Future Energy System Transformation -
Balancing Innovation, Investment and Policy

Natural Gas Utilization Workshop
Overcoming Hurdles of Technology Implementation
November 1-3, 2016

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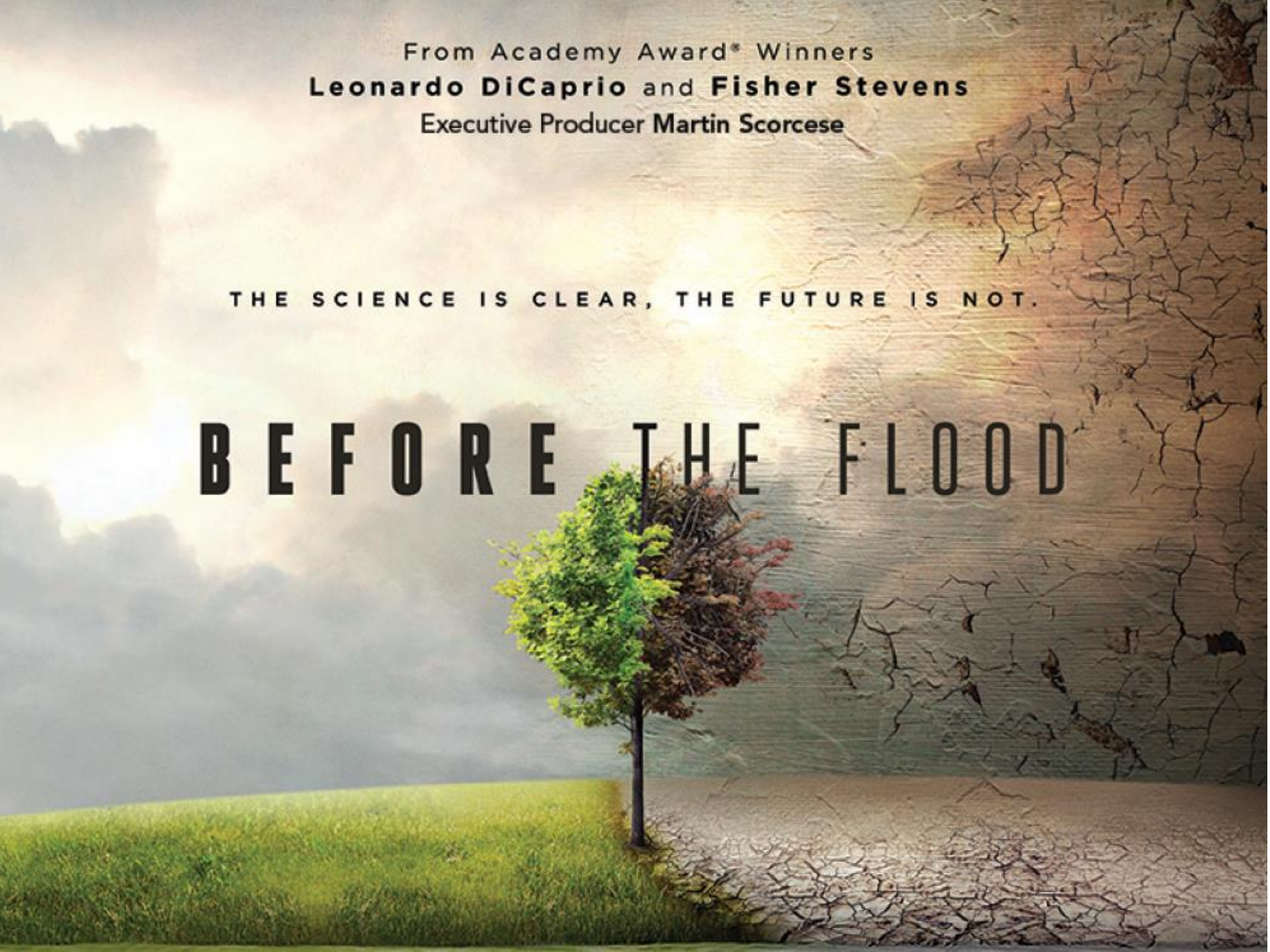

From Academy Award® Winners
Leonardo DiCaprio and Fisher Stevens
Executive Producer Martin Scorcese
THE SCIENCE IS CLEAR, THE FUTURE IS NOT.
BEFORE THE FLOOD

