The Opportunity of Global Nuclear Innovation

Prof. Rachel Slaybaugh

12 April, 2016

Japan Atomic Industrial Forum

Tokyo, Japan

Berkeley
UNIVERSITY OF CALIFORNIA

"…in 2012 around 7 million people died
– **one in eight of total global deaths** –
as a result of air pollution exposure."
– World Health Organization

https://storify.com/ucirvine/made-in-china-air-pollution-as-well-as-exports

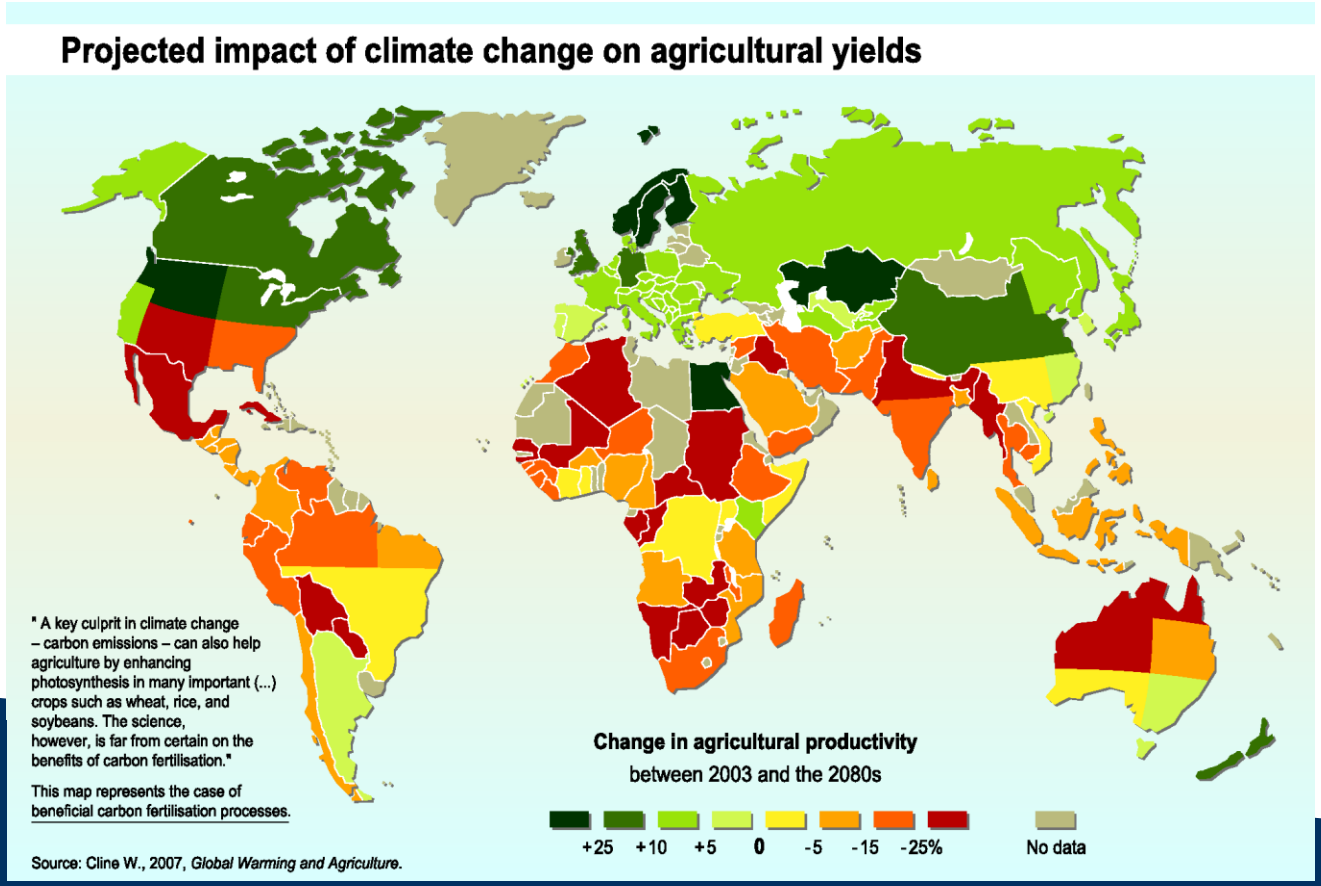
1.2 billion people lack access to electricity;
2.7 billion people lack clean cooking facilities
– International Energy Agency

http://www.thestar.com/news/world/2013/07/22/how_electricity_has_the_power_to_transform_the_lives_of_girls_around_the_world.html

Berkeley
UNIVERSITY OF CALIFORNIA

"…climate change represents **an urgent and potentially irreversible threat to human societies and the planet** and thus requires the widest possible cooperation by all countries…"

– COP21 Agreement



Environment, Health, Prosperity

How do we help the world develop **sustainably**?

http://www.insidesources.com/wp-content/uploads/2015/11/bigstock-Energy-4298515-300x300.jpg

