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Sandia National Laboratories

Presentation by Gretchen Jordan

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New Benefit-Cost Studies of Renewable and Energy Efficiency Programs of the U.S. Department of Energy: Methodology and Findings

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TIA Consulting, Inc.

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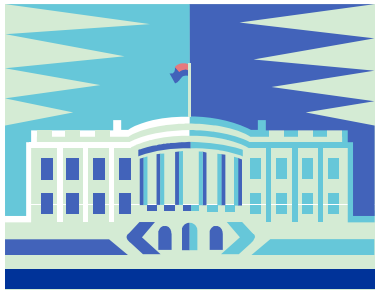
Outline

- Background
- Objectives of Studies
- Attribution – a Special Focus
- Economic Benefits
- Environmental benefits (GHG, Health)
- Security benefits
- Knowledge benefits

White House S&T Priorities stress evaluation and developing policy tools



Agencies **should describe in their budget submission how they are**

- Prioritizing activities toward four challenges (economy, energy, health, defense)
- Expecting outcomes in above areas, providing quantitative metrics
- Building capacity to rigorously evaluate programs; showing how assessments have been used to eliminate or reduce programs
- Operating in the open innovation model and supporting long term high-risk, high payoff research

Agencies will:

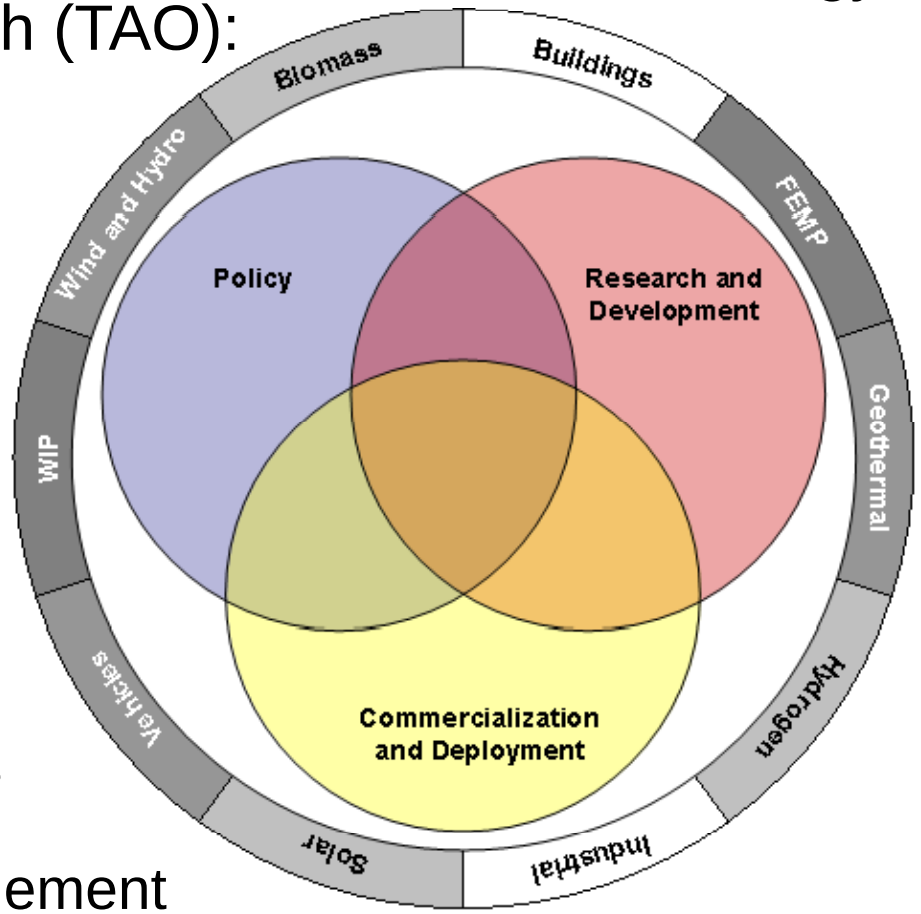
- Develop outcome oriented goals for S&T, target investment toward high performers, develop 'science of science policy" tools that can improve management and assessment of impact

