsored Research

Organization – Institute for Natural Gas Research

Theme	Application	Champion	# of Projects	# Concepts	# Colleges	# Affiliate	# SIMs Faculty	# Pubs	# Centers	5 Yr Sum, Million $
Energy Supply	Oil and Gas Exploration and Production	Marone, Chris	1	64	12	37	71		11	28.9
	Water Processing	Kumar, Manish	5	30	8	31	36		14	12.3
	Infrastructure		0	8	6	13	17		6	4.3
			6							**45.5**
Energy Demand	Power Systems	Webster, Mort	1	5	15	20	95		6	47.5
	Transportation Fuels and Advanced Vehicles		0	3	3	2	5		3	7.8
	Chemicals and Materials Products and Processes		0	5	3	16	9		3	3.1
	Buildings		0	0	10	0	24		0	70.1
			1							**128.4**
Energy System Design	Collaboration	Reep, Jamie	2	13	0	1	0		15	0.0
	Supply Chain Energy	Tracey, Steve; I	4	7	3	14	6		1	0.9
	Innovation	Alger, Monty	0	6	0	3	0		0	0.0
	Education	Alger, Monty	2	7	6	9	15		0	2.5
			8							**3.5**
		Total:	**15**							**177**

Penn State Energy University - DRAFT

Theme	Application	# of Projects	# Concepts	# Colleges	# Affiliate	# SIMs Faculty	# Pubs	# Centers	5 Yr Sum, Million $
Design and Management	Climate Science and Ecosystem Change	0	0	12	0	131		0	59.4
	Energy Policy, Planning and Economics	0	2	18	5	28		0	6.3
		0							**65.7**
Energy Supply.	Oil and Gas Exploration and Production	0	65	12	37	71		11	28.9
	Water Processing	0	30	8	31	36		14	12.3
	CO2 Capture, Sequestration	0	0	5	1	16		0	6.3
	Coal Utilization	0	0	6	1	21		0	9.2
	Nuclear Energy	0	0	3	1	15		0	7.6
	Solar Energy	0	0	15	0	50		0	41.4
	Wind Energy	0	0	10	1	10		0	1.9
	Biomass Energy	0	0	14	1	85		0	49.3
		0							**156.9**
Energy Infrastructure.	Smart Grid	0	1	6	1	18		0	6.6
	Infrastructure	0	8	6	13	17		6	4.3
	Energy Storage	0	0	11	1	49		0	29.4
	Supply Chain Energy	0	7	3	14	6		1	0.9
		0							**41.2**
Energy Use	Energy Efficiency	0	0	6	0	5		0	1.4
	Power Systems	0	5	15	20	95		6	47.5
	Transportation Fuels and Advanced Vehicles	0	3	3	2	5		3	7.8
	Buildings	0	0	10	1	24		0	70.1
	Chemicals and Materials Products and Processe	0	5	3	16	9		3	3.1
	Combined Heat and Power (CHP)	0	1	5	1	5		0	2.6
		0							**132.4**
Education and Outreach	Human behavior, communications and ethics	0	0	0	1	0		0	0.0
	Education	0	10	6	9	15		0	2.5
	K12 Education	0	0	0	0	0		0	0.0
		0							**2.5**
									398.8

Innovation – External Engagement

Strategic

Sponsor Needs & Solutions (2) → Agreements, Terms (A) → Sponsor Commitment (6) → Approved Projects (7)

Collaboration

Program / Project Concepts (3) → Joint Innovation Sessions (4) → Prioritized Projects (5) → Project Execution (8)