Global Nuclear Innovation

- The world is concerned with a lot of big things
- Nuclear energy can be an important part of a suite of solutions
- Our current model doesn't work as well as we'd like
- There are ways that our model could work better
- There are new opportunities for action
- We can build structures to capitalize on and expand those opportunities
- To be a better world

We *Need* Cleaner Energy

- Nuclear's lifecycle emits very little CO_2 or air pollution

g CO_2 eq /KWh	Solar (PV / CSP)	Wind	Nuclear	Coal	Natural Gas
Min	5 / 7	2	1	675	290
Max	271 / 89	220	220	1689	930

- Nuclear energy is an important component, it
  - Exists and is large scale
  - Is reliable / always on
  - Uses little land
  - Can be an economic boon

http://srren.ipcc-wg3.de/report/IPCC_SRREN_Annex_II.pdf

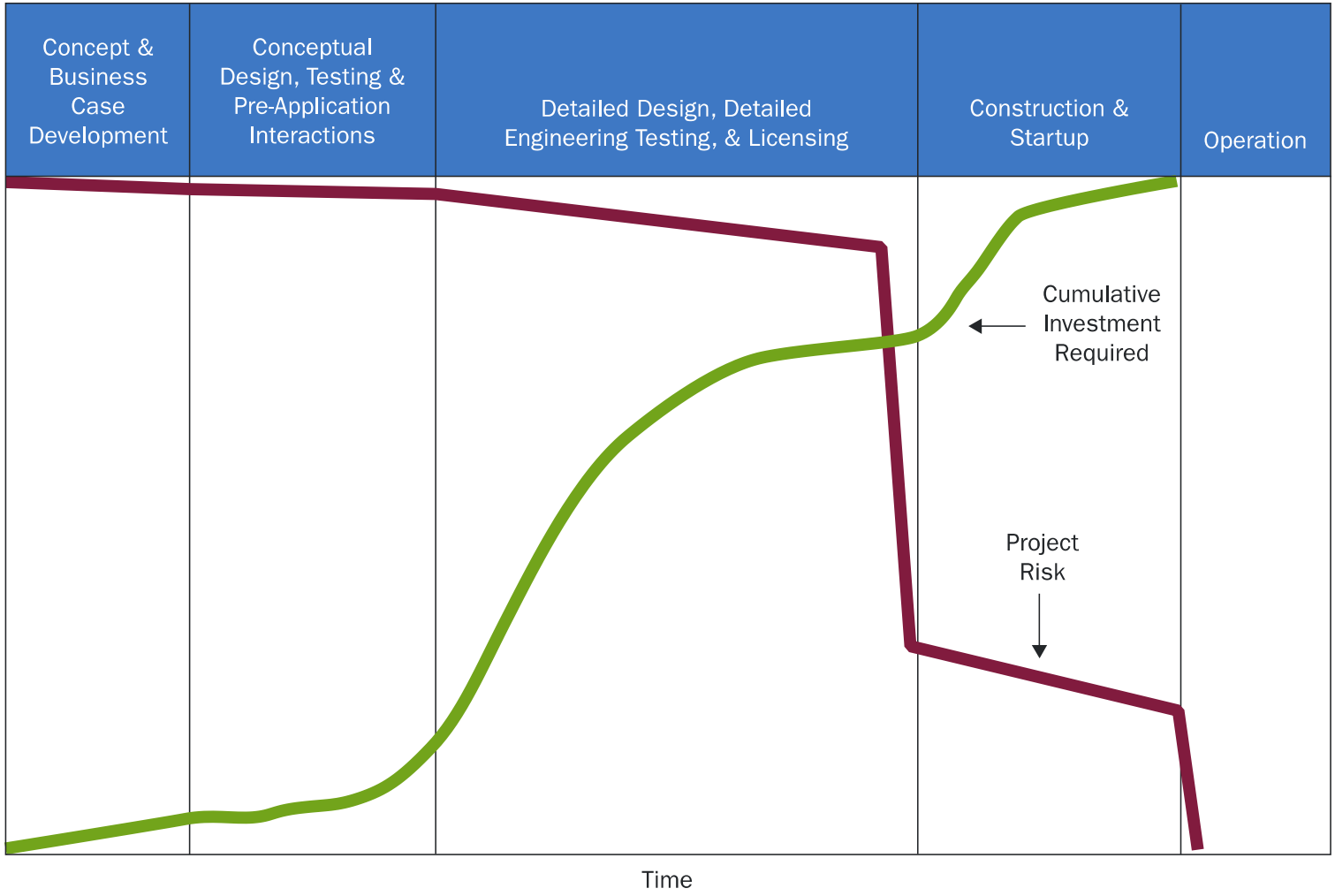
What's Not Working?