*-Peter Orszag, John Holdren, August 4, 2009 (*for the FY 2011 Budget)

Office of Energy Efficiency and Renewable Energy (EERE)

EERE accomplishes its mission through 10 Technology Development (TD) Programs and the Office of Technology Advancement and Outreach (TAO):

- Fuels & Vehicles
  - Vehicles Technologies
  - Biomass/Biofuels
  - Hydrogen
- Power Generation
  - Wind
  - Solar
  - Geothermal
- Energy Efficiency
  - Building Technologies
  - Industrial Technologies
  - Weatherization
  - Federal Energy Management



Ruegg & Jordan, 2010

Objectives of EERE 2009-2010 Studies

(Solar, Wind, Geothermal, & Combustion Engine R&D)

- Demonstrate to investors that EERE research and technology development (R&D) programs & subprograms are “Worth It”
- Develop an improved Benefit-Cost methodology for determining realized economic and other benefits of EERE R&D programs
  - Model government additionality more thoroughly and on a case-by-case basis
  - Move beyond economic benefits
  - Have each study calculate returns to a whole EERE program/subprogram
- Develop a consistent, workable Methods Guide for independent contractors who will perform the evaluation studies

Special Focus: A Matrix for Assessing Attribution

Categories of Information Needed for Additionality Assessment	Technology Timeline (Stage of Research, Development, and Commercialization)→					
	Preliminary & detailed investigation	Develop components	Develop system	Validate/ demonstrate	Commer-cialize	Market Adoption
History of the technology						
What DOE Did						
What Others Did (Rival Explanations—Private Sector and Other Nations)						
What Others Did (Rival Explanations –US & State Government)						
The DOE Effect						
Description of DOE Influence And its strength						
Basis of evidence of influence						

Ruegg & Jordan, 2010

Economic Benefits and Investment Costs (Return on Public Investment)

- Resource changes in the economy resulting directly from application of technology in energy production, e.g., Investment, Energy, or Labor costs
- Economic performance metrics are Net benefits, Benefit-cost ratio, Internal rate of return

Findings in the 4 studies:

Discounted at 7 %, the lower-bound estimates

- NPV ranged from a low of just over $ 1 billion to a high of more than $ 23 billion
- Benefit-to-cost ratios ranged from 2.8 to1 to as high as 53 to 1
- IRR ranged from 14 % to 63 %

Ruegg & Jordan, 2010

Environmental Benefits

- Green House Gas Effects
- Public health benefits – calculated using EPA's COBRA model
- Any notable other effects (treated at a minimum qualitatively)

Findings in the 4 studies:

- GHG effects range from small to a reduction of more than 177 million metric tons of carbon dioxide emissions and 134 thousand tons of nitrous oxide emissions
- In physical units, the health effects of the resulting reductions in air pollution (NOx, PM, and SOx) range from small to avoidance of nearly a 1000 mortalities, more than 1,450 non-fatal heart attacks and 120,000 work days lost due to sickness.

Security Benefits

- Barrels of oil equivalent (BOE) units avoided.
- Monetary value will not be applied to BOE as the methodology is considered to require further development.
- Notable effects on the security of infrastructure will be identified.
- Future potential political and military security issues may be linked to GHG emissions. These effects will be acknowledged where the reduction of GHG emissions is notable.

Findings in the 4 studies:

Energy security effects range from small and non-quantified to an equivalent reduction of nearly 418 million barrels of crude oil, equivalent to a reduction of about 1 percent of the total crude oil imported by the United States from 1995 - 2007.

Knowledge Benefits

- Drawn from counterpart historical tracing studies (Ruegg & Thomas)
- Emphasis on patent and publication outputs and citations within the target industry & other industries
- Attention to “high impact” patents/papers and comparisons among organizations
- Also Licensing of intellectual property; Trained & experienced researchers & networks; Knowledge base; International knowledge flows

Example Findings:

EERE's funding generated knowledge embodied in an estimated 274 patent families in solar PV and more than 900 publications. These provide a foundation on which further innovations in solar energy have built, as well as innovations in the semiconductor industry more generally. All of the solar energy patents of the eight top U.S. solar PV producers are closely linked to earlier DOE-attributed solar PV patents (e.g., ECD (Uni-Solar), BP Solar, Global Solar, and SunPower.

