NARUC Subcommittee on Gas

November 8, 2015

Research and Development by Public Utilities: Should More be Done?

Ken Costello
Principal Researcher
National Regulatory Research Institute
kcostello@nrri.org

Three Takeaways

- Research and development (R&D) is critical for both economic growth and the survival and long-term prosperity of individual firms
- A general concern exists over deficient R&D for both the country as a whole and individual industries, including energy public utilities
- State utility commissions might want to revisit their polices and practices that affect utilities' willingness and ability to invest in R&D

The Importance of R&D

- Innovation (e.g., technological change) is a key element for economic growth and long-term prosperity
  - It can spawn new products, improvement of existing products, or higher efficiency of production processes
  - Economists have long held that technological change is critical for economic growth
- A *precursor* to innovation is investments in R&D
- Demand for R&D is therefore a *derived demand* for improved products/processes that are commercially profitable or achieve some public benefit more effectively or at a lower cost (e.g., knowledge for the sake of knowledge has no commercial value)
- Closer to home, R&D is also critical for advancing long-term policy objectives, like safety, reliability, cheaper energy, and a cleaner environment

The Innovation Process

- "*Innovation* is the search for, and the discovery, development, improvement, adoption and commercialization of new processes, new products, and new organizational structures and procedures" (according to one definition)
- Innovation consists of two basic steps: (1) create new ideas and (2) implement them
- Innovation process normally involves three sequential actions:
  - Scientific process of discovering new knowledge and determining the feasibility of new technologies (**R&D**)
  - **Demonstration** stage where new ideas and technologies are implemented in prototype plants to evaluate performance and cost(required information, e.g., for assessing practical or commercial viability of a technology)
  - **Deployment** involves commercialization of the new technology

National Trends in R&D

- Shift toward short-term R&D projects with quick payback
- Decline over time in the level of R&D funding (in constant $) by the federal government
- Total spending on R&D (public plus private) has been relatively stable over the past three decades at roughly 2.5% of GDP
- But the share of private R&D has increased while the share of public R&D has fallen
- After 1980, small firms rivaled and even surpassed large firms in terms of R&D intensity
- Because of the federal budget situation, we can expect lower R&D financial support from the federal government in the future
- There is concern over the downward trend in basic research affecting future innovation
- There is also concern over the low level of R&D in the energy industry
- R&D is vulnerable to budget cuts, by both the government and business sector, since its contributions are long term in nature and difficult to quantify
- During 1953-1987, the real annual growth rate in federal R&D spending was 4.9%, during 1987-2008 it grew at just 0.3%, and during 2008-2013 it declined by 1%
- The federal government funded most of R&D before the 1980s; share of business sector funded R&D rose relative to federal-funded R&D since the mid-1960s

Some Facts on R&D in General

- R&D in the U.S. totaled $456.1 billion in 2013
- Funding by the business sector accounted for $297.3 billion, or 65% of the national total
- The federal government funded $121.8, or 27% of U.S. R&D
- Of the total R&D, basic research accounts for 18%, applied research for 20% and development for 62%
- Government is the most important source of financial support for basic research
- Over 50% of basic research is conducted by universities and colleges, 56% of applied research by the business sector, and almost 90% of development by the business sector (*see* slide 8)
- Five industries (that include chemicals, pharmaceuticals and medicines, electronic products) accounted for 87% of domestic business R&D in 2013
- There is a wide difference in R&D intensity across industries (*see* slide 9)
- For all industries in 2013, the R&D intensity was 3.3%; 3.8% for manufacturers and 2.7% for non-manufacturers
- The U.S. is the world's largest R&D performer but its share has declined over time
- The U.S. spends less R&D as a percentage of GDP than many other developed countries
- Empirical evidence shows the social rates of return on R&D to be much greater than the private rates of returns

Some Facts on Energy R&D

- Utilities, which include power generation, transmission, and distribution, natural gas distribution, water supply and sewerage treatment, spent just 0.1% of revenues on R&D
- Federal government energy R&D as a percentage of GDP has dropped since the 1970s, and private sector energy R&D has been flat
- The federal commitment to energy R&D is less than 0.5% of the annual nationwide energy bill
- While U.S. expenditures for energy R&D has risen in recent years, they are only about one-half the level in real dollars of R&D in late 1970s during the oil crisis
- Federal R&D expenditures have shifted toward "clean air" programs, such as energy efficiency, renewable energy, and modernization of the electric grid
- DOE receives about 7% of the total federal budget for R&D (Defense gets 50% with Health and Human Services receiving 25%)
- DOE has different R&D arrangements: contracts with industry, work at its labs, and grants to universities and industry consortia
- As discussed later, we have seen R&D drastically curtailed in the natural gas sector