…But it's not perfect

- Rate of change
- Poor public communication
- Small range of products
- Innovative mindset?
- Economic viability
- Capital intensity
- Used fuel and waste / long-term fuel supply
- Safety and security

We must *shift* **how we think** about nuclear energy and nuclear innovation

Why Isn't it Working?
Financial Risk



Why Isn't it Working?
Communication and Understanding

Lack of trust; little public understanding of risk; insufficient discussion about risk

Impacts cost, policy, career choice, viability…

Residual bad will from original program secrecy

Also impacts public health in underappreciated way

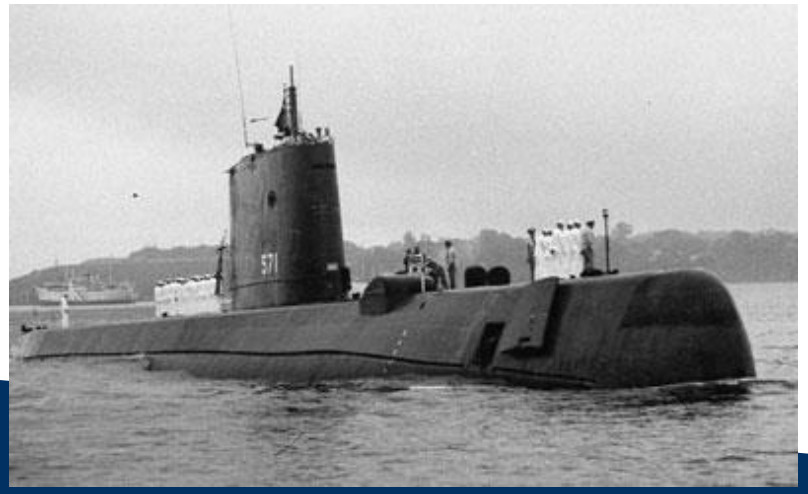
- Three Mile Island
  - Some increase in stress-related health effects [1]
- Chernobyl
  - Significant increase in stress-related health effects [2]
- Fukushima
  - ~1 600 deaths from stress of evacuation [3]

Berkeley
UNIVERSITY OF CALIFORNIA

[1] Baum, Andrew et al. (1983). Emotional, Behavioral, and Physiological Effects of Chronic Stress at Three Mile Island. *Journal of Consulting and Clinical Psychology, 51 (4),* 565-572.
[2] Cwikel, J. et al. (1997).Two-year Follow-up Study of Stress-related Disorders among Immigrants to Israel from the Chernobyl Area. *Environmental Health Perspectives, 105 (6),* 1545-1550.
[3] http://www.nytimes.com/2015/09/22/science/when-radiation-isnt-the-real-risk.html?_r=0

Why Isn't it Working?
Drivers and Regulatory Models

- In other fields, profit motivates innovation
- In nuclear, profit is anti-aligned with big changes
- We were innovative when motivated
- Innovation drivers have lessened
- Lost place to have failures; lost mindset



http://science.howstuffworks.com/nuclear-submarine3.htm

New Motivations Could Change the Game

Environment

Health

Prosperity

What Could Nuclear Innovation Look Like?

What If?

- National and international scientific resources are leveraged

https://www.olcf.ornl.gov/titan/

https://www.jaea.go.jp/english/04/ntokai/kasokuki/kasokuki_02.html

What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available

What If?

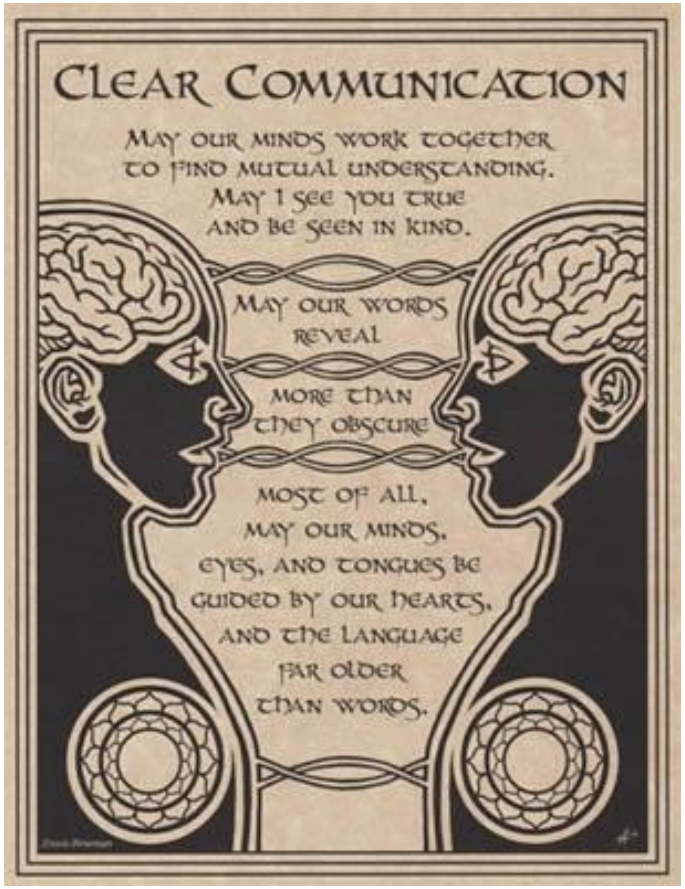
- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible

What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible
- Policy supports global cooperation and market health

What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible
- Policy supports global cooperation and market health
- Communication is clear



http://adviceyouneed.net/2014/08/12/the-lost-art-of-communication/

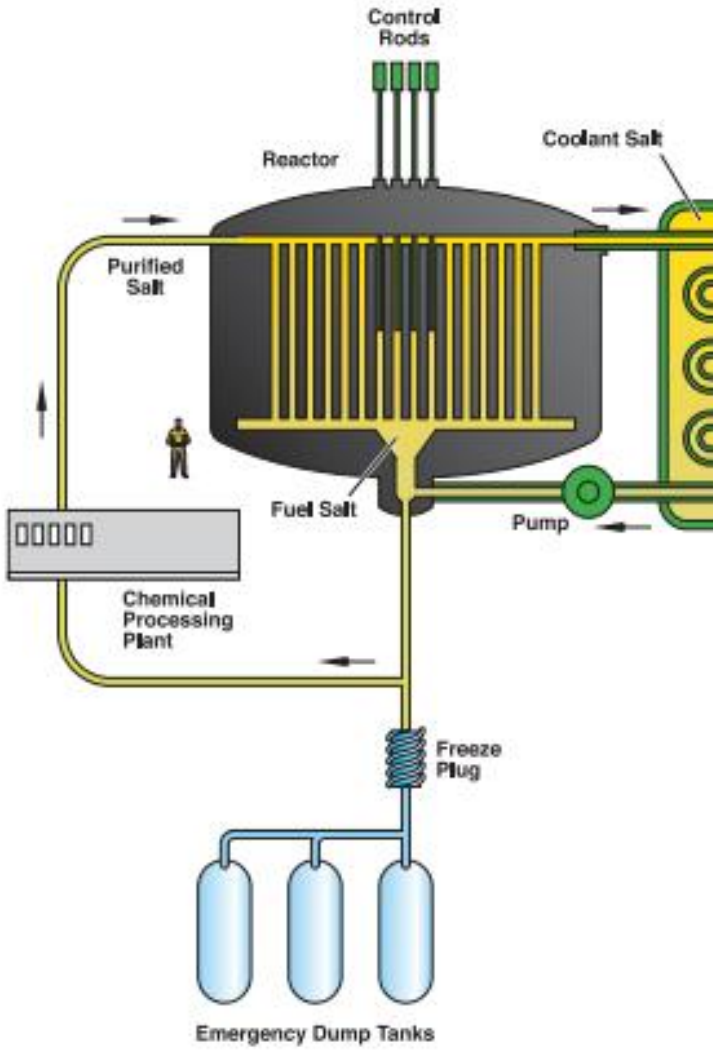
What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible
- Policy supports global cooperation and market health
- Communication is clear
- Technology needs are met

http://physicsworld.com/cws/article/news/2011/jul/01/testing-nuclear-materials-on-the-nanoscale

What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible
- Policy supports global cooperation and market health
- Communication is clear
- Technology needs are met
- Big improvements become viable



What If?

- National and international scientific resources are leveraged
- An inspired, innovative workforce is available
- Regulation is fast and responsible
- Policy supports global cooperation and market health
- Communication is clear
- Technology needs are met
- Big improvements become viable

Companies are rewarded for making the world better

The World Thrives

But **how** do we get there?