Ruegg & Jordan, 2010

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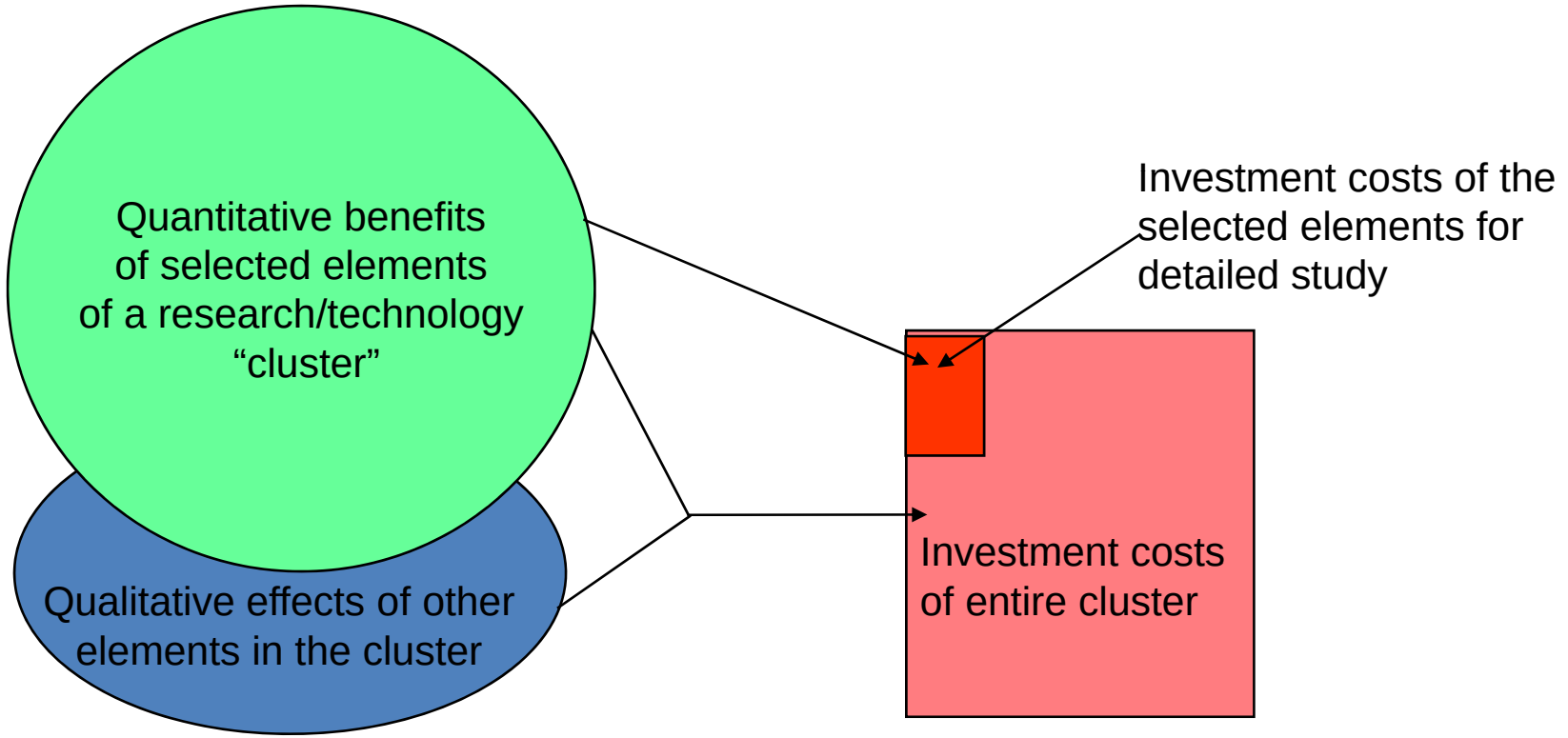
EERE Evaluation Website
http://www1.eere.energy.gov/ba/pba/performance_evaluation.html