Funding and Performing Sector of Different Stages of Research

	Basic Research	Applied Research	Development
Business Sector	35.3% (24.2%)*	55.2% (56.3%)	80.9% (88.4%)
Federal Government	47.0 (11.8)	36.8 (16.6)	17.8 (8.9)
Other Entities (e.g., universities, nonprofit groups)	17.7 (64.0)	8.0 (27.1)	1.3 (2.7)

Source: National Science Foundation

* Performing sector

R&D Intensity for Different Industries (2013)

Industry	R&D Intensity
All industries	3.3%
Manufacturing	3.8
Chemicals	4.5
Pharmaceuticals and medicines	10.3
Automobiles, trailers and parts	2.4
Computer and electronic products	10.6
Electrical equipment	2.9
Non-manufacturing industries	2.7
Software publishers	9.0
Computer systems design	8.4
Finance and insurance	0.7
Utilities	0.1

Source: National Science Foundation

The Economics of R&D: Challenges Abound

- Expensive
- Initiated by technology-push or demand-pull incentives
- Expenditures can incur several years before the firm reaps additional revenues or other benefits
- Inherently risky (“dry holes” are common) – costs and success are difficult to predict, and benefits are often distant
- In a dynamic world, R&D for one technology can quickly become obsolete with the introduction of newer, more promising technologies
- Benefits can be appropriated by others, competing firms in the industry or the public at large (“free riders”)
- The above comments imply that firms are unlikely to innovate unless the payoff from successful innovation is large, which is usually the case
- The market may also under-allocate resources to R&D, for example because of public benefits
- Innovation usually begins with R&D, but not always

R&D in the Private Non-Regulated Sector

- Driven by the profit motive
- Tradeoff of an early adopter between additional costs and potentially higher benefits
- For example, leaders can reap higher profits but often incur higher costs than later adopters because of learning by doing and scale economies
- For many non-regulated firms, survival depends on keeping a technological edge over competitors
- Firms shoulder all of the risk
- Benefit-sharing exists between firms and consumers (short-run v long run)
- The willingness of firms to undertake R&D depends on market structure (competition, monopoly, oligopoly)

Rationales for Public Funding of R&D

- R&D has well-known free rider and public good characteristics (e.g., non-exclusivity)
- Distinctions between different stages (basic, applied and development) in risk and time span before expected benefits
- Firms view R&D from the perspective of profit expectations, thus focusing on the end stages of R&D
- Firms tend to conduct their R&D, for example, on "applied" projects where the payoff to them is more certain and immediate
- R&D is a public good that is likely to be suboptimal in scale without public support whether for the energy sector or other sectors of the economy
- Firms may consider the risk associated with R&D too high relative to the expected return (e.g., because of distant returns and uncertain outcomes)
- Market forces often fail to innovate or develop new technologies that provide the greatest benefit to the public *(Why?)*; government should fill that gap
- Government spending on basic research has provided many of the ideas and breakthroughs enabling progress in society
- Government faces the challenge of allocating funds to projects with the highest potential social payoff (e.g., funding decisions based on an independent, peer-reviewed process)
- Overall, public sector R&D should address social needs warranting greater investment than what the private sector is willing to undertake

Four Distinct Actions on R&D

- Selection of projects as part of a R&D portfolio
- Funding levels
- Funding sources
- Project management

R&D by Public Utilities

- Energy-utility industry R&D spending has declined in absolute dollars since the mid-1990s
- One reason is that in responding to increased competition, utilities cut back on internal R&D in addition to reducing their support for collaborative research managed by EPRI and GRI
- As mentioned earlier, R&D intensity for utilities is much less than for U.S. industries as a whole
- Historically, utilities conducted much of their R&D through collaboration and outside vendors
- NARUC has passed two resolutions endorsing R&D in the energy utility sector
- Successful energy utility innovation consider technical performance, economic cost, commercial competitiveness, and environmental effects
- Utilities are both producers and consumers of innovation
- Industry-funded R&D may have to involve more basic research in the future, as the federal government is likely to spend less on R&D than in the past
- One economic argument is that more emphasis should fall on R&D and less on subsidies to promote new technologies that achieve specific policy objectives (e.g., clean air); the more efficient and effective approach would be to price pollutants and other externalities