- VC's
- Ben Franklin
- Small Companies

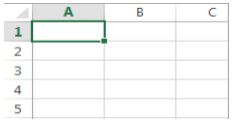
Engagement Proposal

Solution Creation

Integration

1) -----
2) -----
3) -----
4) -----
…

Prioritization



Project Management

Research

Penn State Sponsored Research

$800 MM/year

Innovation Sessions

Innovation – Projects

Strategic

Sponsor Needs & Solutions

Collaboration

Program / Project Concepts

Research

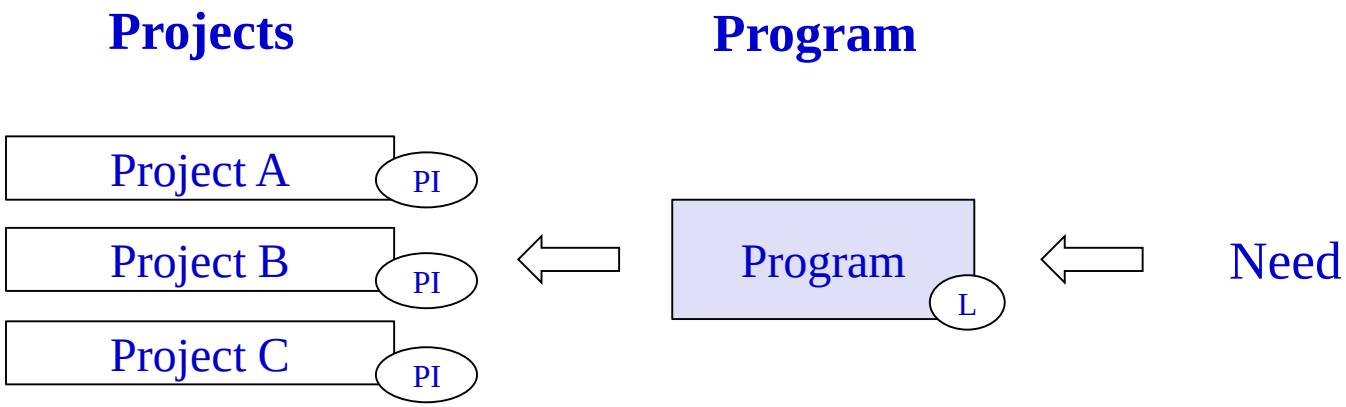
Penn State Sponsored Research

$800 MM/year

Horizontal	# Concepts
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 Products and Processes	5
Transportation Fuels and Advanced Vehicles	3

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

Innovation – Programs



Program:

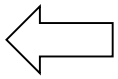
- Integrate Multiple Faculty and Disciplines
- Translate External Need into University Projects
- Same Challenges Exist in Business

Innovation – Program Design Example

Project Concepts

Diagenesis and Loss of Function of Proppant Packs in Shale	Long-term Oil/Gas/Water Recovery in Unconventional and Conventional Reservoirs
Fracturing fluid loss and retention by reservoir formation – implications on productivity	Transport and production decline characteristics of liquid-rich gas shale plays
Multi-stage and multi-mechanism gas production enhancement in shale	Innovating Decline Curve Analysis for Unconventional Reservoirs with Spatial and Temporal Statistics

Program



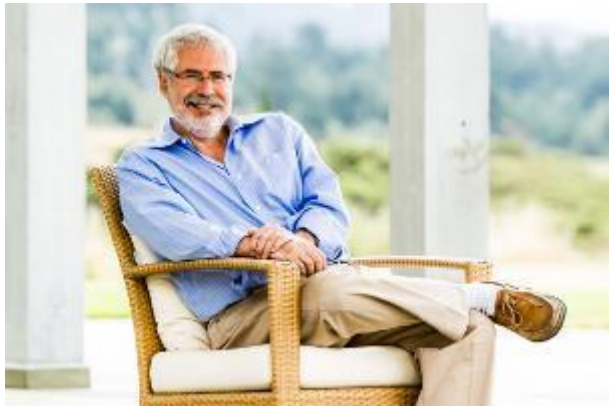
Well Restimulation Tool

Initial Program Concept:

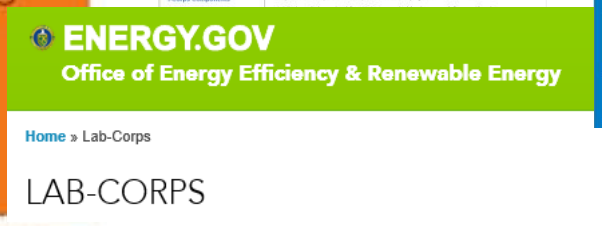
Develop a Tool to predict well behavior based on range of re-stimulation designs

