STIMULATING INNOVATION ON BEHALF OF CANADA'S ELECTRICITY AND NATURAL GAS CONSUMERS

A DISCUSSION PAPER PREPARED FOR

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

Innovation in the natural gas and electric utility industries promises benefits for customers in the form of improved reliability, energy cost savings, environmental benefits, and economic growth. An increased emphasis on innovation by utilities could yield a range of new technologies, applications, processes, and business models—e.g., more efficient end-use equipment, smart-grid technologies and services, advanced low-carbon energy sources, energy storage technology solutions, and community energy systems. Such innovations can provide cleaner, less expensive energy services to Canadian households and businesses while creating jobs, bolstering Canadian competitiveness, and promoting Canada's position among global energy leaders.

Innovation involves activities that span invention, commercialization, and ultimately deployment of new technologies and business processes. The private sector is a primary engine for innovation, spurred by the opportunity for large financial rewards from bringing new products and services to market. The government also plays a critical role, particularly where the public benefits from innovation are large enough to justify public funding and where the financial rewards for the private sector are not large enough to compensate for development risks. The public benefits from innovation are especially large for the utilities industry given, for example, the important role that new technologies must play in supporting economic growth and in achieving Canada's energy efficiency and climate change goals. In light of these benefits to customers and society at large from utility innovation, regulators and utilities should take appropriate actions to ensure that regulatory frameworks encourage utility innovation. The opportunity to create new regulatory mechanisms to promote innovation is enhanced by utility regulators' ability to take a longer-term and more strategic view than the market in order to promote the public interest and to advance critical policy goals. Regulatory participation is particularly valuable because utility innovation is infused with the public interest.

This paper examines the roles that Canada's utilities and regulators can play to promote innovation. It offers a framework to consider the roles for government, utilities, and other private-sector entities in innovation. Finding a significant role for utilities, the paper recommends a model for utilities and regulators to adopt for promoting innovation. Based upon an extensive survey of the multiple innovation models that regulators, governments, and utilities around the world have utilized to address the challenges to innovation, this paper finds that the optimal approach for Canada is for utilities to form industry consortia focused on innovation that can pool customer funding from across jurisdictions and enable valuable collaboration and knowledge sharing. Utility regulators should provide crucial guidance and oversight and establish evaluation criteria that include customer benefits from innovative investments. Provincial governments should ensure that utilities and regulators have a mandate to pursue innovation efforts aligned with national and provincial energy policies.

THE NEED FOR INCREASED UTILITY INNOVATION

THE CHALLENGES & OPPORTUNITIES RELATED TO ENERGY INNOVATION

Canadian natural gas and electric utility customers stand to gain substantially from increased levels of innovation. Overarching analyses of the returns from investments in innovation generally and utility and energy innovation demonstrate that benefits to society and utility customers substantially outweigh the costs of innovation investments. Moreover, such large returns on investments in innovation indicate that society under-invests in innovation and that this under-investment is particularly true in the case of utility innovation.

A 2012 report from the Mowat Centre at the University of Toronto summarized the economic literature on the social returns to innovation investments across industries:

> *Although measuring the exact social rates of return to R&D is difficult, there is a substantial body of research comprised of decades of in-depth studies providing authoritative estimates. The main conclusion—that public returns to R&D are very high—has not changed from the early inquiries in the 70s to the literature today. [Based on the] results of previous studies of Canadian, U.S., and G7 social rates of return to R&D … Canadian results show social rates of return to R&D between 70 and 160 per cent. U.S. numbers, including both country-wide and industry-specific studies, range between 28 and 175 per cent, and the G7 rates are also very high, ranging from 66 to 123 per cent. These very high returns support the case for investing public funds in technology R&D in order to bridge the gap between private and social return and to capture the full benefit of R&D investments.*[1]

Table 1 summarizes the benefit-to-cost ratios reported for several organizations focused on energy and utility innovation. These large benefit-to-cost ratios indicate substantial untapped potential for additional investments in utility innovation with large returns for ratepayers and society at large.