Examples of Broader Motivation

http://www.gatesfoundation.org/What-We-Do/Global-Health/Malaria

Breakout Labs

NA

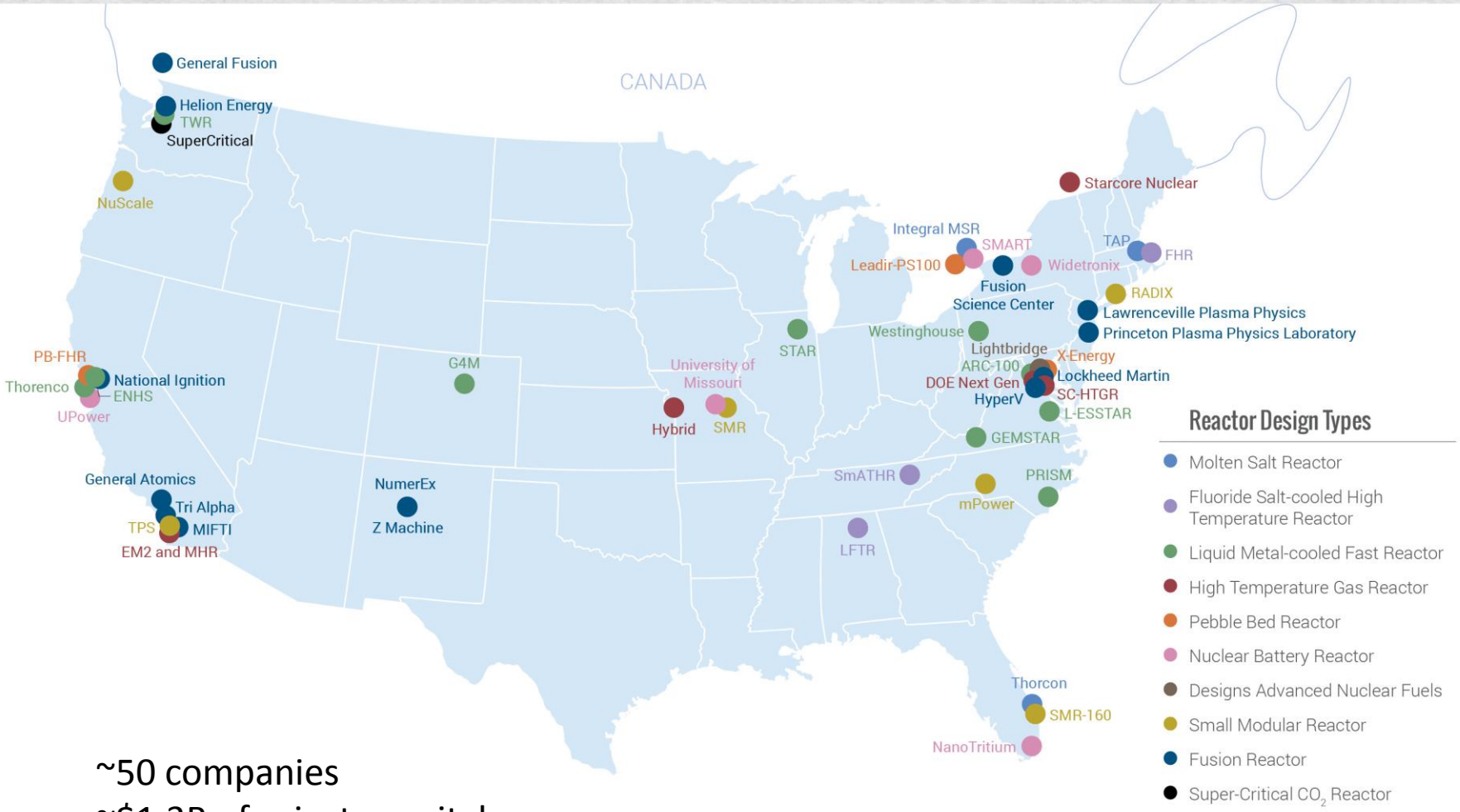
Y Research

YCR is a non-profit research lab.