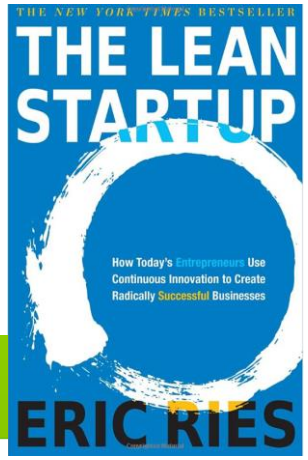
- Discussions – Opportunity to Connect Multiple Project Concepts
- Need a Method to Design Program Tied to Market Need

Innovation – Developing New Programs



Steve Blank
www.SteveBlank.com





Lean Start-Up

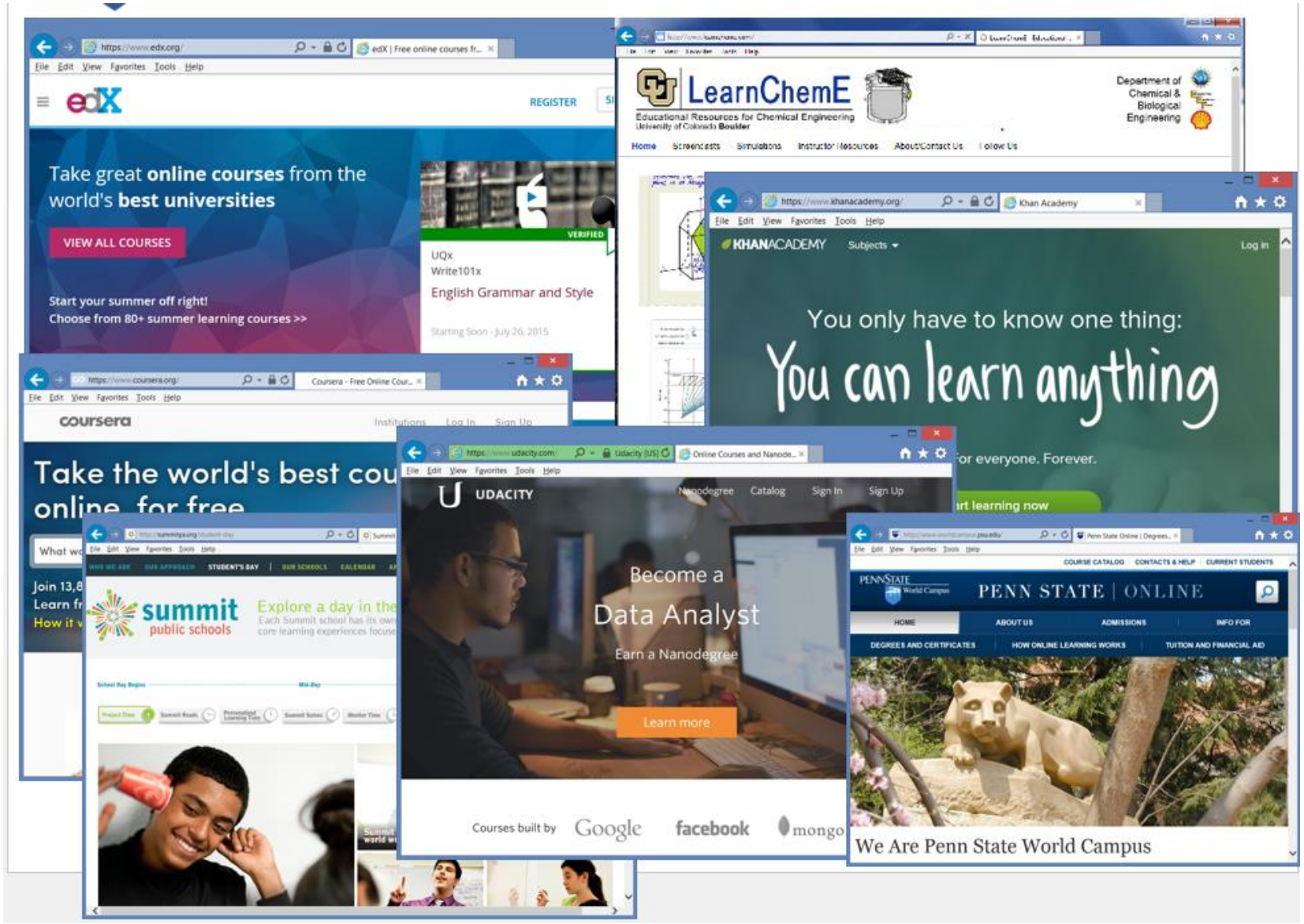
Business Idea (Program Concept) → Lean Start-up Methodology → Market (Customers) → "Start-Up"