Table 1: Benefit-to-Cost Ratios Reported for Energy and Utility Innovation Investments[2]

Organization	Reported Benefit-to-Cost Ratio
U.S. Department of Energy	4.3:1
Gas Technology Institute	4:1 to 8:1
Electric Power Research Institute	1.5:1 to 5:1
New York State Energy Research and Development Administration	4.9:1
California Public Interest Energy Research	2.1:1 to 5.1:1

Important energy and environmental policy goals related to climate change and energy efficiency can only be effectively achieved with contributions from new technologies (e.g., highly efficient appliances, distributed generation, electric and natural gas vehicles), processes, and business models. Changes in energy markets and new technology advances create opportunities for innovative energy end uses (e.g., natural gas and electric vehicles). The integration of many new technologies into existing utility distribution networks presents unique challenges that call for innovative technical and regulatory solutions. Utilities

must solve the challenges of connecting technologies that are located on customer premises in a way that preserves the reliability of the network and enhances the customer value provided by natural gas and electricity. Technologies such as energy storage further integrate the natural gas and electricity industries and will require innovation in business and regulatory processes to keep pace with technology and ensure that customers benefit to the extent possible from technology innovation.

A combination of market, policy, and industry constraints hinder sufficiently robust innovation efforts directed at maximizing the value of Canada's energy resources for the benefit of energy consumers and society. These market failures and other factors lead to less than the socially optimal level of investment in utility innovation. This under-investment means that Canadian electricity and natural gas customers miss out on opportunities for innovation and the energy cost savings, service reliability improvements, environmental gains, and other benefits that such innovation can deliver. The Canadian economy also loses out on the employment gains and enhanced competitiveness that come from new technologies and more efficient energy use. But, together, utilities, regulators, and customers can forge new partnerships to fund, execute, and exploit innovation opportunities.

THE UNIQUE ROLE OF UTILITIES IN SUPPORTING INNOVATION

Many regulators and other stakeholders recognize the value of innovation activities undertaken by regulated utilities. Innovation efforts by a utility enable it to evaluate emerging technologies and make informed investment decisions regarding those technologies.[3,4]

Most recently, regulators in Great Britain and the United States have cited utility innovation as an explicit objective of regulatory policies that are intended to promote distributed generation and other changes in the utility regulatory and business models.[5]

Utilities are ideally positioned to understand the impact of evolving regulatory policy objectives on their own needs and the needs of their customers, to foresee opportunities for innovation, and to determine the projects most worthy of funding.[6,7] Utilities are also best positioned to field test new technologies that must operate on their networks.[8] Utilities are close to their customers in a way that research institutions or manufacturers are not. Utilities understand the demographics of their customers, their customers' energy usage patterns, and the unique circumstances of their service territories (e.g., climate, industries) better than, for example, a technology vendor would. The long-term relationships and established communication avenues that utilities have with ratepayers can facilitate, for example, testing devices in residences and businesses to get actual performance data. Innovation programs often require joint efforts by numerous stakeholders, including regulators, governments, technology vendors, research institutions, contractors, utility customers, and public-interest groups. Utilities have a long history of successfully managing relationships with these diverse stakeholders. Finally, utility regulators play a critical role in implementing national and provincial energy policy, and utility-driven innovation programs are a natural avenue for regulators to implement energy policy. Moreover, innovation funding authorized by regulators can prove more stable over time and insulated from political dynamics that tend to impact government funding initiatives.[9]