Back up

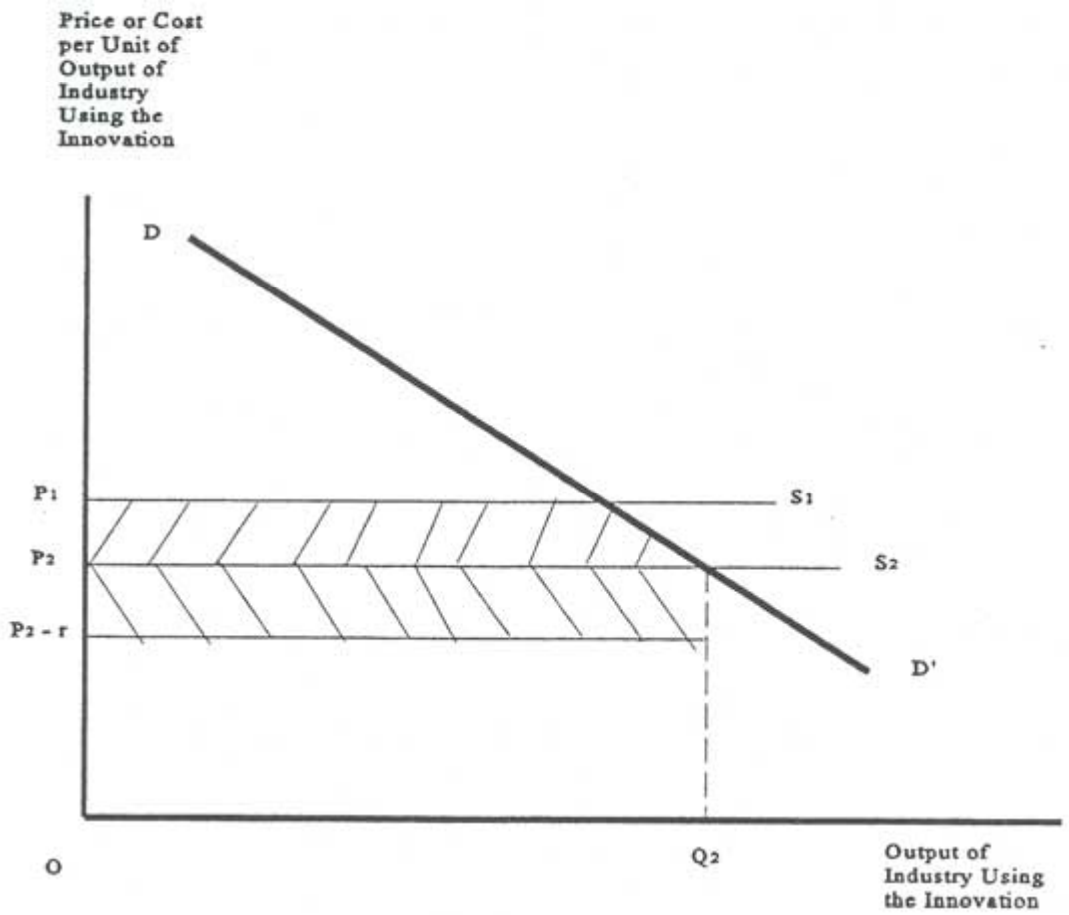
"Cluster Analysis" Approach: benefits of elements of a research/technology cluster" compared to entire cluster costs



Selection of Technologies for Detailed Assessment

- Desired Characteristics
  - Already commercialized
  - Identified as “big winners”
  - Data exists for linking EERE activities to the technology
- Selected Technologies may be
  - A whole system (e.g., an advanced wind turbine or geothermal plant)
  - A component of a larger system (e.g., blades for a wind turbine, or high temperature cement for a geothermal well application)
  - Infrastructure research embedded in an innovation (e.g., new air foil designs for wind turbine blades, or turbulence modeling for inflow)
  - New or improved process (e.g., faster deposition methods for PV)

Mansfield Model of Social Benefits from a Product Innovation that Reduces the Costs of the Industries Using It



Source: Edwin Mansfield, *Estimating Social and Private Returns from Innovations Based on the Advanced Technology Program,* 1996.