Energy is “Big” – Assets, Investment, Costs

Global Energy Use = ~ 3 Cubic Miles of Oil Equivalent

*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

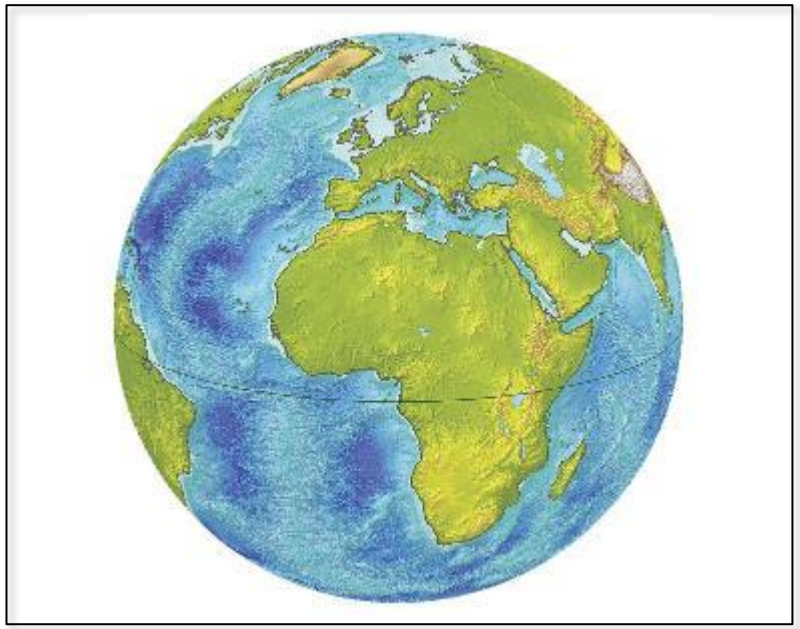
Scale of Fossil Energy Supply (~82% Total Supply)

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

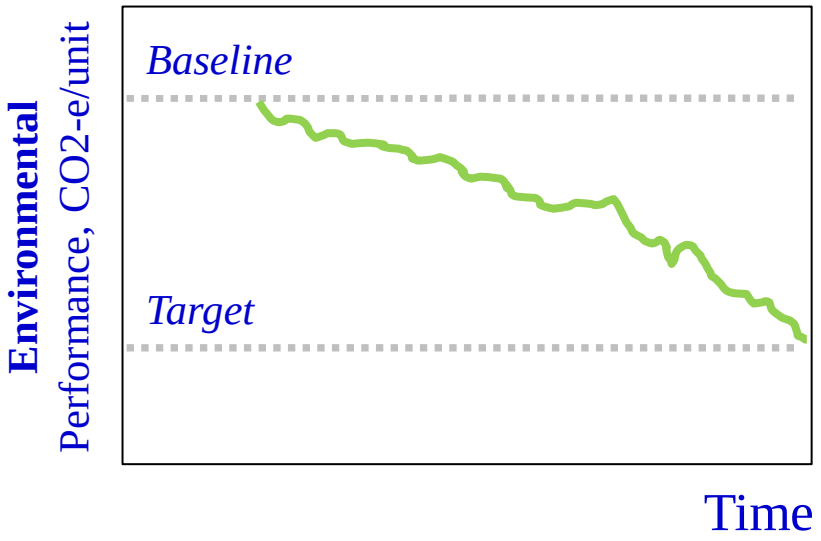
“A Cubic Mile of Oil : Realities and Options for Averting the Looming Global Energy Crisis “, Crane, Kinderman & Malhotra

Global Energy Transformation – “Inside Out”

