EXPENSIVE ENERGY IS NOT ENOUGH: A TECHNOLOGY SUPPLY- SIDE APPROACH TO U.S. ENERGY POLICY

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America's Addiction to Fossil Fuels Entails:

- **Huge Environmental Costs**
- **Huge Economic Costs**
- **Huge Geopolitical Costs**

"There is high agreement and much evidence that .. stabilization can be achieved by deployment of technologies that are either currently available or expected to be commercialized in coming decades, *assuming appropriate and effective incentives .. for their development, acquisition, deployment and diffusion and addressing related barriers* (our ital.)."

-- IPCC Synthesis Report, 2007

Our Proposal Addresses the Italicized Assumption

A Major Federal R&D Program To Stimulate Innovation In Energy Technology is Justifiable, Essential and Urgent

- Conservation Measures Using Existing Technology will not Compensate for Future Increased Energy Use by China, India and Other Expanding Economies
- Few of the Needed Technologies are Technically or Economically Ready for Deployment on the Huge Scale Necessary
- Market Incentives, When They Are Put In Place, Will Induce Needed Innovations Too Slowly to Meet the Urgent Need

Such a Program Should Involve Very Large Public Investments:

- **Approaching the dimensions of a major military transformation**
- **Achieving the size and scope (but NOT the form) of the Manhattan Project or the Apollo Mission**
  - **These were Unified Projects Seeking a Single Product for a Single Customer**
  - **Energy Involves Multiple Technologies, Multiple End-Uses, Multiple Sectors, Multiple Customers, Multiple Time Horizons – a Vastly More Complex Innovation System**

Its Operations Should

- **Go beyond research and development to include other aspects of the innovation process**
- **Encompass a wide range of technology**
  - ***Many Energy Choices are Needed***
  - ***There is NO SILVER BULLET***
- **Spur and Support the private sector**
- **Be technology neutral as far as possible, consistent with the need for measures to overcome obstacles specific to particular technologies**
  - **As opposed to the current lobbyist free-for-all**

Macro, Demand-Side Policies (like Carbon Tax, Cap-and-Trade) are Needed – But are Unlikely to be Enacted Soon

Supply-Side Measures are Needed to Complement Demand Side Measures

- **Imperfections in the Market for Technology Require Public Intervention**
- **Incumbent Technologies are Strongly Entrenched and Heavily Subsidized**
- **Consumer Attitudes Mitigate the Effects of Demand-Side Measures**
  - **Cars are Purchased for Power and Style**
  - **Conservation Investments Require Quick Payoff**

Most Importantly, Energy is Far from a Level Playing Field

- **Government Subsidies to Fossil Fuels *(1950-2003*) Amount to**
  - **oil: $300 billion (close to 50% of total federal subsidies)**
  - **Gas: $90 billion (12% of total subsidies)**
  - **Coal: $90 billion (12% of total subsidies)**
  - **Contrast: Renewables - 7% of total subsidies**
    - **(Bezdek & Wedling, Issues in S&T Spr.06)**
- **Energy Innovation Will Not Provide New Functionality - New Technology Lands in 'Occupied Territory'**

So Innovation will not Respond Quickly to High Energy Prices

We Need Not Wait to Begin on the Supply Side

- **Political Barriers to Supply-Side Measures are Likely to be Much Lower**
- **Supply and Demand-Side Measures Can Proceed in Parallel Whenever Demand-Side Measures are Adopted**

A Tough, Multi-Dimensional Challenge

- **The Needed Investments are on a Huge Scale**
- **Many Technologies will be Needed:**
  - **Both Radical and Incremental Technologies**
  - **Some Now, Some Much Later**
  - **Many Generations will Evolve over Decades.** ***AVOID LOCK-IN***

The Private Sector Must Lead in Energy Innovation . . .

- ***Only the Private Sector Can Launch New Technologies***
- **Government Can Stimulate Innovation in <u>Partnership</u> with Industry**
- **Government "Industrial Policy" Won't Work**
  - **[in the political sense that 'government is doing it, private sector get out of the way']**
- **Neither will 'Command and Control'**

. . . But . . .

