Generic logic models for research, technology development, deployment, and innovation

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(diagrams and references)

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Example 1.
Research, Technology/ Development and Deployment Programs


Example 1. U.S. DOE EERE Proposed measurement framework includes 5 inter-related areas that will provide useful data.

(Feedback loops not shown)
Example 1. Proposed Generic Measures for U.S. DOE/EERE categorize R&D and market readiness

**Program Management**
- Portfolio balance
- Stakeholder involvement
- Performance-based planning
- Human capital
- Program infrastructure
- Quality implementation
- Efficiency
- Continuous improvement

**Technology Readiness**
- RD&D capabilities/infrastructure
- R&D Advances (non-stage gate)
- RD&D stage
  - Preliminary investigation
  - Detailed investigation
  - Development
  - Validation
  - Commercial launch
- RD&D cycle time
- Technology characteristics
- Breadth of applications
- Knowledge transfer & utilization
- Options value of technology

**Market Readiness**
- Knowledge infrastructure
  - Access, adequacy of tech info (mkt assess, decision support tools, websites, general ed.)
- Policy/Government infrastructure
  - Supportiveness of codes, standards, regulations, incentives, physical infrastructure
- Business infrastructure
  - Manufacturing, distribution, installation, and servicing capacities
  - Financial capacities
  - Economic attractiveness (NPV, IRR, ROI) to supply chain; competitive advantage
- End user
  - Visible demonstrations of technology/practice
  - Economic attractiveness (NPV, IRR, ROI, payback) to end user; relative advantage

**Ultimate Outcomes**
- Market size & share
- Energy benefits
- Environmental benefits
- Economic benefits
- Security benefits
- Spillovers in market

**External Factors**
- Market Needs/Opportunities
- DOE business infrastructure
- Congressional earmarks
- RD&D progress outside EERE
- Characteristics of competing & supporting technologies

**External Factors**
- State, local, other federal policies and incentives
- Economics (Material & labor costs, energy prices, etc.)
- Social/Cultural norms (preferences, time horizon, etc.)
- Characteristics of competing & supporting technologies

Draft 08/03/07
Example 2.
Research, Technology/ Development and Deployment Programs

U.S. DOE Energy Efficiency and Renewable Energy (EERE) 2004

Jordan, G., John Mortensen, John Reed, George Teather. Using Logic Models in Managing Performance of Research and Technology Programs, IAMOT 13th International Conference on Management of Technology, April 4, 2004
Example 2: EERE’s draft logic model links strategies/activities to goals

**Inputs**
- Federal, state & local government funding
- Private funding, Personnel, Facilities, Past R&D results

**Activities**
- Program planning & assessment
- Develop & maintain program infrastructure
- Conduct research
- Develop technology
- Demonstrate technology
- Developing government & market infrastructure
- Deploy technology

**Outputs**
- Benefit estimates, Priorities identified, Budget requests, Program plans
- Public & private labs and test beds, Knowledge bases, Trained S&T personnel, Partnerships
- New knowledge, proof of concepts as represented by data, publications
- Technology prototypes - initial - intermediate - commercial
- Performance analysis
- Test, improve, & validate commercial-scale technology, Give industry hands-on experience
- Codes and standards, Trained personnel, Audits tools, State programs
- Government purchases, Information disseminated, Early seeding of technologies

**For**
- Programs, CFO, OMB, Congress
- Programs, partners
- R&D community
- Relevant partners
- Relevant communities
- Relevant industries
- Relevant markets
- Potential purchasers

**Outcomes**
- Program funding in appropriate areas; Efficiency, Fiscal responsibility
- Relevant S&T expertise, capabilities and facilities to deliver programs
- Concepts & designs with possible applications, Knowledge spill-over
- Potentially commercializable technologies to replace existing or fill a system need
- Investment by industry in innovative or advanced commercial products
- Favorable policies, capable delivery channels for EERE products
- Widespread adoption of EERE products; More productive use of energy
- Economic, security, and environmental benefits
- Technology leadership