Policy



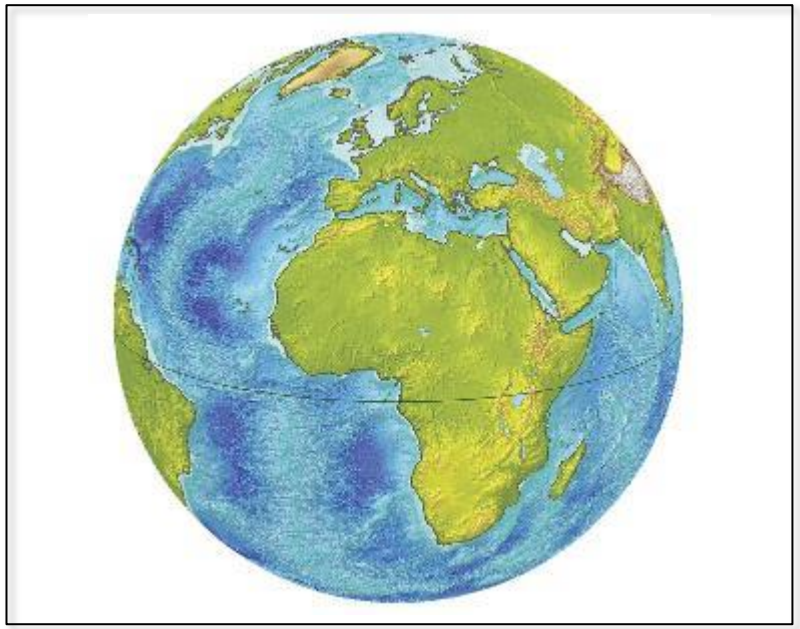
Innovation **Investment**



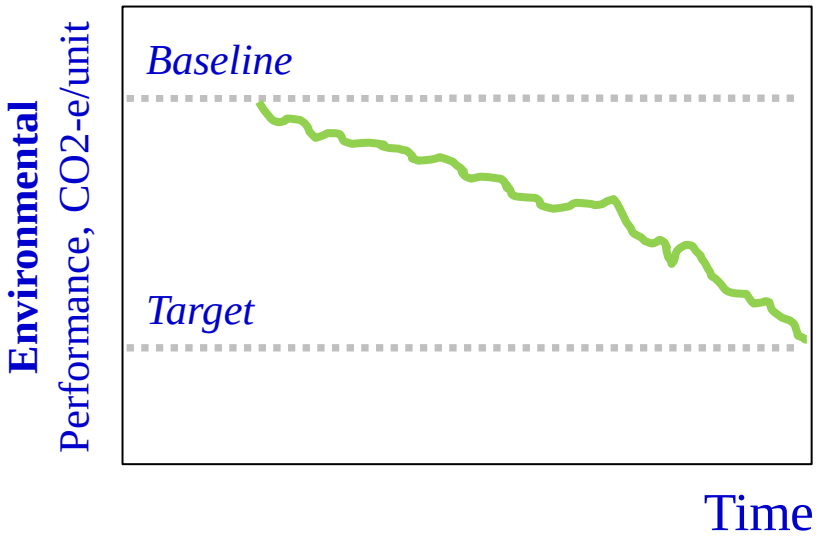
Support Economic and Population Growth
Improve Environmental Performance

Global Energy Transformation – "Outside In"