http://www.mission-innovation.net/

Berkeley
UNIVERSITY OF CALIFORNIA

Introducing the Advanced Nuclear Industry

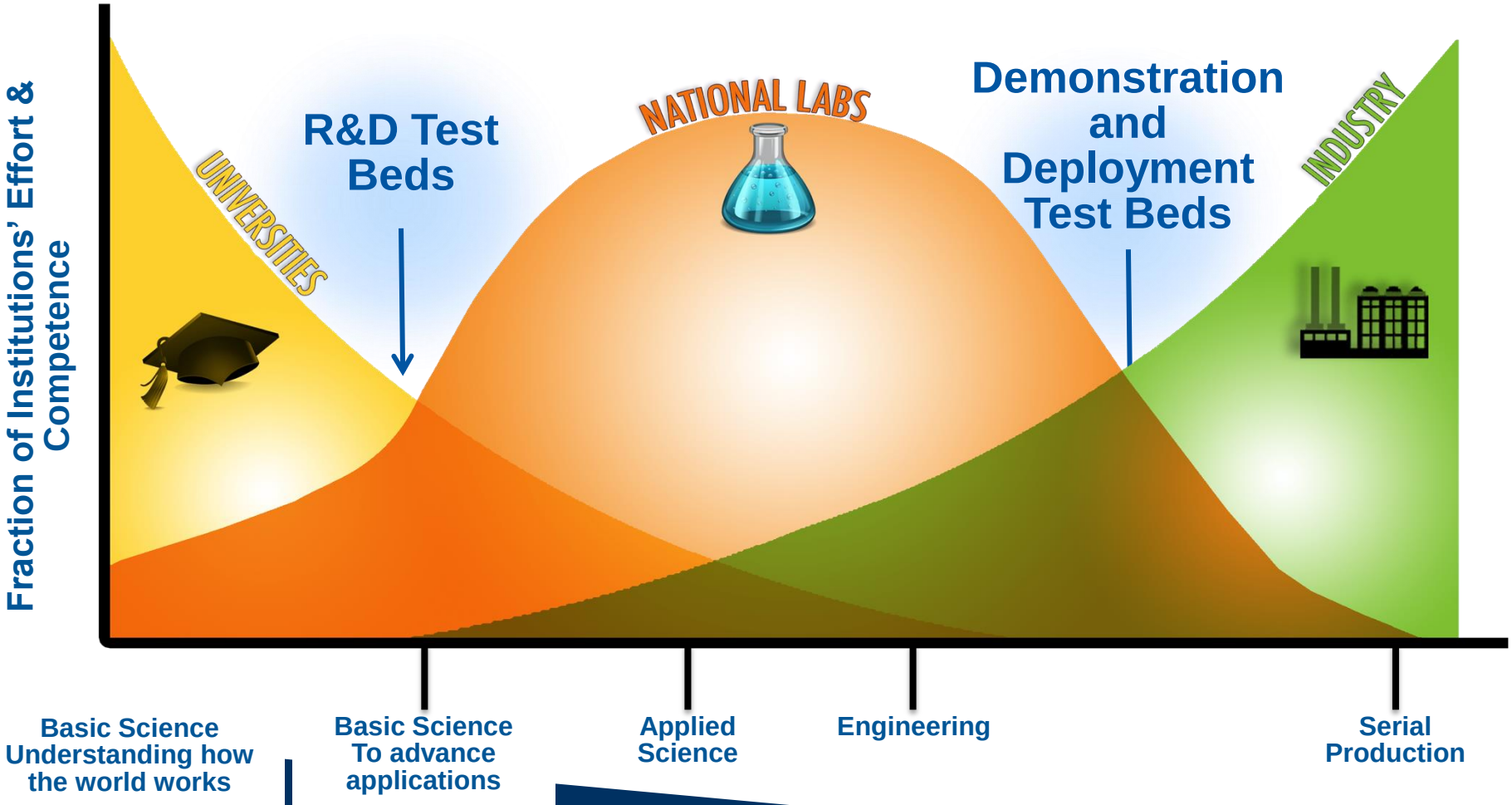


~50 companies

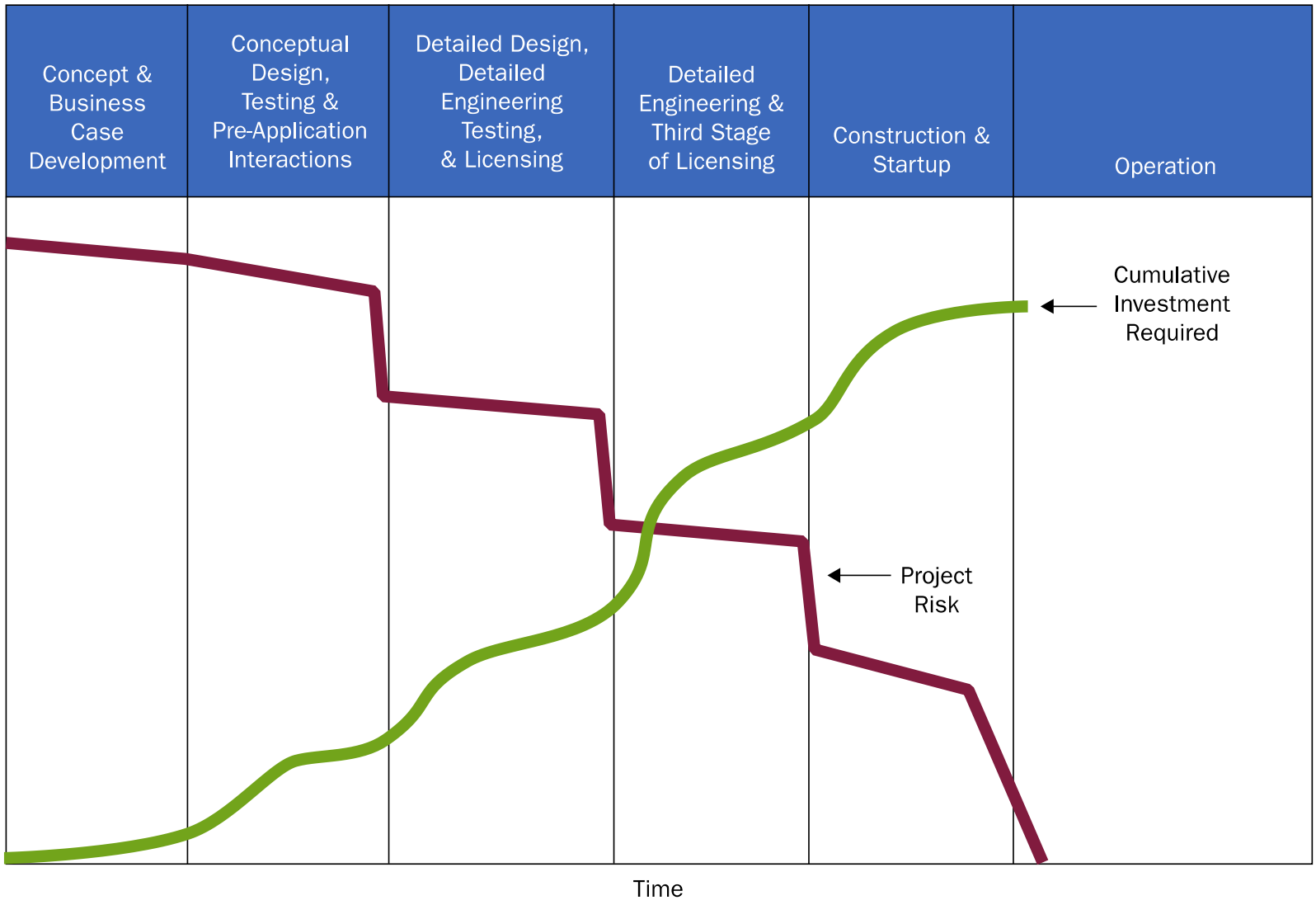
~$1.3B of private capital

third way
fresh thinking

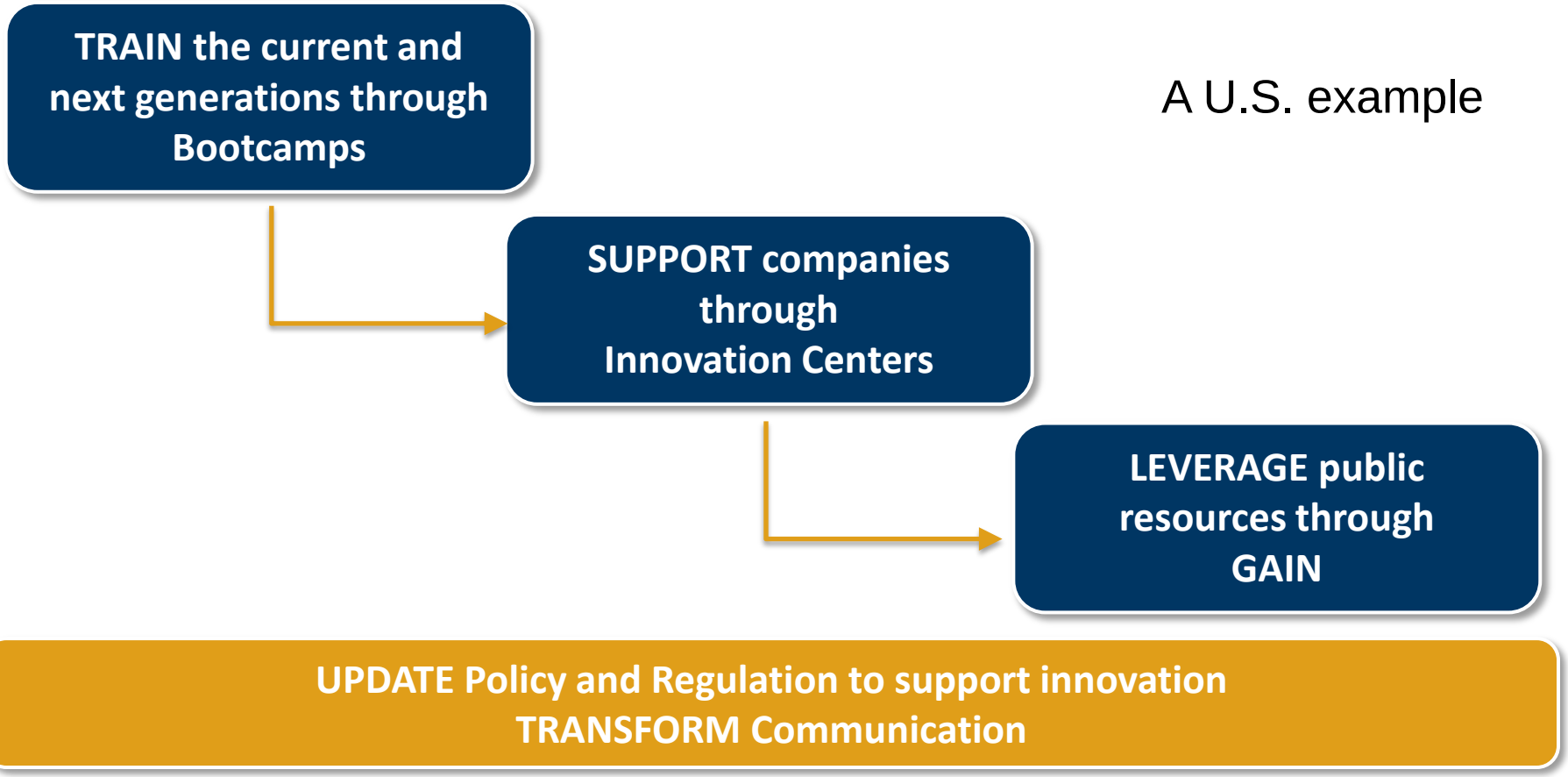
Bridge the "Valleys of Death"



Shift the Curve



Build A Pipeline



A U.S. example

Nuclear Innovation Alliance

- The NIA's mission is to lead advanced nuclear energy innovation by addressing:
  - Regulatory Pathways
  - Testing and Development
  - International Cooperation
  - Financial Support
- Assemble companies, investors, experts, stakeholders, students
- Find ways to bring new ideas to market more efficiently