**External Influences**
- Political environment
- Quality of R&D proposals
- Unpredictable nature of R&D
- Cost and performance of competing technologies
- Industry willingness to take risk
- Energy prices
- State of the economy
- Government policies and regulations
Example 2: Each box in the logic model is a potential measurement area

Inputs
- Federal funding (millions of nominal $)
- Private funding (millions of nominal $)
- Federal personnel (FTEs)
- # of RD&D facilities

Activities
- Program planning & assessment
- Develop & maintain program infrastructure
- Conduct research
- Develop technology
- Demonstrate technology
- Developing government & market infrastructure
- Deploy technology

Feedback Loops

Outputs
- % programs w/benefit estimates
- % program w/program plans
- # of journal articles
- # of presentations
- # prototypes - initial - intermediate - commercial
- Prototype cost & performance
- # and % of commercial-scale technologies validated
- # codes and standards, # personnel trained, # audits, # state programs
- # of tech’s purchased by gov’t, # of materials disseminated, # of website hits

For
- Programs, CFO, OMB, Congress
- Programs, partners
- R&D community
- R&D Community, Industry
- Relevant industries
- Relevant markets
- Potential purchasers

Outputs
- # of potentially commercializable technologies
- # of journal article citations
- # of innovative or advanced commercial products with improved cost & performance
- # of recommendations for using advanced commercial products and practices
- # and % of advanced commercial products by adoption stage
- # of technology spinoffs

Outcomes
- % programs w/ benefit estimates
- % program w/ program plans
- # of journal articles
- # of presentations
- # prototypes - initial - intermediate - commercial
- Prototype cost & performance
- # and % of commercial-scale technologies validated
- # codes and standards, # personnel trained, # audits, # state programs
- # of tech’s purchased by gov’t, # of materials disseminated, # of website hits

Programs, CFO, OMB, Congress

Programs, partners

R&D community

R&D Community, Industry

Relevant industries

Relevant markets

Potential purchasers

External Influences
- Cost and performance of competing technologies (varies by technology)
- Oil prices ($/barrel)
- NG prices ($/tcf)
- Electricity prices ($/kWh)
- Coal prices ($/ton)
- GDP (billion 1996 $)
- RE production tax credit ($/kWh)
- EE/RE tax credits ($)
- CAFE standards (mpg)
- Vehicle & power plant emission standards (varies by pollutant)

(2004)
Example 3.
Research, Technology/ Development and Deployment Programs

New York Energy R&D Authority

New York Energy $martSM Portfolio Basic Logic

Inputs:
Funds, staff, allies, market knowledge

Activities

Markets
Actors

Multiple stakeholders

Supply-side
Research & develop new technologies

Markets/Infrastructure
 Coordinate, provide information, incentives to businesses & institutions

Demand-side
Promote, provide incentives to users to adopt new technologies

Short and Intermediate term Outcomes

Deliberate portfolio mix
Progress tracked & used in planning
Whole is bigger than the parts

NYSERDA
Evaluate/select technology opportunities

Researchers, Investors, Manufacturers

Credible data
Demonstrated technology performance
More investment in developing technology

Increased knowledge, skills, profitability, certification
Expanded delivery channels
Favorable standards, rules
Coordinated initiatives and lower transaction costs

Identified opportunities,
Increased awareness, understanding, branding
Changes in behavior and technology adoption
Increased perceived value

Efficient, relevant projects with measurable impact

Increased knowledge & availability of energy and environmental technologies

Sale, adoption, service of technologies in a profitable business and favorable policy infrastructure

Sustainable widespread demand for more efficient energy services and renewable technologies

External Influences:
Economic realities impacting new investment in technologies & energy improvements in some sectors, energy prices, effect of changing political climates, legislation & regulation, cost & performance changes in technologies that support or compete with those targeted by NYSERDA, existence and activities of numerous other public & non-profit organizations promoting similar objectives