Policy

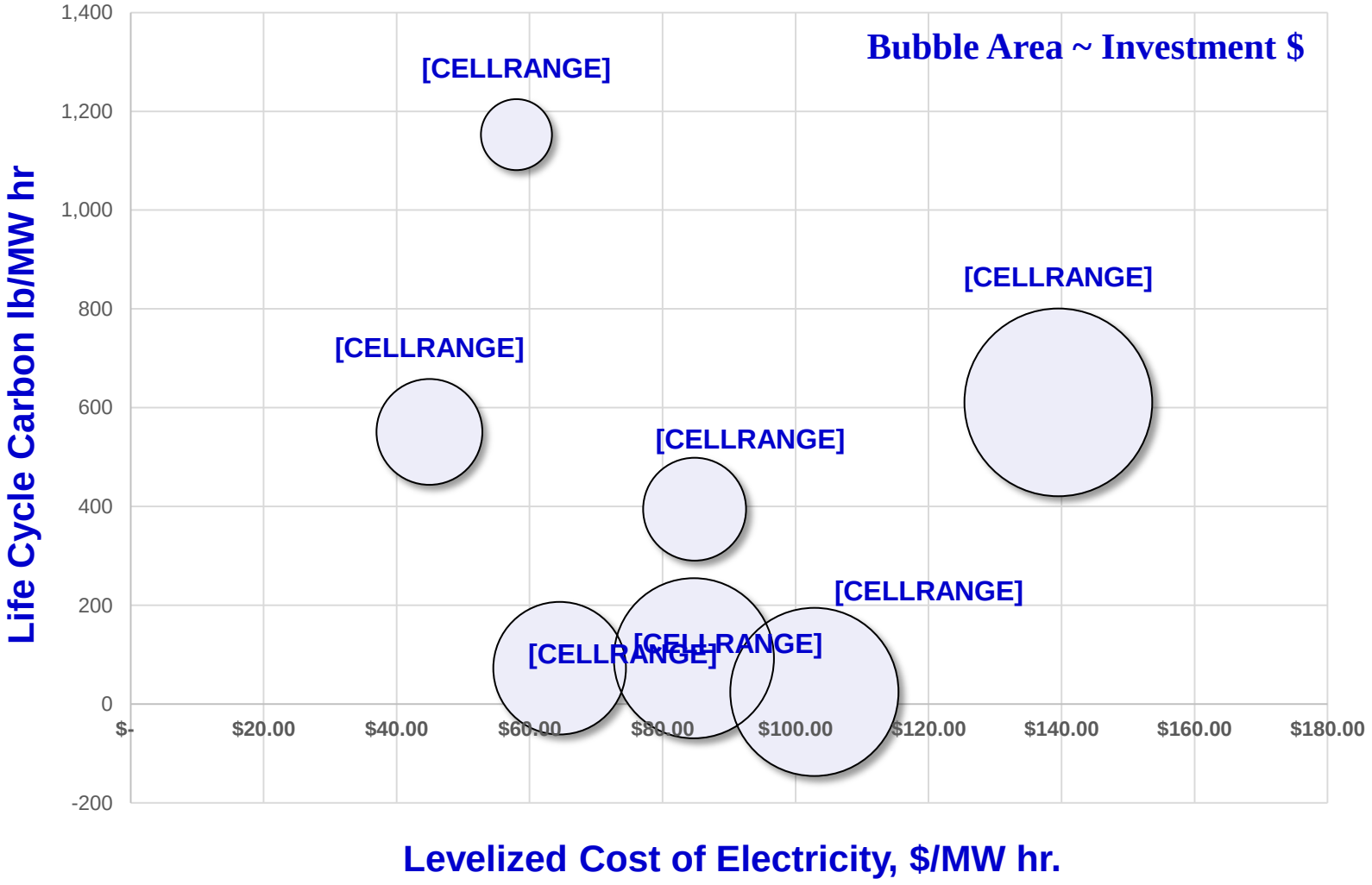


Innovation **Investment**



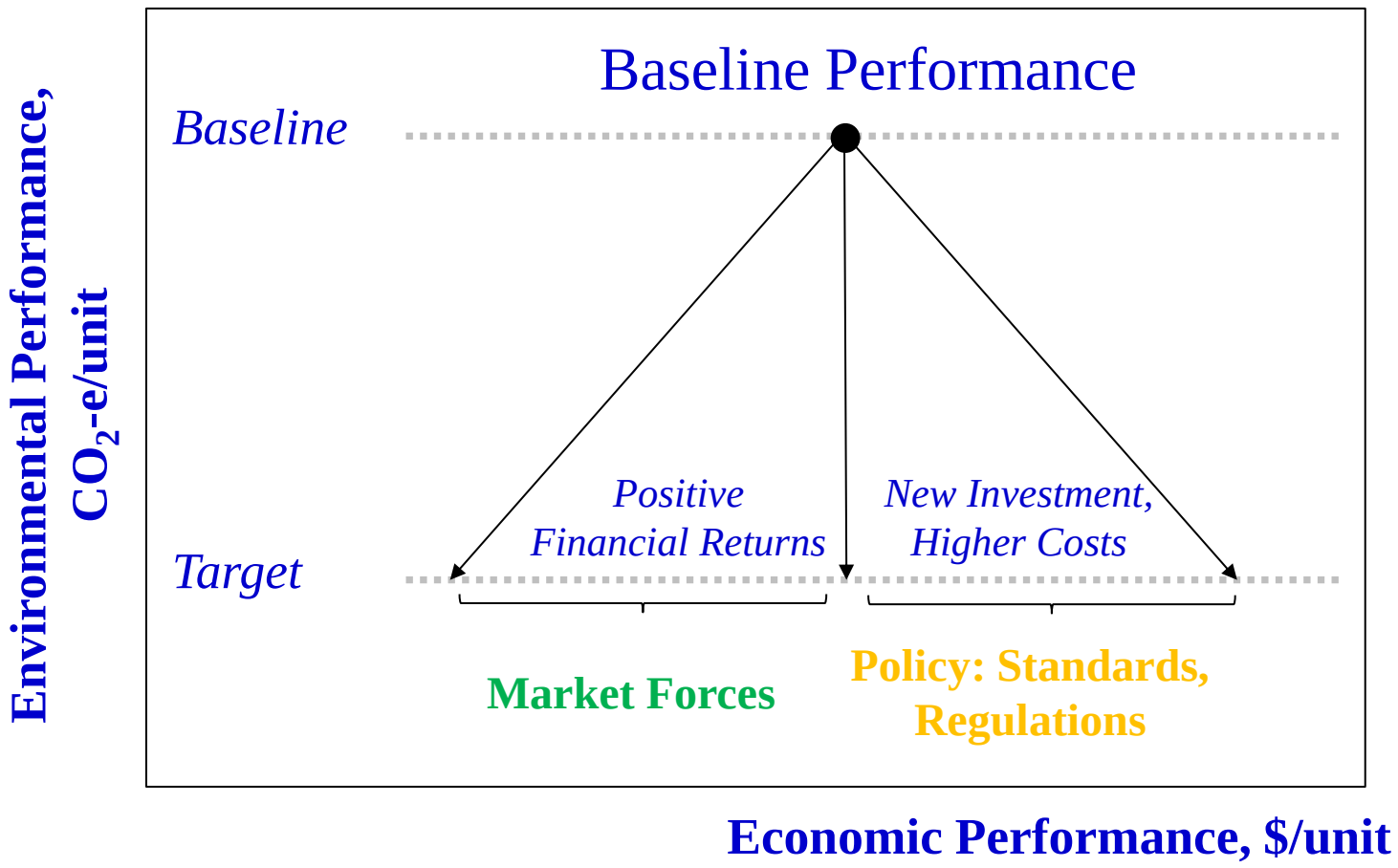
Given Goals – Combinations of Investment, Innovation, and Policy Required to Achieve