The Case of Gas Utilities

- Government funding of gas distribution R&D is significantly less than for electric and potable water utilities
- Draconian cutbacks in government and industry-funded R&D over the past 15 years
- The elimination of DOE R&D funding earlier this decade reduced the federal government's support for gas distribution infrastructure
- As gas markets became more competitive, some pipelines called for elimination of the mandatory mechanism to fund GRI
- Utilities in 29 states are funding GTI (but at a much lower level then utility funding for GRI in the 1980s and 1990s)
- Potential benefits of innovation include improved pipeline safety, reductions in methane emissions, greater energy efficiency, and more efficient and effective pipeline inspection and repair processes
- Any assessment of R&D adequacy is constrained by the absence of statistics on R&D funding for gas distribution and transmission
- **Legitimate policy question**: Are current levels of R&D funds for gas distribution adequate?

The Case of Gas Utilities - *continued*

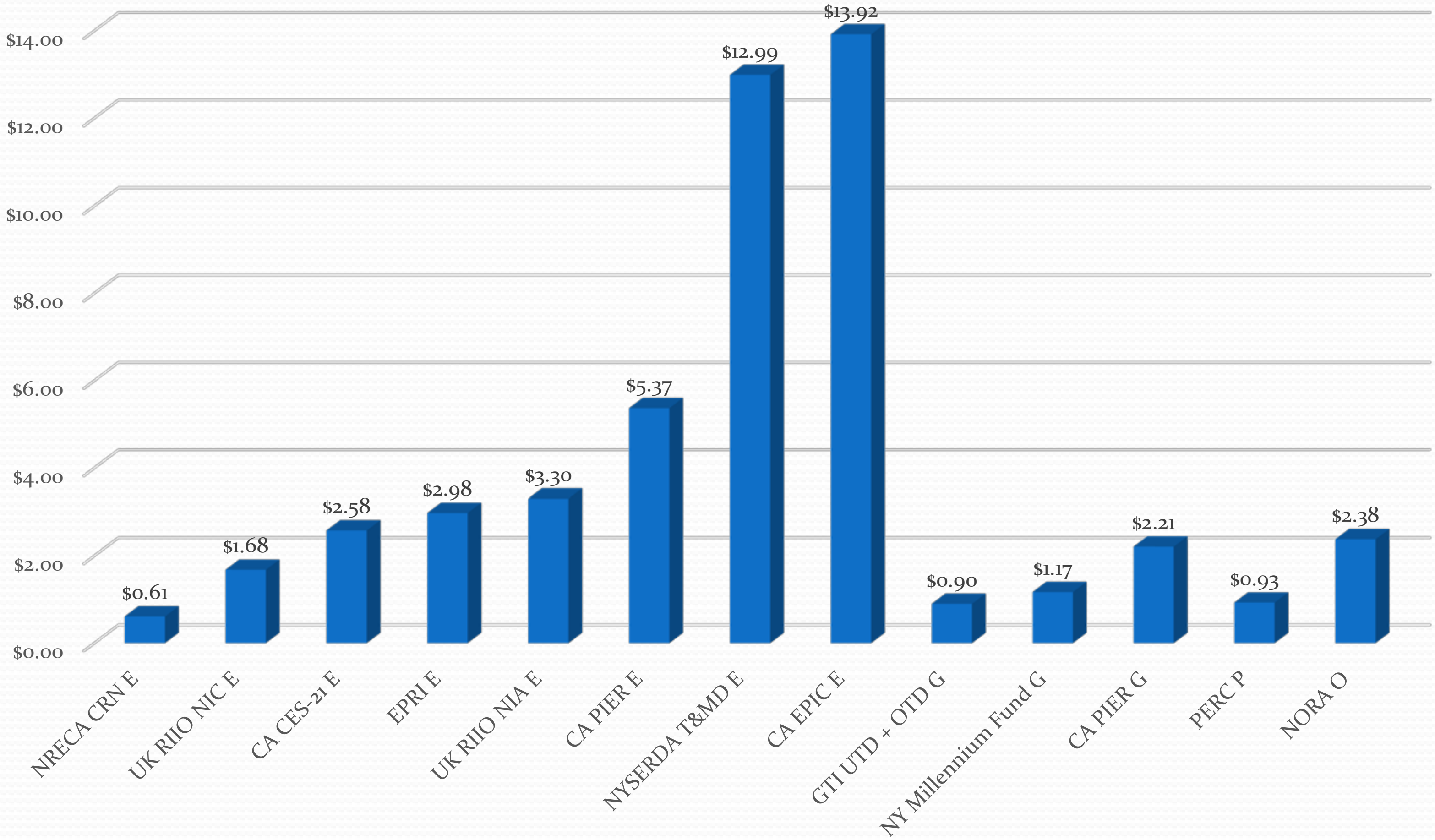
- GRI funding peaked at over $200 million in early and mid 1990s
- GRI was formed in 1976 in response to industry needs to develop new sources of supply
- FERC-required analyses showed that GRI R&D programs were highly cost-beneficial
- GTI provides R&D to meet industry needs in safety, reliability, a clean environment, and cost management (*see* next slide)