Lean Program Design

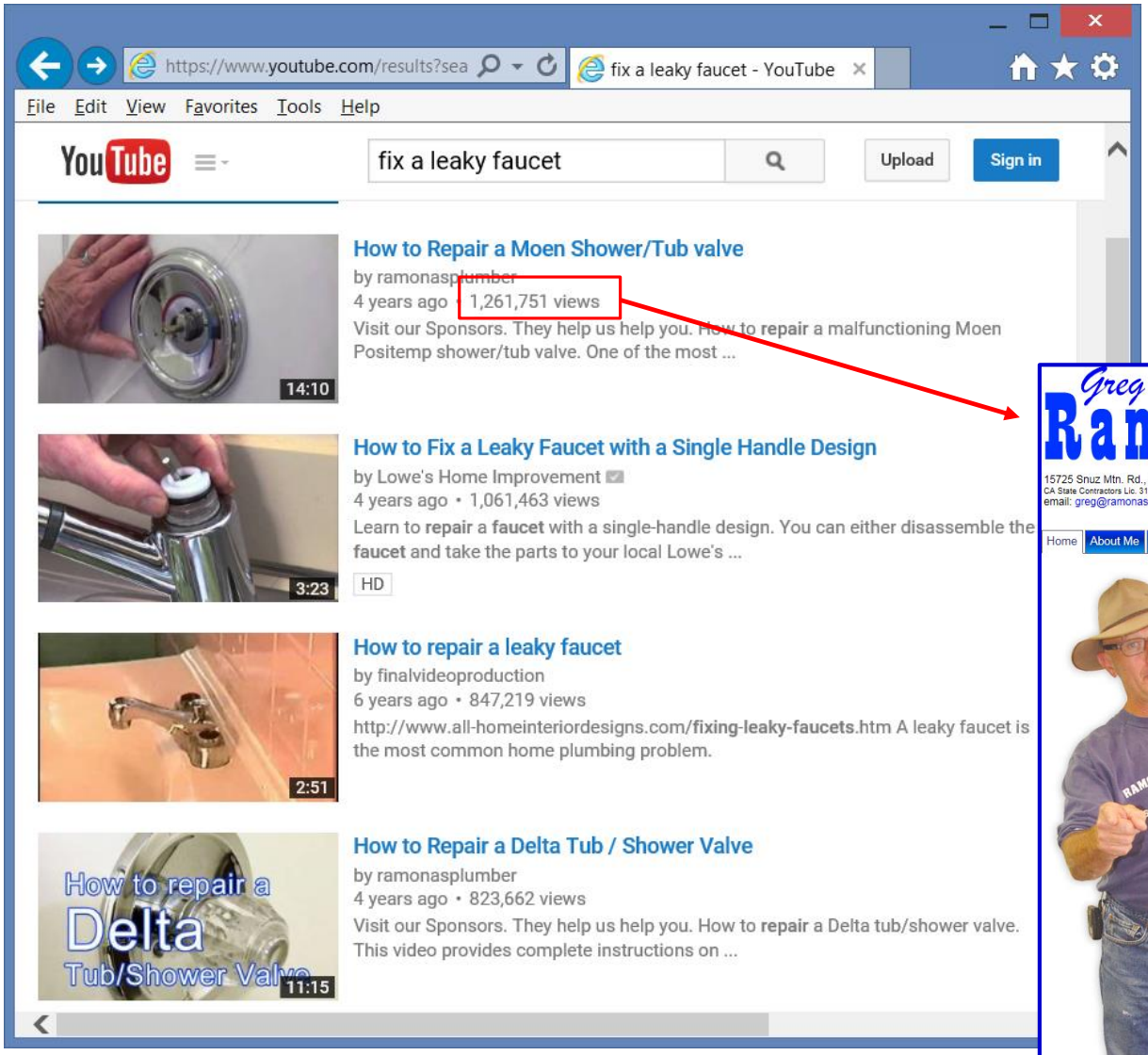
Program Proposal ←

- "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