Cost of Electricity vs. Life Cycle Carbon Emissions

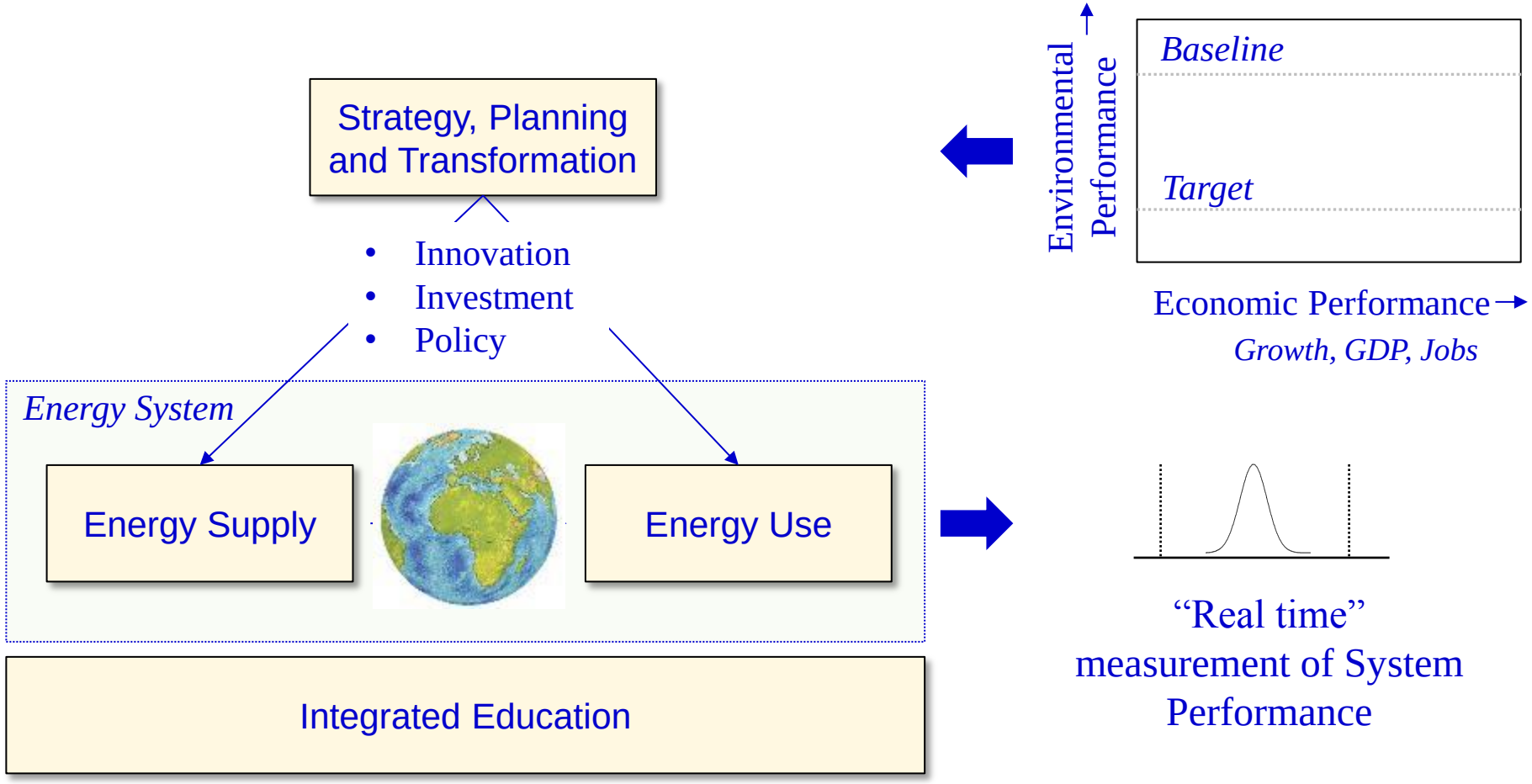


Sources:
-Cost Information: EIA AEO2016 Levelized Costs, August 2016
-Life Cycle Carbon: Data from 2015 NETL Life Cycle Analysis Presentation at June EIA Energy Conference