THE INNOVATION PROCESS

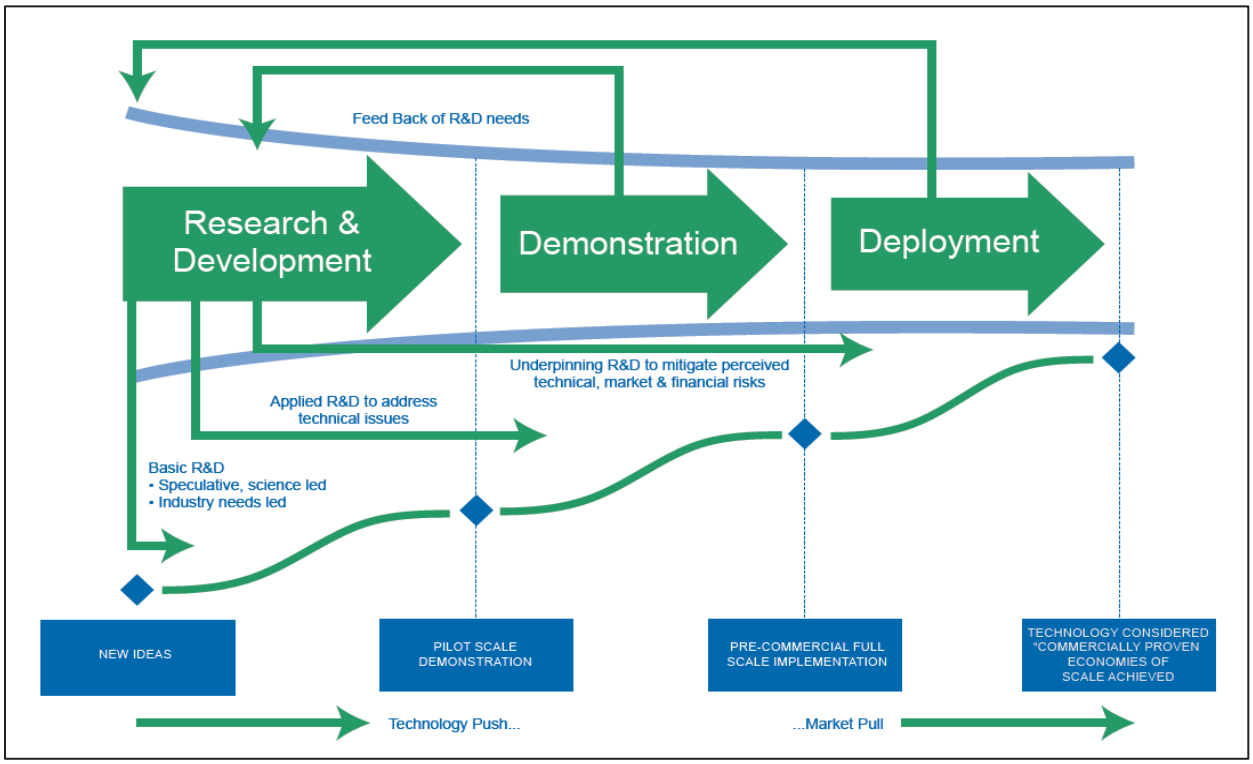
It is useful to think of innovation in terms of the commonly used three-stage framework: research and development, demonstration, and deployment ("RDD&D"), explained below (and illustrated in Figure 1).

- Research and development ("R&D") ranges from basic "blue-skies" research through applied research, generic development, and finally product development. R&D can include lab-scale and pilot-scale testing of new technologies.
- Demonstration refers to the installation and operation of pre-commercial technologies in real-world conditions and at a scale that provides reliable information to evaluate and refine the technologies.[10]
- Deployment is the early commercialization stage when the technology becomes "commercially proven" but likely requires support as it becomes competitive with existing technologies (e.g., by realizing economies of scale) and overcomes various market barriers.

As Figure 1 illustrates, innovation is not a simple linear process. Rather, iterative learning and feedback are critical components. For example, experience with large-scale demonstration projects can uncover new areas for R&D to improve a pre-commercial technology. In addition, the risk associated with different stages of innovation tends to decrease as new technologies approach commercial maturity.

Figure 1 also conveys that policymakers can use two general types of policies to spur innovation—namely, "technology push" and "market (or demand) pull" policies. Technology push policies provide incentives or funding for firms or other entities to engage in RDD&D. Technology push policies include R&D tax credits, direct R&D funding, and grants for technology demonstration projects. Market pull policies create a demand for new technologies among consumers that spurs deployment and provides an incentive for increased innovation activity to supply the new technologies demanded by the market. Market pull technologies include rebates for energy efficient appliances, renewable electricity mandates, and carbon taxes. Technology push and market pull policies can be further classified as either direct or indirect, depending on whether they promote innovation more generally (e.g., a broad R&D tax credit) or specific technologies (e.g., funding for large-scale demonstrations of a particular technology).

Figure 1: The RDD&D Process



Source: Energy Research Partnership, *UK Energy Innovation*, 2007, at 2.

Utility innovation refers to innovations relevant to the natural gas and electric utility industries and includes technologies applicable to gas transmission, distribution, and end use and to electricity generation, transmission, distribution, and end use. It often requires overcoming a set of non-price and non-technical market barriers to widespread adoption. These market barriers can include regulatory impediments, weak distribution channels for technology vendors, lack of experience in installation and maintenance among service providers, and lack of consumer information on the benefits of new technologies. Efforts at "market facilitation" to accelerate widespread technology deployment can include regulatory streamlining (e.g., facilitating or simplifying permitting), workforce development, and customer education and outreach.[11]

While discussions of innovation tend to focus on the most concrete examples—i.e., new technologies—utility innovation also encompasses the development of new business and regulatory processes and models. For example, utility innovation can include pioneering new approaches for engaging customers in energy efficiency and conservation programs or creating new business and regulatory models for utilities to deploy advanced technologies (e.g., community energy systems).