Public Benefits

Reduced energy use for all customer sectors

Increased system reliability and reduced peak load

Reduced environmental impact of energy production and use

Increased competition and consumers and businesses saved money
NYSERDA R&D Logic - DRAFT

Inputs:
Funds, staff, NYSERDA competencies, partnerships

NYSERDA Select & Manage R&D Projects to:
- drive portfolio changes over time to respond to current needs, and
- Provide public benefits

Activities
Research for Policy
- Study to inform policy & R&D community

Outputs
White papers, workshops; Policy-relevant research

Outcomes
Informed policies & programs; R&D opportunities & standards identified, publicized

Product Development
- Study, Prove Concepts
- New knowledge: -papers, articles -data
- Develop new or improved product
- Intermediate scale prototypes
- Performance/cost specifications improving
- Test & improve products
- Data from tests
- Establish standards
- Hands on experience (industry)
- Feedback to R&D
- Investment/interest growing
- Commercial scale product developed
- Potential demonstrated
- Product proven/introduced in market

Demonstration
- Demonstrate products, inform markets
- Data from tests in different context
- Feedback to R&D policy makers
- Visibility & data from showcases

Pre-deployment
- Educate, provide incentives to supply & delivery
- Training, certification
- Production incentives
- Innovative designs
- Other barriers lowered

Policy and Product development and pre-deployment process (5-10 years)
Knowledge for future R&D and products
Firms have credibility & market infrastructure is supportive
Products manufactured as replacement, stand alone, or part of system and purchased by early adopters

Environmental benefits
- New
- Accelerated
- Expanded

Energy benefits
- generation, energy/load management, efficient use

Economic benefits
- cost of compliance, NY jobs

External Influences:
Cost, Performance of existing technologies; Industry willingness to take risks; Uncertainty of R&D; Energy prices; Government policies

Draft 07/29/2004
Example 4.
Logic of Technology (or Practice)
Deployment (Diffusion in Market)


See also
EERE deployment programs typically undertake these activities

<table>
<thead>
<tr>
<th>Analyze and Plan</th>
<th>Develop Technical Information</th>
<th>Assist Public Entities</th>
<th>Assist Businesses</th>
<th>Outreach and Partner</th>
<th>Assist and Fund Purchases</th>
<th>Provide Tools and Technical Assistance</th>
<th>Reviewing and Reporting</th>
</tr>
</thead>
</table>

Partnering with or targeting these audiences

| Technical and other personnel in laboratories, government, firms, colleges, universities | Federal, state, and local agencies and nongovernmental organizations | Investors and financiers, manufacturers, distributors, retailers, architects, engineers, trades people | End user organizations, firms and individuals |

To achieve the following intermediate outcomes

| Market and product knowledge | Create, advance, and package market and technical knowledge to make energy efficiency more accessible and implementable | Change the policies, structure and operation of public entities to smooth the advance of energy efficiency and clean energy supply | Create and enhance products, create and align market channels, enhance marketing, and develop installation and support infrastructures | Adopt, replicate, institutionalize, and enculturate energy efficient and clean energy supply practices and technologies | New knowledge, alternative institutional arrangements and processes, new product and service ideas, new opportunities, |

That produce the following long-term outcomes or impacts

| Reduced energy use and emissions, increased clean energy supply, and enhanced productivity and global security |

Reed and Jordan
A detailed deployment logic model

To conduct these activities

- Plans and analyzes
- Creates and Organizes Knowledge and Infrastructure
- Creates Partnerships
- Conducts Outreach
- Conducts Training
- Delivers Practices and Technology
- Tracks Evaluates and Reports

Producing these outputs

To identify:
- By developing Software Publications
- Manufacturing Extension Partnerships
- Utilities
- PGC Organizations
- Industry and business
- Others
- ESA teams
- IACs
- Manufacturing Extension Partnerships
- Utilities
- Websites
- Web casts
- Mailings
- Publications
- ESA specialists
- Plant personnel
- Students at Industrial Assessment Centers
- Qualified Specialists
- Consultants
- Utilities
- Others
- Through:
  - ESAs
  - EERE Info Center assistance
  - IAC Assessments
  - Software downloads
  - MEP activities
  - EPACT Voluntary Agreements
  - EPACT financial assistance