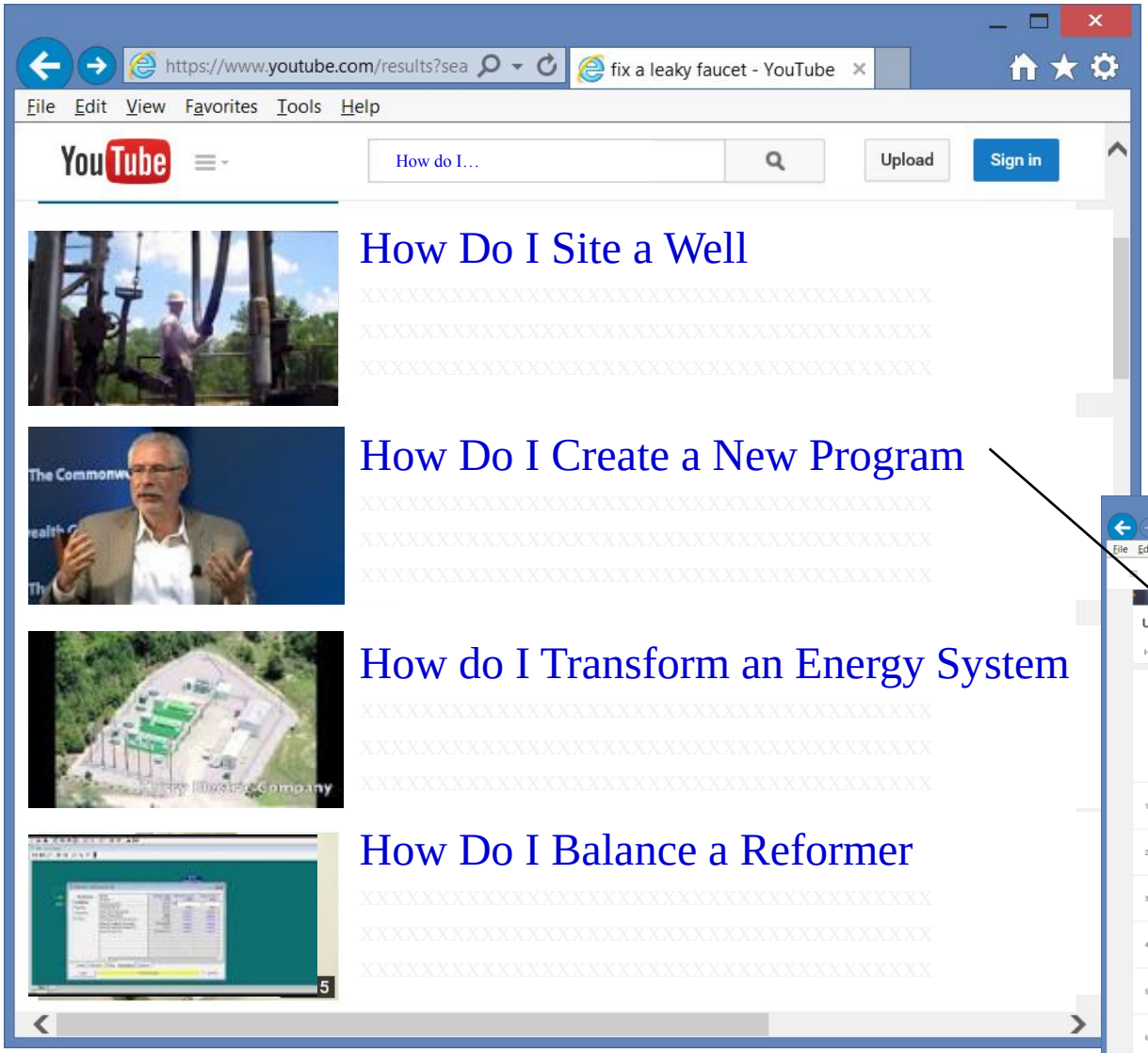
Technology-Enabled Education

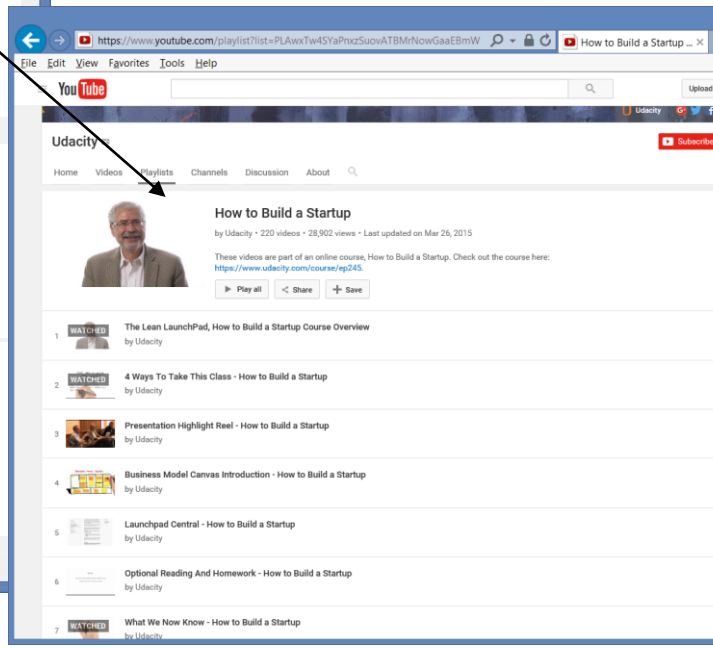


“How Do I … Fix a Leaky Faucet”