The RDD&D framework outlined above has several implications for utility innovation:

- The iterative nature of innovation and the feedback linking different stages point to benefits from collaboration between research institutions, equipment manufacturers, and utilities. For example, through such collaboration utilities can draw upon their experience demonstrating new technologies in the field under large-scale, real-world conditions to inform the R&D efforts of equipment manufacturers to

overcome any challenges the utilities encountered.

- The demonstration and deployment stages suggest a particularly important and direct role for utilities given their ownership and operation of electric and gas networks and strong relationships with their customers who are the ultimate users of many innovative technologies.
- Knowledge sharing requirements can help ensure that knowledge generated from RDD&D activities is available for all relevant parties to exploit, thus maximizing the value of investments in innovation.
- Innovation efforts should not be confined to technology development but should also include developing new business and regulatory approaches that can help advance new technologies or otherwise provide benefits to customers.

CUSTOMER AND SOCIETAL BENEFITS FROM UTILITY INNOVATION

The development and widespread deployment of new technologies in the natural gas and electric utility industries (including end-use applications adopted by utilities' customers) can provide widespread public-interest benefits to customers and Canadian society more broadly:

- **Public Safety** – Particularly for gas transmission and distribution, new technologies can improve the safety of operations, for example, by detecting or preventing leaks.
- **Reliability** – New technologies can make distribution systems more resilient and can help utilities diagnose and quickly recover from electricity outages. For example, distribution automation, distributed generation, and community energy systems (or microgrids) are innovations that offer reliability benefits.
- **Energy Cost Savings** – New end-use technologies can reduce energy consumption or displace more expensive fuels and lower customers' costs. For example, RDD&D efforts have in the past led to multiple generations of new, more highly efficient appliances, and further innovation along those lines is possible. In addition, new technologies for natural gas-powered and electric vehicles can displace more expensive and polluting petroleum use. Energy storage offers the potential to improve system load-factors and reduce peak demands throughout the electricity system.
- **Environmental Benefits** - Increasing energy efficiency and switching from more polluting fuels reduces air emissions (e.g., greenhouse gases) and other environmental impacts. RDD&D efforts have led to increasing deployment of renewable electricity generation technologies (e.g., wind and solar power) and renewable gas. Further innovation is possible to yield more cost-effective renewable energy options that can be more widely deployed.
- **Economic Development** – Lower energy bills can provide an economic stimulus as they leave households and businesses with more money to spend and invest.[12] Moreover, investments in innovation can create new companies and new jobs (e.g., in manufacturing, installation, and service). Illustrating this benefit, Canada has seen the growth of a substantial wind and solar supply chain over the past two decades. As new technologies lead to more efficient energy use and lower-cost alternative fuels, innovation can enhance Canadian competitiveness.

OBSTACLES TO UTILITY INNOVATION

Despite the substantial benefits that utility innovation can deliver, current investments in utility innovation are less than the socially optimal amount; this is evident from the substantial marginal returns that investments in utility innovation deliver. Unique aspects of the utility industry and regulation make investments in innovation especially challenging. Market failures common to energy industry innovation (i.e., externalities) and to innovation across industries also hinder investments in utility innovation.

BARRIERS TO INNOVATION UNIQUE TO THE UTILITY INDUSTRY

Several factors hinder the willingness or ability of utilities to invest in innovation: (1) the relatively limited competitive advantage and shareholder returns to be gained from innovation by regulated monopolies; (2) the mismatch between the relatively low-risk, conservative utility business and regulatory model and the risk profile of innovation; and (3) issues of culture and core competencies at utilities.