Through:
- IAC database
- ESAMS
- BTPS database
- LEU database
- Info Center tracking
- Customer information
- Peer reviews
- Metric reporting
- Case studies
- Outcome/impact evaluations

Partnering with and targeting

- Staff
  - Management
  - Congress
  - National Laboratories
- Consultants
  - Researchers
  - Academics
- Manufacturing
  - Extension Partnerships
  - Utilities
- Public Goods Charge
  - Organizations
  - Regional efficiency organizations
- Industrial firms
  - Consultants
  - Students
- A&E Firms
  - Contractors

To induce the following interim outcomes

- Increased market intelligence
- Better understanding of market segments
- Knowledge gaps filled
- More accessible knowledge
- More knowledge providers and producers
- Gas and/or Electric Utilities and PGC
  - Promote ITDP training and technical assistance
  - Expand electric efficiency programs to include gas
  - Create new electric and gas efficiency programs
  - Recruit customers
  - Use ITDP tools and methods
- Manufacturing Extension Partnerships
  - Recruit clients
  - Increase resources focused on energy efficiency
  - Offer efficiency programs
  - Support industry efforts to become more efficient
- Awareness of:
  - Program opportunities
  - ITDP tools
  - Publications
  - Efficiency opportunities
  - Efficiency solutions
- IAC Graduates
  - Take relevant jobs in industry and consulting firms
  - Use tools and techniques learned at the IAC
  - Implement efficiency measures and practices
- Consultants
  - Promote ITDP programs
  - Adopt ITDP tools and approaches
  - Recommend technologies and techniques that increase energy efficiency
- Nonparticipating firms
  - Observe
  - Decide
  - Implement
  - Confirm value
  - Replicate in plants
  - Enculturate
- Participating firms
  - Seek information
  - Decide to use
  - Implement
  - Confirm value
  - Replicate in plants
  - Enculturate

To achieve these ultimate outcomes/impacts

- Reduced energy use intensity, reduced emissions, managed costs, moderated fuel price effects, and improved productivity benefits
Example 5. Logic of Innovation (R&D, Launch and Market Uptake)

Example 5. A Systems Logic Model of the R&D to Adoption Life Cycle
Example 5: DOE Renewable Energy
Do these groups transfer knowledge?

- Basic research
- Utilization & Behavioral research
- Applied research
- Quality Research, Product refinement
- Development research, Validation
- Manufacturing research

R&D on desired characteristics, then R&D to increase reliability so 30 year warranties could be offered

Research on PV module recycling, waste disposal, usage of toxic materials to protect workers

Teamed research on generic, industry wide R&D problems getting volume up, costs down

PV Pre-incubator project helps small businesses transition from concept verification to tech. development

Built production process off existing wire saw technology; Fund an independent testing facility that also provides reference cells

Knowledge of Nano science & technology

Research on adv. Semiconductor and nano-structured materials

Research on PV devices utilizing semiconducting colloidal nanostructured materials
Example 5: DOE Renewable Energy
Do these groups transfer knowledge?

Developed curriculum and installed PV on school roofs; codified & published best practices; Provide model legislation

Product characteristics:
- relative advantage (operating cost)
- compatibility (use for hot water, etc.)
- complexity (simple drop in to roof)
- trialability (no harder than conventional)
- observability (green pricing)

Developed information & infrastructure:

Develop proven financing techniques; training/certification for installers

Fund showcases for people to view real application; Make aware of benefits

End Outcomes, System effects

Reduced pollution and dependence on imported oil. DOE R&D accelerated development of PV modules by 12 years
Example 6.
Impacts of Health Research –
Canadian Academy of Health Sciences
Framework


See also
Example 6: The Canadian Academy of Health Sciences Logical Framework for Understanding the Impacts of Health Research

Modified from CAHS Report on ROI for Health research available at www.cahs-acss.ca/making-an-impact-a-preferred-framework-and-ind...
Example 6: Detail

Research results...