“How Do I …” Energy Examples

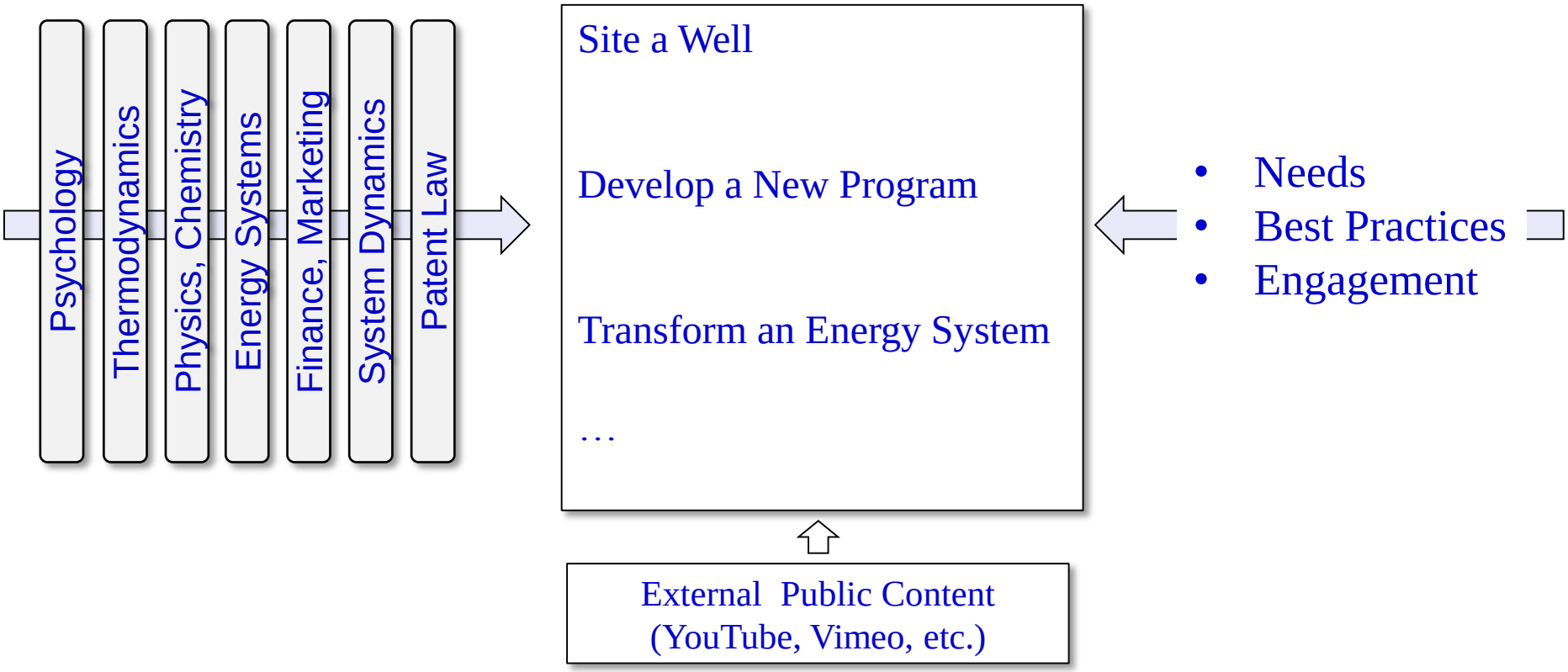




Technology-Enabled Collaboration

Penn State | **Start Here** | **Business**

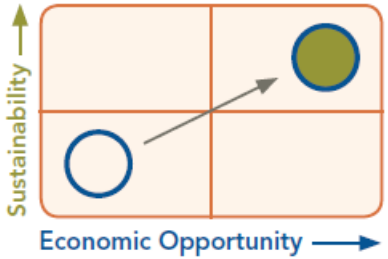
How do I …



Use Online Technology to Build a New Integrated Collaboration Model

Focus Areas - Institute for Natural Gas Research

Energy System Transformation

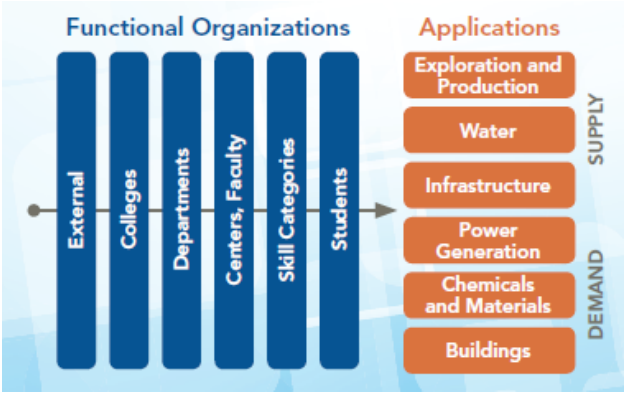