In many industries, companies invest in innovation in order to gain competitive advantage and because of the prospects to earn outsized returns for shareholders from investments in innovation. The unique nature of the utility industry, however, means that utilities have a limited upside from successful innovation. As rate-regulated monopolies, utilities do not typically compete with one another. Moreover, regulators set prices for utility services to provide a reasonable level of profit for utility shareholders. If utility shareholders invested their own funds to yield successful innovations that delivered benefits to customers, the shareholders would still only expect to realize the regulated rate of return on rate base, thus minimizing the financial incentive to invest in RDD&D. Even if a utility operated an unregulated subsidiary to provide innovative products or services, the capped returns for providing regulated services still dampen the incentive for regulated utilities to adopt new innovations.[13]

Regulated utilities focus on providing safe, reliable, and affordable service to their customers. The demands of safely and reliably operating large, complex energy networks necessarily make utilities conservative in nature and focused on limiting risk. Utility regulation is also a generally conservative process, aiming to maintain reliability and security of supply, ensure stable prices for customers, and consistent, reasonable returns for utility shareholders. In contrast, the innovation process is inherently a higher risk undertaking. While the risk profile varies along the innovation spectrum, many RDD&D efforts do not succeed as hoped and others can be wildly successful yielding very large benefit-to-cost ratios. This fundamental mismatch between the approach toward risk under traditional utility regulation and the risk profile of innovation is widely recognized.[14,15,16,17] The frequent lack a specific mandate for utility regulators to promote innovation—and the resultant lack of a clear signal to utilities that innovation should be a core focus—exacerbates this mismatch.[18] The utility regulators who have provided the strongest support for utility innovation do so to further a legislative mandate to promote the public interest by supporting innovation. For example, the California Public Utilities Commission has been among the most supportive of utility innovation efforts (as detailed in Attachment B), and the

Commission's statutory authority and directive to support public-interest RDD&D with ratepayer funds makes this strong support possible.[19] California also illustrates how clear government energy policies and goals related to innovation can bolster the ability of regulators and utilities to establish long-term models to fund and carry out innovation efforts.

Some observers also note that the lack of incentives for innovation by utilities means that many utilities have internal cultures and capabilities that are not well aligned with innovation. Efforts by utility managers and regulators to promote "creative energy" and the "ethos, internal structures, and third party contacts" conducive to innovation within utilities can facilitate greater levels of innovation.[20,21] A countervailing observation is that utilities employ a large number of engineers whom are usually problem-solvers by education and nature.

EXTERNALITIES

Externalities constitute another market failure relevant to innovation in the utility industry. Certain primary benefits that result from innovation do not result in monetary gains to either the developer of an innovation or its users. This is readily apparent in the case of greenhouse gas emission reductions from innovative clean energy technologies and energy efficiency. Investments in new technologies that reduce greenhouse gas emissions and lower the risk of dangerous climate change yield benefits for society at large. Absent carbon pricing or similar policies, there is little or no direct financial compensation associated with those benefits, thus driving a wedge between the private returns that a firm can realize from such innovation and the overall social return.

SPILLOVER BENEFITS FROM RDD&D

A well-known market failure, generally referred to as the spillover benefits from RDD&D, means that market forces alone will lead to an under-investment in innovation across industries in light of the gains to society from incremental investments in innovation. These spillover benefits stem from two characteristics of the information generated from investments in innovation. First, information generated from innovation activities can be utilized by an entity without reducing the ability of any other entity to use it (economists say that such information is "non-rival"). Second, no one firm can fully prevent other firms from appropriating information it has generated via innovation activities (as such, information is described as "non-excludable").

Because information is non-rival and non-excludable, a firm that bears all of the private costs of funding innovation (and thus, for example, creating valuable knowledge about a new technology) cannot expect to realize all of the economic gains from that investment since the resultant knowledge will inevitably also benefit other entities who can profit from it in turn.[22,23] When the private returns to RDD&D expenditures are thus lower than the total returns to society, companies will tend to underinvest in innovation. Regulators have acknowledged this problem, for example, when determining the benefits of demand-side management ("DSM") programs.[24]

These spillover benefits apply across the spectrum of innovation activities to varying degrees. Investments in basic and applied R&D can lead to advances in scientific or engineering knowledge that can prove valuable to a wide range of entities. Investments further along the innovation chain also generate spillover benefits. For example, learning-by-using refers to the creation of knowledge about the

existence, characteristics, and performance of a technology via demonstration and deployment.[25] Notably, successful investments in demonstration and deployment of a new technology, service, or business model by one firm can significantly reduce uncertainty for (and thereby benefit) all market participants.[26]

The spillover benefits from RDD&D suggest public or broad-based industry support for innovation is required to achieve optimal funding levels.