Environmental x Economic Performance

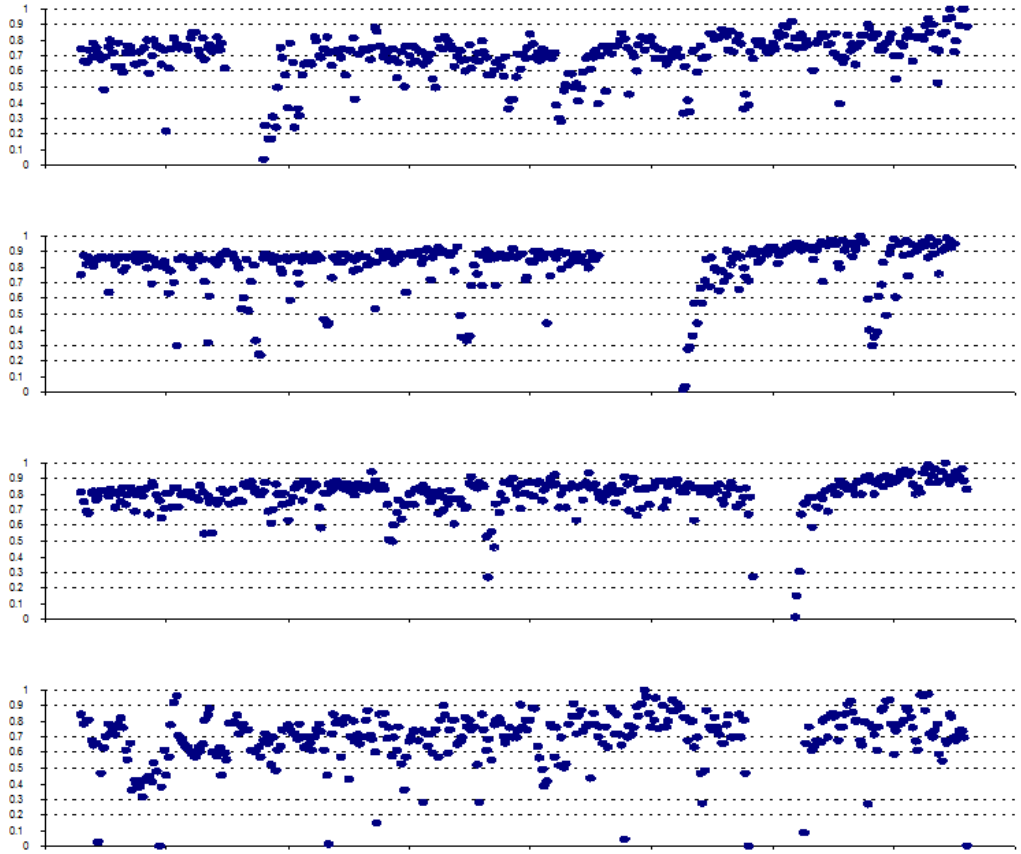


Enabling Energy System Transformation



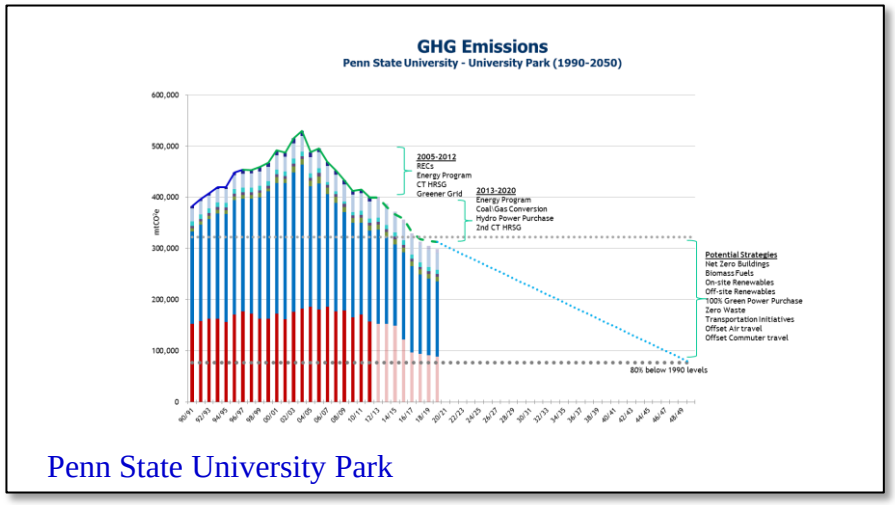
- Output measurements - system performance and progress
- Strategy Planning - Options & Trade-offs
- Innovation – Across Energy Value Chain
- Education – Common accessible education, all stakeholders

Global Process Improvement Example

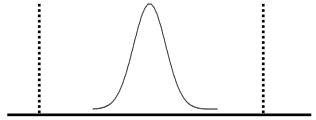


- Process Entitlement, shift / control
- Normalized results, asset benchmarking
- Innovation – step change performance

“Real time” Environmental Performance



Penn State University Park



Real Time CO2-e Output
Measurement, Life Cycle Basis

Concept:

- Real-time measurements of CO_2-e to measure performance, cloud hosted.
- Prioritization, benchmarking, translation and new innovation design
- Phase 1: University network to design and implement and engage local stakeholders

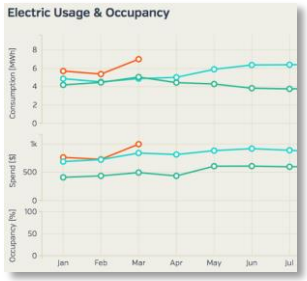
Goals:

- Real-time CO_2-emissions measurements - online, cloud hosted
- Energy transformation process – common approach, local team implementation
- Education - project based learning supported by shared online content
- Innovation – new design concepts, evaluation, sharing

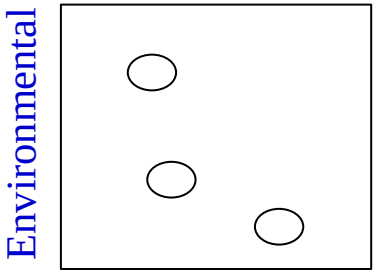
Penn State – Spring 2016 Student Projects