GAIN: Public-Private Leverage

GAIN
Gateway for Accelerated Innovation in Nuclear

New DOE-NE Initiative within the Clean Energy Initiative

Integrated institute managing a distributed test-bed and demonstration platform, dedication to innovation in Nuclear Energy

Public-private partnership including Industry, Entrepreneurs, National Laboratories, and Academia

Headquartered at the Idaho National Laboratory

- Tens of $B in DOE and partner assets (experimental and computational)
- More than $1M in yearly investments for R&D and infrastructure
- $12.5B in loan guarantees
- $10M in SB vouchers
- Expertise and intellectual infrastructure

Innovation Centers

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulator

GAIN

Test Bed

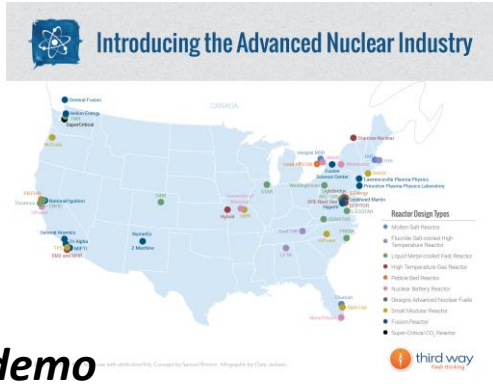
Key Physical Capability

Core Innovation
(Reactor Concept, Fuel, Communications, Regulation)

Key Intellectual Capability

Investment Community

Developers



- Seeded with Federal Funds
- Fungibility of Staff to Core Institutions
- Aggressive Innovation

- ***Can have Centers at early innovation and at demo***

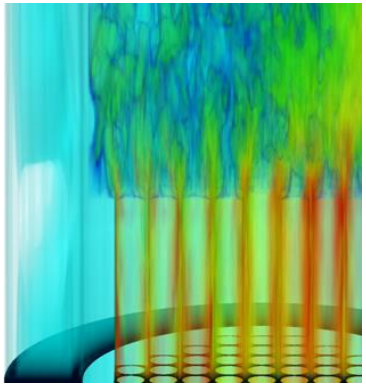
Nuclear Innovation Bootcamp

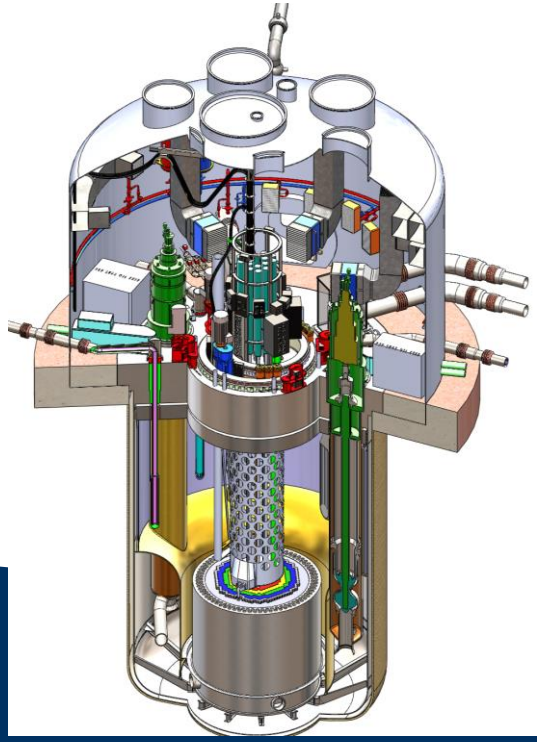
http://www.nuclearinnovationalliance.org/bootcamp

- Teach students *how* to innovate:
  - Entrepreneurship
  - Nuclear aspects
  - Non-traditional material
- Two week pilot program August 1-12
- Team design projects
  - Teams have non-technical member
- Large company involvement
- Experts teach and mentor
- Judged completion

Nuclear Innovation Bootcamp

- Full program Summer 2017
- Deeper content
- Expand to include professionals





Berkeley
UNIVERSITY OF CALIFORNIA

Nuclear Innovation Pipeline

- Goal: reduce the non-technical barriers while enabling technical breakthroughs

- Global participation; expand model
- Beyond GAIN: need a coordinated interagency (U.S.) and international strategy for global deployment

Global Nuclear Innovation

Now is the time

Motivated by Global Health, Prosperity, and Environment, we have the opportunity to **reinvent** the way we do things

What do we want the world to look like?

Thank You

Acknowledgements

- Nuclear Innovation Alliance
- Third Way
- UC Berkeley
- Department of Energy
- Idaho National Laboratory
- Sutardja Center for Entrepreneurship
- MIT
- University of Wisconsin
- Cyclotron Road
- Google
- Southern Company
- Transatomic
- TerraPower
- Venrock
- Lightbridge
- Advanced Reactor Concepts
- General Fusion
- Exelon
- INPO