- **Both Public and Private R&D are Down Sharply Since 1980**
- **The Recent "Flood" of Venture Capital (Only *$2.5 Billion in a $1.5 TRILLION Energy Market*) Goes to Subsidized 'Magic Bullets' like Corn Ethanol**

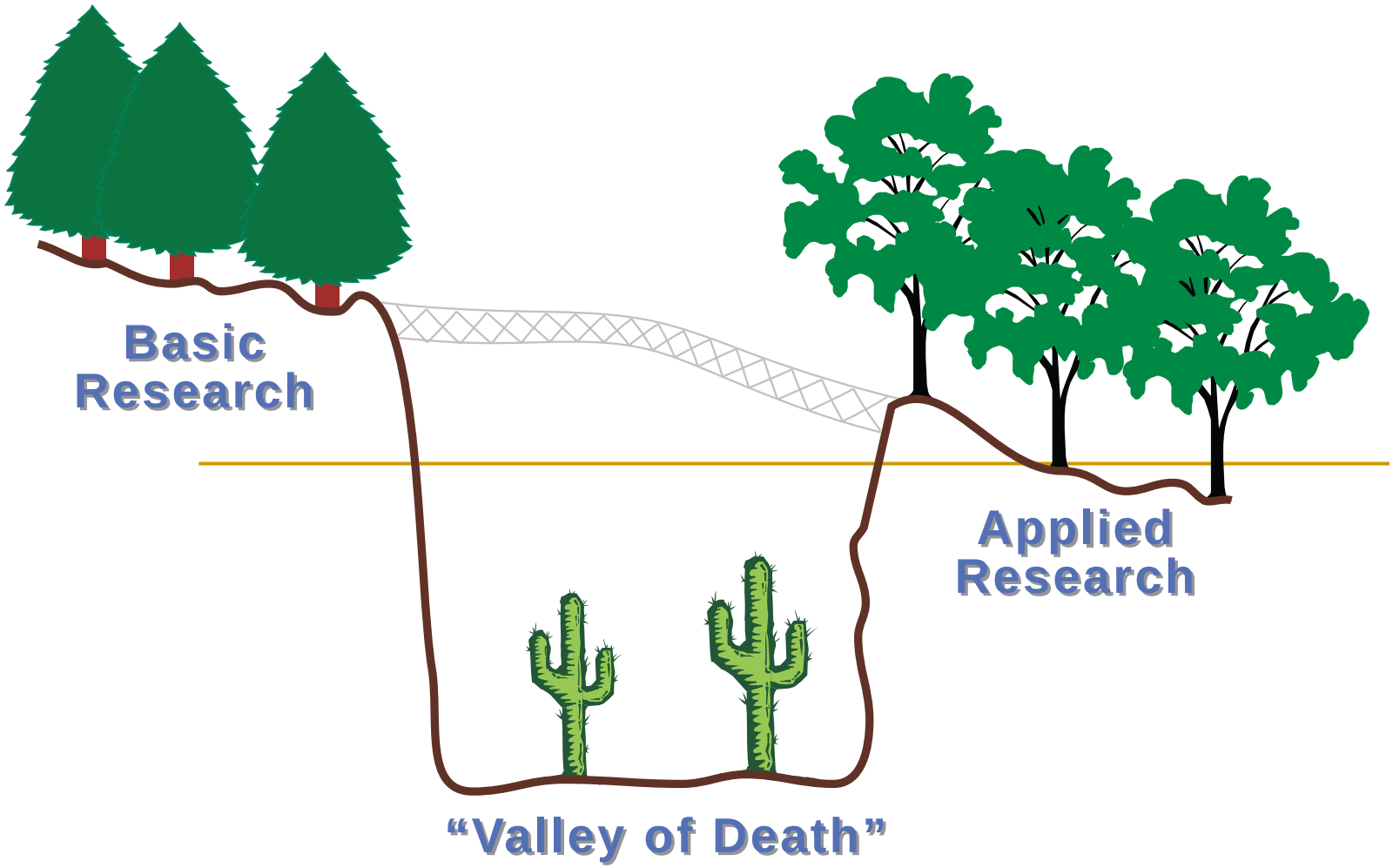
Government Intervention in the Development and Launch of Key 'Enabling' Innovations is of Long Standing