Measurements

Analysis



Benchmarking



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

Penn State

Company N

City A

University B

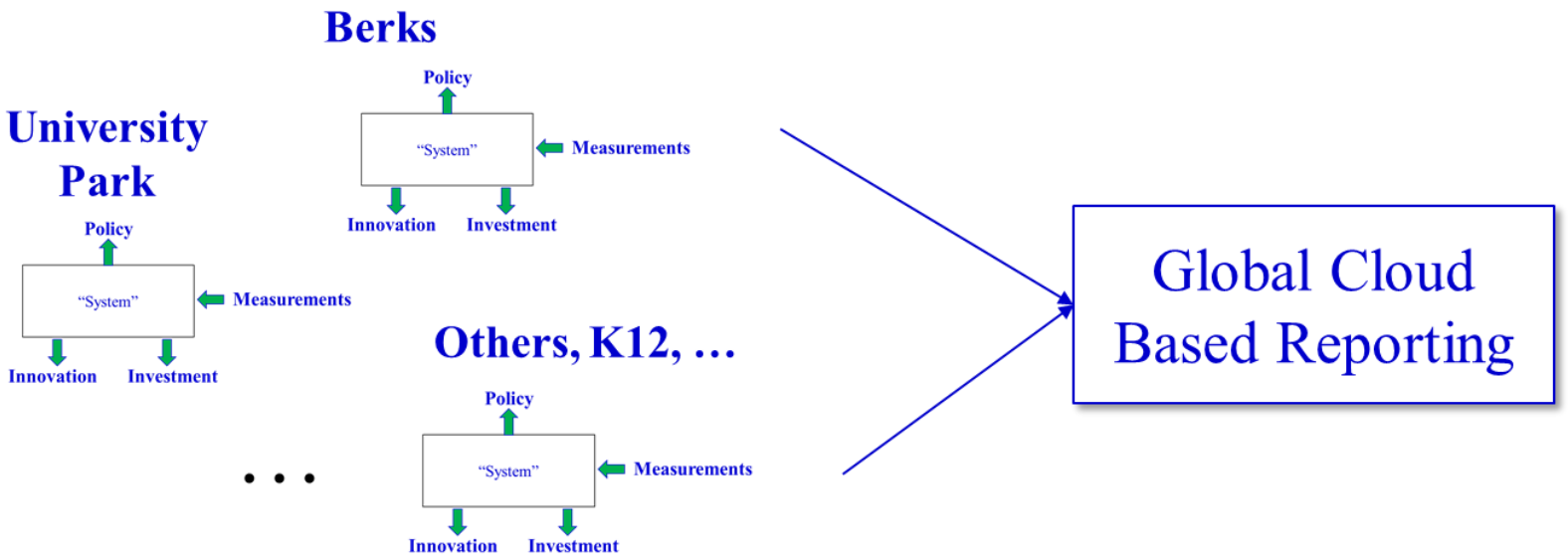
University A

. . .

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

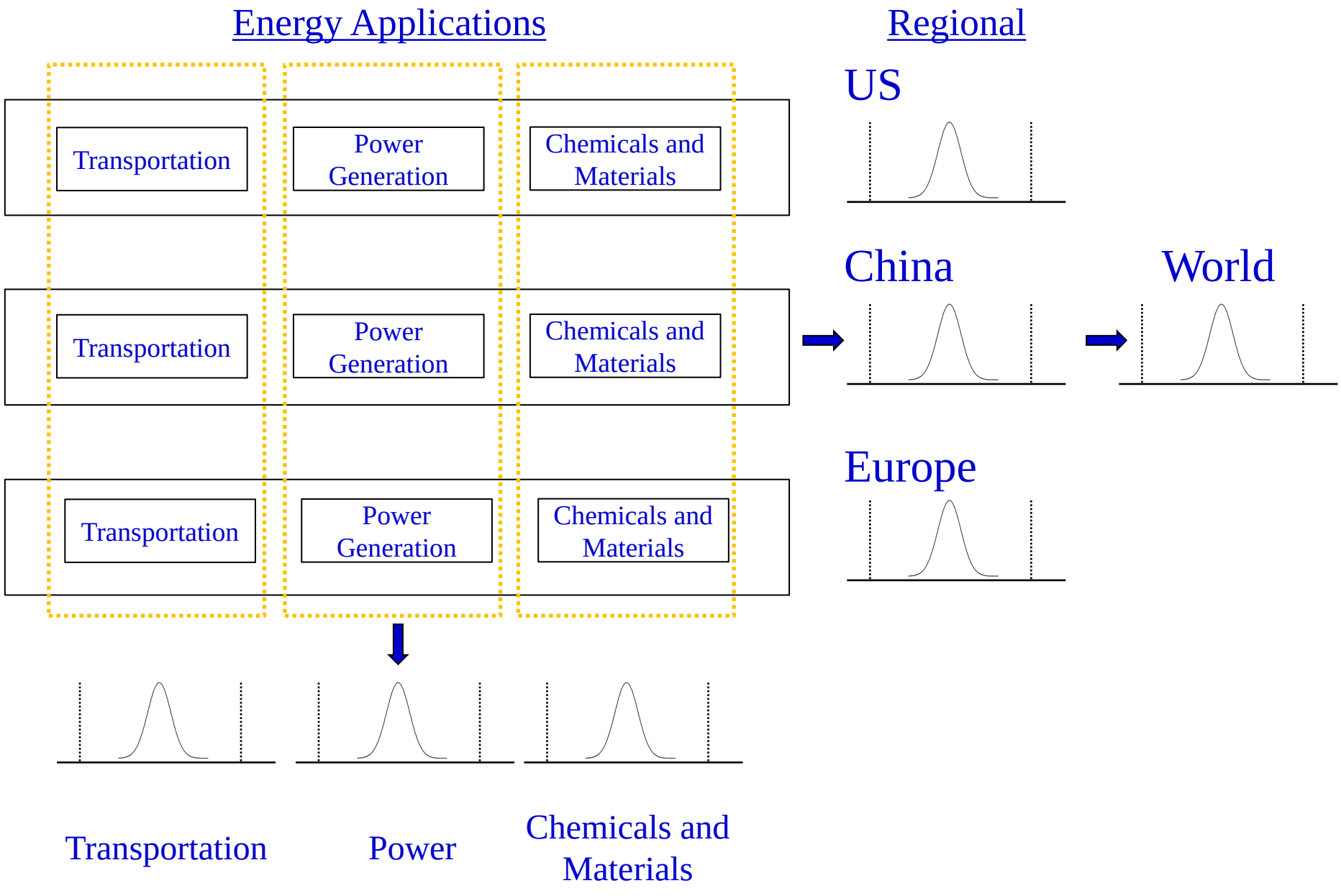
https://lucidconnects.com/
http://www.energycap.com/
http://energyhippo.com/