Global Research

Canadian Public/private Health Research
- Biomedical
- Clinical
- Health services
- Population and Public health
- Integrated research

Knowledge Pool, Consultation, Collaborations

Health Industry
- Products/Drugs
- Product/drug development & testing
- Services, databases
- Practitioners’ behavior
- Clinical/managers guidelines
- Institutional Policies (hospitals, etc.)
- Social care practices

Other Industries
- Products/services
- Built environment
- Work environment

Government
Interventions at multiple levels related to health care, social care, Public health
- Resource allocation
- Regulation
- Policy
- Intervention programs
- Taxes & subsidies
- Education curriculum

Research Decision Making
At levels of Academic, Institution,
- Funders (Industry, Government, Foundations)
- R&D agendas/investment
- Tackling harder more complex problems

Public Information, Groups
- Advocacy groups
- Media
- Attitudes
- Knowledge of
- Confidence in research data

Healthcare System
Quality for Cost (appropriateness, acceptability, competence, continuity, effectiveness) and Accessibility
- Adherence to guidelines
- Reduced errors
- --hospital accreditation

Intermediate Health Outcomes
Prevention and Treatment
For disease, illness, injury, or progressive condition
- Prevention
- Diagnosis/prognosis
- Treatment/palliation
- Post-treatment

Population Health Risks
- Age & genetics
- Personal behavior
- Social determinants (education, networks, etc.)
- Environmental factors
- Built environment
- --social environment

External Influences:
- (Population) Health Status and Function (disease prevalence and burden)
- Well Being and Economic Prosperity

Health Status, Well Being, Economic conditions

Well Being, Economic conditions

Global Research
Example 7.
Logic of Accelerating Technology
Introduction in U.S. Supply Chains

A Framework for Assessing Accelerated Product Innovation, Manufacturing, Early Market Growth

U.S. Global Competitiveness in Manufacturing Energy Technologies; National Energy and Economic Benefits

- **O3**: Capabilities for continued innovation
  - Added capabilities – technical and market
  - Available capital for R&D, scale up, production
  - Supportive business practices, gov’t. policies

- **O2**: Growth in US manufacturing
  - Stronger networks, knowledge exchange
  - Added value to characteristics of new product
  - Stronger product supply chain

- **O1**: Accelerated new product commercialization, adoption
  - Added value to characteristics of new product
  - Stronger product supply chain

**Inputs**

- EERE Investments/Activities and Collaborations (Technical, Information/Relationships, Business, Policy)

**Ultimate Impacts**

**Interim Effects**

**Outcome Objectives**

**Short & Intermediate Conditions for Progress**

External Influences:
- Technical
- Information/Networks
- Economic
- Policy

DOE/EERE 2013
Detailed Logic of Accelerating Technology Introduction in U.S. Supply Chains

U.S. Global Competitiveness in Manufacturing Energy Technologies; National Energy and Economic Benefits

Accelerated Commercialization, Adoption
- New products, features available, including energy efficient, environment friendly; measure of their value added.
- New production features available (e.g., mobile, flexible, lower costs of transport).
- Faster time to development, market.

Growth in U.S. Manufacturing
- Domestic production of components, end products in a supply chain.
- Increased production due to advantages of using a new process.
- Emergence of new markets where U.S. firms are competitive.
- Sales, employment, market share.