GTI’s Objectives

- “Expand the supply of affordable natural gas and renewable energy”
- “Ensure a safe and reliable energy delivery infrastructure”
- “Promote the clean and efficient use of energy resources”
- “Reduce carbon emissions to the environment”

These objectives advance the welfare of either gas consumers or society as a whole

Collaborative R&D Costs per Customer



Source: Concentric Energy Advisors, *Stimulating Innovation on Behalf of Canada's Electricity and Natural Gas Consumers*, May 2015, modified by GTI

A Few Examples of Innovation in the Natural Gas Sector

- Fuel cells powered by natural gas
- 3-D and 4-D seismic mapping
- Hydraulic fracturing
- Gas turbines
- Application of GPS technology
- Methane detection and measurement
- Gas sensing and monitoring
- Natural gas vehicles
- Micro CHP for home use

The Effect of Utility Regulation

- Regulation affects: (1) the amount utilities spend to innovate, (2) the speed at which they innovate, (3) the nature of innovative activities, and (4) the management of R&D projects
- A *core question* relates to the regulatory incentives for innovative activities by utilities
  - Economists have criticized traditional rate-of-return (ROR) regulation for providing utilities with less-than-robust incentives
  - But history has shown that, depending on the operation of ROR regulation and specific conditions, a utility could be either over-motivated or under-motivated to innovate
    - ✓ Electric utilities have often been adopters of new technologies under favorable conditions
    - ✓ For example, periods of regulatory lag under decreasing costs, high sales growth and no retrospective reviews

Major Policy Matters

- Incentives for utilities to innovate (i.e., utility demand for innovation)
- The effect of a new business model on creating new demand for innovation by utilities, customers and third-parties
- Role of R&D in innovation (link between R&D and innovation)
- Parties carrying out innovation (utilities, third-parties, e.g., Google): Why should utilities get involve with the development of new technologies; can't other entities better serve this role?
- Groupings of innovations (supply-side, demand-side, private benefits, public benefits)
- Utility-customer demand for innovation
- Regulatory objectives for R&D
- The benefits of collaborative research
- Role of regulators in accommodating and supporting innovation that is in the public interest
- Regulatory guidelines or principles on utility R&D

Specific Questions for Regulators

- Who are the beneficiaries of innovation?
- How can utility customers benefit from innovation?
- How do customers express or signal their demand for innovation?
- How are innovations filter through to customers?
- Who are the potential creators/suppliers/users of innovation?
- What would motivate utilities to innovate?
- What are current artificial barriers to R&D?
- Who should initiate action? Do utilities always identify promising new technologies and other innovations to their regulators, or do regulators sometimes have to take the initiative?
- Does the current portfolio of ratepayer-funded R&D investments represent a good balance?
- How can we know that utilities are adequately innovating?
- Why would utilities ever want to stifle innovation?
- Why would utilities be apathetic toward innovation?
- How does R&D translate into innovation or products/processes that are commercially viable?
- What can regulators do to ensure that utilities adopt innovations in the public interest?
- How do regulators determine that a particular innovation is in the public interest?
- How do regulators know that utility customers are receiving full value for their R&D dollars?

Different Regulatory Postures on R&D/New Technologies

- Support utility proposals
- Keep abreast of emerging technologies
- Require utilities to evaluate emerging technologies as to their feasibility and economics
- Mandate utilities to adopt certain new technologies and other innovations (micromanagement?)