THE RATIONALE FOR CUSTOMER FUNDING FOR INNOVATION

As explained above, various factors work to limit the incentives that utility shareholders have to invest in innovation. Yet, utility customers and society at large realize the gains from utility innovation (e.g., energy cost savings, environmental benefits). The broad benefits to society from innovation explain why governments around the world invest taxpayer funds in RDD&D across sectors and specifically in energy. The extent to which customers directly benefit from utility innovation supports the notion that greater customer funding of innovation is warranted.

Table 2 illustrates a framework for considering when customer-funded utility innovation efforts are appropriate and when taxpayer-funded or purely private-sector efforts are more appropriate.

Table 2: Framework for Government, Utility Customer, and Private-Sector Innovation Efforts

<table>
<tr><th></th><th>Taxpayer-Funded Innovation</th><th>Utility Customer-Funded Innovation</th><th>Private-Sector Innovation</th></tr>
<tr><td>R&D</td><td>Government is best positioned to fund basic R&D that is high risk and has potentially broad-based benefits</td><td>Limited to where customer benefits are probable and utilities have unique capabilities or insights. Co-funding can spread risk and reward across utilities and jurisdictions and even share risk and reward with taxpayers generally or private firms.</td><td>Limited by substantial spillover benefits at this stage.</td></tr>
<tr><td>Demonstration</td><td rowspan="2">Government cost-sharing or subsidies are warranted in proportion to the likely spillover benefits and externalities.</td><td rowspan="2">Customer-funding is warranted where the likely benefits (e.g., energy costs savings, reliability improvements) largely accrue to utility customers.

Utilities' innovation efforts are best directed where utilities have unique, strategic advantages—e.g., demonstrating new technologies on their networks.</td><td>Industry cost-sharing is often appropriate since technology vendors are likely to gain from successful demonstrations.</td></tr>
<tr><td>Deployment</td><td>Public funding is less necessary as deployment accelerates and spillovers become less pronounced (absent substantial externalities).</td></tr>
</table>

THE CURRENT STATUS OF UTILITY INNOVATION EFFORTS IN CANADA

The Canadian federal and provincial governments provide some taxpayer funding for RDD&D projects relevant to the electric and gas utility industries. Certain provinces and utilities also provide limited support for utility innovation programs (Attachment A provides several examples of such federal and provincial efforts). A small number of Canadian utilities make substantial investments in innovation; however, those investments are largely focused on short-term, operationally directed projects. Of note, the Canadian gas industry has taken recent steps to create an industry consortium to advance RDD&D efforts. Nonetheless, Canadian utilities and regulators have not adopted innovation models comparable to those in other countries, and this presents a substantial opportunity for gains for utility customers from increased funding for utility innovation.

EXAMPLES OF CURRENT CANADIAN UTILITY RDD&D EFFORTS

Certain large Canadian utilities maintain significant internal R&D organizations. The Crown Corporation utilities, wholly owned by the provinces, appear to have by far the largest such internal R&D efforts. The Institut de recherche d'Hydro-Québec ("IREQ") reports an annual investment of $100 million in its innovation projects.[27] Ontario Power Generation ("OPG") reported R&D expenses of $113 million in 2012; however, most of OPG's R&D spending has historically been focused on short-term, lower-risk programs that provide incremental operational improvements, particularly for its nuclear power plants.[28,29] Some Canadian utilities also participate in innovation efforts undertaken primarily by U.S.-based industry consortia, such as the Electric Power Research Institute ("EPRI") and the Gas Technology Institute ("GTI"). In addition, there are cases where provincial regulators allow utilities to pursue RDD&D efforts, particularly as they relate to energy efficiency. For example, the Ontario Energy Board ("OEB") issued guidelines for natural gas utilities' DSM programs in 2011 that provided for R&D and pilot programs to be reviewed on a case-by-case basis and funded from utilities' generic DSM program budgets.[30] The Natural Gas Technologies Centre ("NGTC") provides important Canadian RDD&D capacity related to the development of more efficient energy technologies, working with clients that have included Enbridge Gas Distribution, Gaz Métro, Union Gas, the National Research Council Canada, and Natural Resources Canada.