- **Historically though the defense technology sector, especially in Information Technology –**
- **Military Support Helped Launch five major 20th Century Technology Waves: (Ruttan)**
  - **Aircraft, Nuclear Energy, Computing, Space, and the Internet**
- **But Military Involvement in Energy is Limited and Specific, so Energy will Require Support from Civilian Budgets**

Bridging the 'Valley of Death' between Research and Innovation is the Critical Bottleneck around which to Design Policy Instruments

Launch Paths -- and Hence Policy Instruments -- will Differ from Technology to Technology

The Valley Of Death



Hence the Need for a New Analytic Framework

- 1. Classify Energy Technologies According to their Likely Launch Pathways
- 2. Match Policy Packages to Pathways of Technology Launch
- 3. Plug Gaps Between Existing Institutions for Stimulating Innovation in Energy Technology

Step One: We Have Classified 12 Major Energy Technologies According to their Likely Launch Pathways

Objective: Encourage Innovation in an Entire Class of Technologies and Avoid Favoring One Technology over Another (Technology Neutrality)

Energy Tech Launch Categories (1)

- **1. Experimental technologies requiring long-term research**
  - **Examples: Fusion, Hydrogen Fuel Cells**
- **2. Disruptive innovations that can be launched in niche markets where they are competitive, and achieve gradual scale-up building from this base.**
  - **Examples: Solar PV's and wind for off-grid power**

Technology Launch Categories (2)

- **3. Secondary innovations - uncontested launch: components in larger systems that face immediate market competition based on price, but are acceptable to the system manufacturer.**
  - **Examples: Batteries for Plug-in Hybrids, Enhanced Geothermal**
- **4. Component innovations - contested launch: secondary, component innovations having inherent cost disadvantages and facing political and economic efforts by incumbents to block their introduction.**
  - **Examples: Carbon Capture and Sequestration, Biofuels, Nuclear Power**

Technology Launch Categories (3)

- **5. Incremental advances in conservation and end-use efficiency.**
  Examples: improved IC engines, Building Technologies, Appliance Standards
- **6. Advances in manufacturing technology and scale-up of manufacturing for all types of energy technology so as to drive down production costs.**

Step Two: We Have Matched Policy Packages To Pathways Of Technology Launch

- **Policy packages should apply across new technologies to create technology neutrality as much as possible**
  - **Differential policies for each technology could jeopardize optimal advance**
- **Drop back-end incentives in most cases if macro demand-side policy passes**
  - **Front end incentives are easiest politically, while back end mandates are hardest**

Policy Packages for Promoting Energy Innovation (1)

- **(1) *Front End Support* *to research, development, prototyping and demonstration:***
  - **For all technologies**
  - **Examples – direct support to R, D, P & D), public-private R&D partnerships, monetary prizes to individual inventors and innovative companies, and support for technical education and training**
- **(2) *Back End Incentives* (carrots) to encourage technology deployment:**
  - **For secondary (component) technologies**
  - **Examples - tax credits for new energy technology products, loan guarantees, price guarantees, government procurement programs, new product buy-down programs**

Policy Packages for Promoting Energy Innovation (2)

- **(3) *Back End Regulatory and Related Mandates* (sticks):**
  - **For secondary technologies - contested launch**
  - **Prospect of political battles since launch will be contested**
  - **Examples: standards for particular energy technologies in building, construction, and comparable sectors, renewable portfolio standards, fuel economy standards, emissions taxes, general and technology-specific intellectual property policies.**

Step Three: Plugging The Gaps Between Existing Institutions Promoting Energy Innovation

Gaps in Existing Supports to Energy Innovation

- **"Front-End"**
  - **Translating Research into Innovation**
  - **Carefully Monitored Demonstrations of Engineering-Intensive Technologies (Carbon Sequestration, Biofuel Processing)**
  - **Improved Manufacturing Processes**
  - **Manufacturing Scale-Up**
- **"Back-End"**
  - **Installation of Conservation Technology**
- **"Roadmapping"**

We Propose to Fill the Gaps with the Establishment and Funding of:

- **1) *ARPA-E*: A translational R&D entity**
- **2) A *wholly-owned gov't corporation* to:**
  - **Share the financing of carefully monitored demonstrations of large engineering projects**
  - **Encourage and incentivize industry consortia to cut costs of manufacturing technologies and processes**
  - **Speed the scale-up of manufacturing production capacity**
  - **Finance installation of conservation, efficiency and related new technologies in residential and commercial markets**
- **3) *A Think-Tank* to develop a detailed "roadmap" for the requirements for the development and launch of particular energy-related innovations, and to recommend policies to facilitate them**

(1) The ARPA-E model for translational research -

- **Right-Left: identify challenge on the 'right side' of the pipeline and then nurture the science breakthrough on the 'left side' to get there**
- **Move from breakthrough to innovation**
- **Hybrid model blends university researchers with startups and smaller firms**
- **Small, flexible, flat, non-hierarchical, collaborative networks, with turnover, risk-taking culture, and great talent**

(1) The ARPA-E model for translational research (cont'd)

- **Needs research funding at a scale to make a difference**
- **Powerful competitors within DOE**
- **Hence the need for an Island-Bridge model:**
  - **An "ISLAND" FREE FROM BUREAUCRATIC STRESSES AND PRESSURES**
  - **But with a BRIDGE BACK TO THE DECISIONMAKERS WHO CAN IMPLEMENT ITS DISCOVERIES**

(2) The Government Corporation

- **Helps assure commercial involvement and projects that meet commercial standards (unlike a gov't bureaucracy)**
- **Insulates demonstrations from Congressional interference**
- **Draws talent from the commercial and financial sectors and compensates them accordingly - not a gov’t bureaucracy**

(2) The Government Corporation (cont'd)

- **Promotes industry consortia to cut manufacturing costs through process improvements (SEMATECH Model)**
- **Supports Financing to Speed Production Scale-Up beyond what would happen with private incentives**
- **Enhances the flow of credit to conservation, efficiency and related new technologies in residential and commercial markets.**
  - **Government Sponsored Enterprise [GSE] Model, like 'Fannie Mae'**

(3) The Roadmapping Think Tank

- **Should be tied to industry consortia, with access to private, academic, and public sector expert leaders on energy technologies (SEMATECH Model)**
- **Assesses technologies to identify areas of needed pre-competitive research and likely obstacles to launch**
- **Develops common packages of "Back End" incentives for groups of technologies so as to help promote technology neutrality**

SUMMARY: A NEW CONCEPTUAL FRAMEWORK FOR COMPLEX SYSTEMS INNOVATION

- **Energy Innovation requires an effort to launch multiple generations of technology into a complex system**
- **Multiple technologies are required, to be launched into a multitude of established private sector markets**

A Three Step Analysis:

- **1. *Launch Pathways:* Group technologies to be implemented into categories based on launch characteristics**
- **2. *Policy Packages:* Use these launch pathways to guide federal innovation policy roles:**
  - **Technology Nurturing: R&D, P&D (Prototyping and Development)**
  - **Incentives (until macro demand side pricing is enacted)**
  - **Regulatory mandates**
  - **Bundle policies, available across technologies, so as to be technology neutral**
- **3. *Gap Analysis:* to identify gaps between existing institutions for supporting innovation**

We Have to Avoid Numerous Mine Fields

- **Addressing a Broad Range of Technology and the Whole Innovation Process . . .**
- **Not with Favored Technologies (“Silver Bullets”)**
- **Not by Pork Barrel (“No Lobbyist Left Behind”)**
- **Avoiding Capture by National Labs or by Particular Parts of the S&T Community**
- **Avoiding the Temptation to Scale Up Technologies Before they are Ready**
- **Despite Powerful Opposition From Incumbent Technologies**

A Rational Energy Policy has Eluded us for 50 Years.
This is The Toughest Technology <u>Implementation</u> Task We Have Faced.

A Program Commensurate with the Scope of the Energy Problem can be Realized Only with Determined Presidential Leadership

The Marshall Plan Faced a Comparable Situation, and Required a 'Full Court Press' to be Sold to the Congress and the Nation

The Stakes are High and the Need is Critical.