- Balance Innovation, Investment and Policy
- "Learn by Doing", Penn State Operating Station
- Translate to any Energy System

Innovation

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

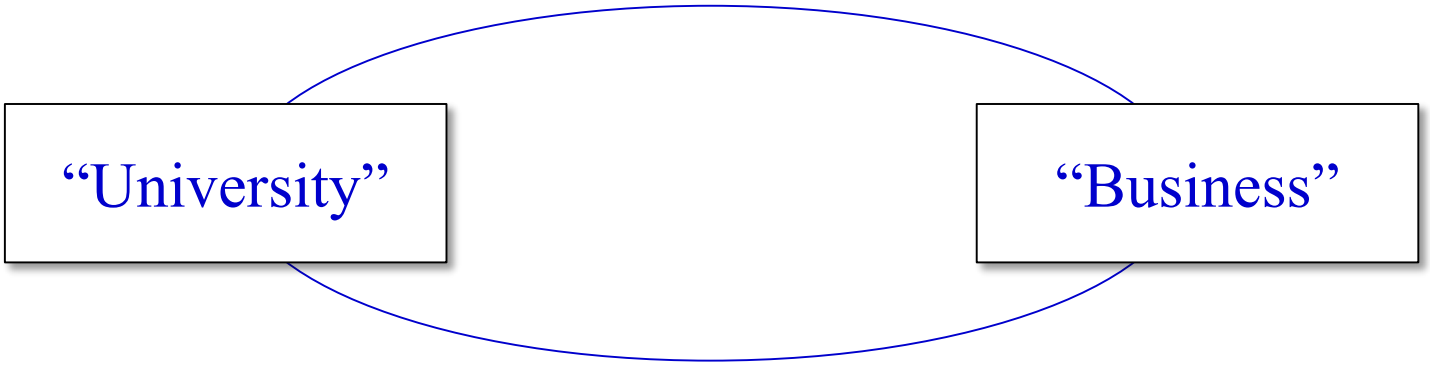
Organization – All Penn State



Technology-Enabled Collaboration

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

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

PennState

Thank You!