Notably, in 2011, the Canadian Gas Association ("CGA") formed Energy Technology Innovation Canada ("ETIC") to stimulate the application of new, and improvements to existing, natural gas end-use technologies. ETIC has four specific areas of focus: industrial use, transportation, renewable natural gas, and integrated community energy systems.[31] According to its business plan: "ETIC will act as an information source and exchange" as well as "a proactive enabler and industry advocate focused on energy innovation and technology" and "will bring CGA member companies and other interested parties together to pursue common interests and goals."[32] As of February 2013, the CGA reported that ETIC had coordinated twenty projects with a total value of approximately $9.5 million.[33]

THE NEED FOR INCREASED FUNDING FOR UTILITY INNOVATION

Expert reports have concluded that Canada needs to improve its energy innovation funding and programs and that utilities and their regulators should play a more prominent role in such innovation. The 2012 report from the Mowat Centre found that:[34]

- Canada's current approach to energy innovation is fragmented, with too many uncoordinated organizations and programs (many of them "too small to matter") reliant on short-term funding;
- Canadian energy innovation policy relies too heavily on direct market pull and indirect technology push policies with insufficient emphasis on direct technology push efforts;
- Canada provides too little funding for demand-side energy technology innovation; and
- Utilities play too small a role in Canada's innovation efforts given their strategic position, especially in terms of their unique relationship to energy end users.

Utilities can fill a crucial niche in energy RDD&D that is not met by other firms. In the case of electricity, research has found that utilities' innovation spending fell dramatically in countries that liberalized their electricity markets; however, this decline in spending was not offset by an increase in funding from equipment manufacturers.[35] This finding strongly suggests that, rather than crowding out innovation investments that private firms would otherwise make, utilities that work with their regulators to invest in innovation fund efforts that would not otherwise take place.

Why should Canada, whose GDP is roughly 12 percent of that of the United States, make substantial investments in utility innovation rather than merely "free-riding" on the investments in utility innovation made by the United States (particularly states like California that have aggressive utility innovation agendas) and other countries?[36] There are four primary reasons that Canadian investment in utility innovation is imperative: (1) simply waiting for other countries to pioneer innovations delays Canadians' enjoyment of the gains from innovation; (2) Canadian utilities face unique circumstances (e.g., climate, renewable resource endowments) that require tailored innovations; (3) Canadians will reap economic development benefits from innovation that they fund; and (4) a greater level of innovation infrastructure among Canadian utilities will enable them to more quickly identify and adopt new technologies that offer benefits to their customers.

In a recent development, the Ontario Independent Electricity Operator ("IESO") is financing innovation in energy storage by contracting for 34MW of energy storage with five companies to demonstrate storage technologies that offer ancillary services to enhance the reliability and efficiency of the network. [37] The projects include large-scale batteries and thermal energy storage that provide ancillary services to the IESO while also meeting customer's thermal and power needs. For example, the thermal energy storage project aggregates thermal loads that can be switched on and off quickly.[38] One of the winners of the competitive storage solicitation offers a "power-to-gas" hydrogen-based storage solution that will deliver 2MW of storage capacity to the Toronto area when it is most valuable, and represents the coordinated reliance on natural gas pipelines and the electricity grid to deliver renewable energy to consumers. [39]

RECOMMENDED UTILITY INNOVATION FUNDING MODEL

Concentric surveyed utility innovation models from around the world and distilled best practices (the best practices and rationales for the recommended model are described below; the detailed survey results are included as Attachment B). Based on Canada's clear opportunity for greater funding for utility innovation and the identified best practices, Concentric recommends that Canadian utilities and regulators establish an innovation model for Canadian utilities that has the following characteristics.

- **Funding**
  - Initial funding level of $3-5 / customer/ year
  - Multi-year (at least three-year) authorization of funding
  - Cost recovery via a dedicated, reconciling mechanism (e.g., a variance account)
  - Fully ratepayer-funded
- **Regulatory Oversight and Program Management**
  - Majority share of funding to be spent on collaborative projects
  - Minority share of funding to be spent on internal, utility-specific efforts
  - Multi-year innovation investment plans subject to regulatory approval and formal stakeholder review
  - Regulatory guidance for criteria to address in "business case" to justify innovation activities
  - Sufficient discretion for utilities to optimize their portfolio of innovation investments without necessarily requiring project-by-project regulatory approval
  - Annual reporting to regulators of projects, spending, and achievements
  - Cost and management discipline promoted via traditional utility oversight
- **Collaborative, Innovation-Focused Entities for Gas and Electric Industries**
  - Program management for innovation efforts
  - Clearinghouse for findings from RDD&D projects
  - Centralized expertise, industry contacts, and RDD&D capacity
  - Substantive direction and oversight from regulators and public-interest stakeholders on Board of Directors or Advisory Council
  - Distinct membership programs with focus areas specific to applications and time horizon—e.g.,
    - Applications (Electric)
      - Generation
      - Transmission & Delivery
      - End-Use
    - Applications (Gas)
      - Transmission and Distribution
      - End-Use
    - Time Horizon
      - Near-term focus
      - Medium- and Long-term focus