Real-Time Measurements .. Start with Universities

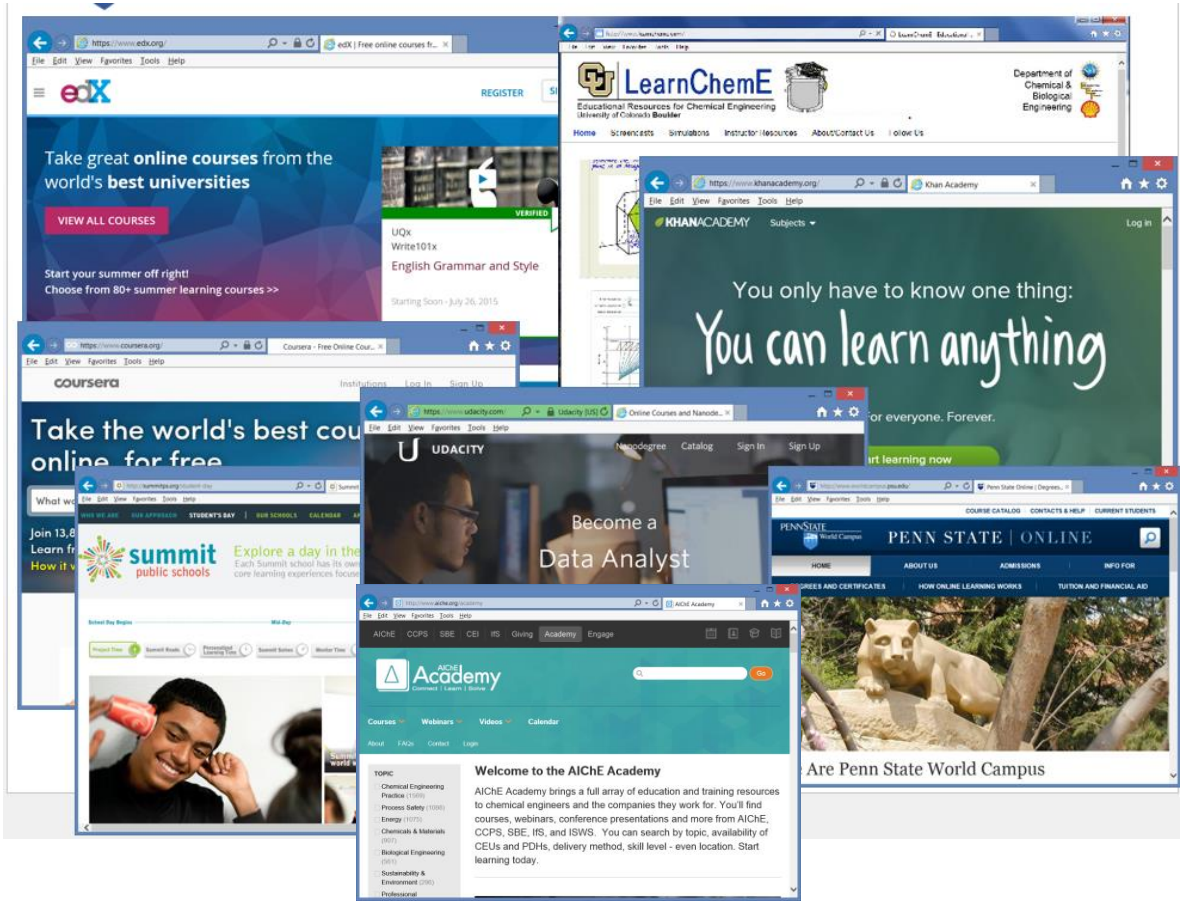


- An Energy System can be a campus, a city, a company, a state, a country, …
- Local energy system improvements with consistent output measurements
- Build to a long term global real-time measurement system

Translation to Global Energy – Life Cycle Basis



Integrated Education



Use Education Technology to Build New Business Process for Collaboration, Accelerating Innovation and Education

Summary

- Focus on Solutions - Global Energy System Transformation Process
- Visible - “Real-time” Visible Performance Measurements
- Engagement - University, Government, Public, Private Partnership
- Innovation - Global practices, Sharing and Translation
- Education - Best content, Global and Accessible

Looking for Partners to Design and Implement

PennState

Thank You!