Definitions

- Net Benefits: time-adjusted benefits minus costs

$$NB = \Sigma B_{PV} - (\Sigma C_{PV} + \Sigma I_{PV})$$

where ΣB_{PV} = sum of present value benefits; ΣC_{PV} = sum of present value non-investment cost; and ΣI_{PV} = present value investment cost

- Benefit-to-Cost Ratio: time-adjusted benefits (net of time-adjusted non-investment costs) divided by time-adjusted investment cost

$$B/C = (\Sigma B_{PV} - \Sigma C_{PV}) / \Sigma I_{PV}$$

- Internal Rate of Return (IRR): the solution interest rate (i) that equates the values of the streams of benefits and costs over time

$$\Sigma B_{(i)} = (\Sigma C_{(i)} + \Sigma I_{(i)})$$

Source: TIA Consulting, Inc.

Example: Vehicle Combustion Engine R&D Study

- R&D costs, 1986-2007: $931 million ($2008, undiscounted)
- Cluster of Technologies in Vehicle Combustion Sub-program:
  - laser diagnostic and optical engine technologies
  - combustion modeling
  - emission control technologies; solid state energy conversion
- Selected for Detailed Analysis: "red" -- focused on heavy duty diesel engines
- Effect of EERE R&D in 2 selected areas: w/o EERE, BTE/fuel efficiency 4.5% lower
- Fuel savings: 17.6 billion gallons of diesel fuel from 1995 through 2007
- Monetary value of fuel savings in $2008, undiscounted: $34.5 billion
- Environmental Benefits, reduction in air emissions: 177.3 million metric tons of CO_2; 0.063 tons NO_x; 3.080 tons PM; 0.096 tons SO_x
  Monetary value of heath impacts avoided in $2008, undiscounted: $35.7 billion
- Security Benefits: equivalent of 417.9 million barrels of imported crude oil = 1% reduction of total crude oil imported by US 1995 thru 2007
- Knowledge Benefits: Foundation for more than 12 important technologies in combustion, plus advances in ion mobility spectrometry
- Performance Metrics @ 7% to 1986: NPV benefits: $23.1 billion; B-CR: 53 to 1; IRR: 63%

Ruegg & Jordan, 2010

Guide for Benefit-Cost Analysis

- Consistency & uniformity across studies (as appropriate)
  - use of unifying framework, consistent definition of terms
  - same economic performance measures, conventions
- Step-by-step guidelines for treating each benefits category
- Tools to assist next best alternative and attribution assessments
- Checklist of essential study characteristics
- Recognition that the studies are each unique (e.g., technology, data quality), and rely on the ingenuity, creativity, and modeling experience of the evaluators
- Draft version of Guide used for first 4 studies
- Revision per lessons learned & publication in 2010

Special Focus:
Specifying the “Next Best Alternative”

- Merits of the subject technology are judged retrospectively against the then “next best alternative”
- Counterfactual – what would otherwise have been used
- Factors affecting the selection:
  - Was the decision constrained or unconstrained?
  - Was the technology new to the world or an incremental improvement over an existing system?
  - Was the technology a total system or a component?
  - Was the technology a product or a process?
- Is static or dynamic modeling needed?

Accounting for “Additionality”

Program may have

- Accelerated technology entry into the marketplace,
  - by speeding the R&D effort as it is carried forward,
  - by increasing probability of technical success,
  - by attracting additional funding,
  - by increasing market awareness;
- Improved the performance characteristics of the technology,
  - by broadening the scope of the R&D effort,
  - by increasing the scale of the R&D effort or technical challenges;
- Changed the cost of a technology,
  - by encouraging collaborative R&D activities; avoid redundancy,
  - by providing specialized facilities/services to an entire industry;
- Increased market size,
  - by reducing barriers to market adoption through information, training, and standards and certification activities,
  - by increasing access of U.S. firms to growing global markets