Stronger Product Value Chain
- Small businesses are involved
- Challenges such as retooling met
- New business models adopted
- Firms add to/modify product line

Added Value to a New Product or Process
- Adaptation of existing, scale up, volume
- New, improved performance, -cost, compatibility

Stronger Supply Chain
- Incentives to enter, to stay
- Market, customer orientation
- Maturity, ability to deliver, on time
- Flexibility, adaptability, robustness

Stronger Networks, Knowledge Exchange
- Connectedness within value chain (e.g., with sources of capabilities), in Supply Chains
- Network characteristics (strategic partnerships, structure, ties, roles)

Supportive Business Practices, Policies
- Appropriate focus, network connections
- Remaining flexible
- Checking potential market regularly
- Favorable policies (tax, regulation)

Added Technical & Market Capabilities
- Existing research, tools, techniques
- Technical challenges solved
- Standards, test facilities, market knowledge, strategies

Availability of Capital at Multiple Stages
- Able to raise private capital; use user facilities
- Early adoption by government

EERE Investments, Inputs
- Technical
  - Fund R&D & test facilities.
  - Develop & provide measurement tools.
- Business
  - Support validation, demonstration.
  - Co fund start up firms, production facilities.
- Government
  - Supportive standards, government policy.
  - Government procurement (early adopter).
- Information/Relationships
  - Provide technical/market analysis, databases.
  - Facilitate networking, public-private partnership.

Ultimate Impacts

Broader Intermediate Outcomes

Short & Intermediate Conditions for Progress

EERE Investments, Inputs

DOE/EERE 2013
EERE Investment in Lithium-ion Battery Plants in the U.S.

Ultimate Impacts
U.S. Global Competitiveness in Manufacturing Energy Technologies National Energy and Economic Benefits

Broader Intermediate Outcomes

Short to Intermediate Conditions for Progress

Added capabilities (Fund R&D; alignment of standards)
Capital available for R&D, scale up, production
Business practices: (require manf. flexibility for inputs)
New partnerships bid for funds, work together
EERE Investments
Co-Fund R&D;
Co fund production facilities in U.S.

Stronger value chain: (materials, coating, binding, container)
Added value: More power durability, range of operating temperature
Stronger supply chain: (U.S. manufacturers, U.S. suppliers operating)

Accelerated battery commercialization, use in electric cars
Growth in US manufacturing of li-ion batteries

External Influences:
Small market for EVs; new firms with few financial reserves; Imbalance in relevant global policies

Inputs

DOE/EERE 2013
Example 8.
Logic of Basic Science Program and Projects

Related discussion:
Logic Model of a Program of Basic Research (U.S. DOE DRAFT - Unofficial)

ACTIVITIES
- Identify/ Direct/Redirect resources to important questions & needs
- Gather/ Build/ Maintain/ Provide resources in select areas
- Perform or Have Performed high quality research
- Disseminate/ Seek Review/ Feedback research plans, findings

OUTPUTS & OUTCOMES
- Students work with DOE or elsewhere
- Construct, operate, facilities
- Facility use - DOE & others
- Propose; Experiment, theorize; Collect & analyze data

- Robust S&T workforce
- Robust S&T Facilities & Equipment
- New structure, new ideas, tools, fields, Opportunities for use by others
- Prove, disprove; Theories, techniques developed & solutions generated

- Inform and be informed by collaborators, peers, potential users
- Strong communities of practice

- Capacity/Agility
- Transitions – findings used

Significant Contributions to DOE Mission, National Needs, Society

G. Jordan
05/13/2002
The Logic of a Basic Research Project

Manage Resources: expenditures by types of activities, skilled staff, core competencies; environment for quality research, soundness of research planning and evaluation, use scientific method

Activities
- Identify and state the problem
- Develop, test and build research tools
- Do research and report findings
- Exchange knowledge in papers, conferences, etc.

Outcomes and Results
- Growing consensus on problems
- New techniques to research problems
- Growing convergence on solutions to problems
- Apply ideas of others in research

New disciplines
New insights and knowledge

Potential impacts of research
Use in R&D or Commercialization
Actual impacts of the research

Reach targeted partners and customers; other researchers, laboratories, students, universities, applied researchers and technology developers, industry; attendees at conferences, readers of publications

G. Jordan 1996
Example 9. National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR)

Evaluation of the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR): Final Report