Why Utilities May Underinvest in R&D/Innovation

- The payoff to utilities may simply be too low relative to the risks
- Utilities (as well as other for-profit companies) discount or ignore completely public benefits
- Traditional utility regulation (1) restricts the threat of competitive entry and (2) tightly controls a utility's prices and profits
- For example, prices are based on a utility's actual costs
- Innovation might lead to the erosion of a utility's monopoly status
- Book depreciation can cause "stranded costs" of old assets
- The conventional wisdom is that regulation causes utilities to be slow to innovate, since the costs and benefits of innovation tend to be uncertain
- As one industry observer has noted, utilities operate within a "culture of caution"

Features of Utility Regulation Affecting Innovation

Feature of Regulation	Effect on Innovation
Entry restrictions for new firms	▪ Reduces competitive pressure on utility to innovate ▪ Natural monopoly structure favors large-scale technologies
Regulatory lag	▪ As to costs, deters innovation because it takes longer for utility to recover its costs ▪ As to benefits, encourages innovation because utility can retain benefits longer
Cost-of-service rates	▪ Diminishes utility's benefits from innovation
Benefits allocated largely to customers	▪ Diminishes utility incentive to innovate
Risk allocated largely to customers	▪ Increases utility willingness to innovate ▪ Unfair to customers if utility captures most of the benefits ▪ Creates a "moral hazard" situation
Ratemaking treats cost savings from conventional and new technologies the same	▪ Utility finds conventional technologies are relatively more attractive
Book depreciation	▪ Can diminish utility incentive to innovate ▪ Can jeopardize utility's ability to recover fully the costs of existing assets
Prudence and "used and useful" tests	▪ Can deter utility from investing in high-risk innovations ▪ Protects customer against subpar utility management performance or unexpected outcomes
Emphasis on reliability and safety	▪ Shifts interest away from cost-saving innovations
Favoritism toward certain innovations	▪ "Jump starts" potentially socially desirable innovations ▪ Risks choosing the wrong technology

Illustrative Regulatory Principles for R&D

- Sustained and stable funding
- Adequate funding levels for achieving regulatory/policy goals
- Consistent with a long-term and strategic perspective
- Portfolio approach for selecting projects within broad programs (challenging because of uncertainty and multiple policy/company objectives)
- Allowing utilities to assume reasonable risks, and encouraging innovation by willing to pass at least some (or all) costs of failure to customers
- *Articulated FERC criteria*: "R&D projects should be well-defined, clearly explained and with consumer benefits, targets and justification"
- Selection of ratepayer-funded projects based on the public interest
- Picking winners can easily lead to unfavorable technology lock-in
- Basic research best funded by government
- Consideration of new R&D funding mechanisms
- Well-managed R&D projects
- Measurable outcomes
- Retrospective and prospective analyses

Fundamental Provisions in Regulatory Guidelines

- Funders of R&D
- Criteria for commission acceptability
- Third-party innovations
- Purpose of pilot programs
- Statement of R&D objectives
- Utility role
- Ex ante/ex post evaluations
- Cost allocation/recovery mechanism

Regulatory Tools to Bolster R&D/Innovation

- Modified ROR regulation (e.g., economic depreciation)
- Price caps
- Focused incentives
- Profit or benefit sharing
- Regulatory lag
- Benchmarking
- Planning (prospective) process
- Regulatory commitment
- Explicit rules
- Policy guidance (e.g., guidelines on pilot programs)

Concluding Comments

- Assessing the adequacy of R&D in the natural gas sector requires that one knows both (1) the *optimal level* and nature of research activities that promote the public good and (2) the *current status* of R&D activities in the sector; both factors are either unknown or highly speculative
- The evidence suggests, however, support for speedier actions and higher levels of R&D funding in the natural gas sector
- Like for other sectors, much of the R&D in the energy natural gas has a public-good nature that is likely to be suboptimal in scale without public support
- The dramatic drop in collaborative R&D by the natural gas utilities over the past 20 years presents a real concern
- Collaborative research has several benefits that regulators should recognize (*see* next slide); such research is more likely when companies are unconcerned about keeping a new technology or new information proprietary
- Utilities would tend to underinvest in innovations that have public benefits or erode their monopoly status
- There is a need for evaluating the effectiveness of R&D funded by utility customers
  - ✓ To ensure that customer are getting bang for their buck
  - ✓ To improve future performance
  - ✓ To learn from failures
- A *poor R&D program* is (1) short-term in nature and (2) thinly spread among countless uncoordinated projects that lack useful performance measures and are disconnected from outcomes

The Benefits of Collaborative Research

- Avoids duplicative efforts and inefficiencies
- Avoids the “free rider” problem
- Exploits economies from pooling company resources to undertake R&D
- Results in a more diversified portfolio of research projects
- Allows companies that lack funds to participate in R&D activities that otherwise they would not have
- Spreads the costs of high-risk projects
- Helps participants stay on top of the latest technology developments
- Overall, enhances the industry’s capability to leverage R&D investments for addressing common needs