RATIONALE FOR RECOMMENDED UTILITY INNOVATION MODEL

Several key themes emerge from the survey of utility innovation models and associated literature that are relevant to the consideration of a new innovation model by Canadian regulators and utilities.

THE PROPER FOCUS OF UTILITY INNOVATION EFFORTS

In general, government funding and programs are best positioned to support high-risk, early-stage R&D where public benefits are broad-based but uncertain. At the other end of the spectrum, technology vendors should play a primary role in funding and carrying out innovation activities that are closely tied to commercializing their own particular offerings since they stand to reap substantial financial rewards from successful commercialization.

In general, utilities ought to focus on innovations with a significant likelihood of direct customer benefits (e.g., cost savings from reduced energy use, improved reliability, new services for customers) or benefits focused on citizens of the jurisdiction in question (e.g., provincial economic development); although, many regulators also take into account more broadly shared societal benefits, most notably environmental benefits that tend to accrue across wide geographies if not globally, as in the case of climate change.

Utilities have a role to play in some more experimental, higher-risk innovation efforts with special relevance to the utility industry, and co-funding to spread the risk among large groups of customers (perhaps nationally or even internationally) may be appropriate—as in the case of EPRI's longer-term, breakthrough-focused innovation efforts.

The majority of utilities' innovation efforts and customer funding should be allocated to the roles utilities are most strategically positioned to fill. Utilities are uniquely positioned to drive innovation activities that require testing or large-scale demonstrations of new technologies on utility networks or with utility customers. Innovation projects that focus on integrating new technologies or identifying the best option from among various emerging technologies are especially suited for utilities' efforts since such projects draw on utilities' unique capabilities and offer fewer direct benefits for technology providers and more benefits for customers.

THE ROLE OF TAXPAYER, RATEPAYER, AND SHAREHOLDER FUNDING

As evident from the survey of utility innovation models, there are numerous examples of national and subnational governments investing taxpayer money in energy RDD&D as well as utility regulators directing customer funds toward RDD&D. There are no obvious examples of utility shareholders funding innovation. Under the U.K.'s Network Innovation Competition, shareholders must fund 10 percent of the cost of an innovation project, but that contribution is, in effect, reimbursed with customer funds if the project sponsor meets the criteria for project success. Notably, in an apparently rare example, the Pennsylvania Public Utilities Commission adopted a 75/25 sharing between ratepayers and shareholders of R&D expenses.[40]

The rationale for customer rather than shareholder funding rests on the crucial fact that utility shareholders' profits are regulated and that the benefits from utility innovation flow through to customers under price regulation (or accrue to other parties

entirely—e.g., society at large or technology vendors). Since customers ultimately reap the benefits of innovation, it is appropriate for them to bear the costs of innovation. In a 2011 resolution celebrating a 40-year collaboration with EPRI, the National Association of Regulatory Utility Commissioners ("NARUC") emphasized just that point when it said that "EPRI is primarily funded by the nation's electric utilities, and those costs are passed through to their consumers who also receive the benefits of the research."[41]

It is also appropriate for customers to bear the costs of innovation projects that do not ultimately deliver successful new technologies. As noted in an international survey of utility innovation, ratepayers should share in the cost of "dead-ends and sub-optimal out-turns" since these are a part of innovation and success is not possible without them.[42]

Why is there a role for utility customers, rather than just taxpayers, to fund innovation? Ratepayer funding of innovation activities can be justified according to a beneficiary-pays argument. In many cases, ratepayers enjoy most of the benefits realized from innovation (e.g., energy costs savings from new highly efficient end-use technologies) and thus ought to pay for that innovation. This beneficiary-pays approach suggests a greater role for taxpayer funding for more basic R&D at the early stages of the innovation pipeline that is likely to have broad social benefits. Even when taxpayer dollars may theoretically be the optimal funding source for certain innovation efforts, in the face of large benefits for utility customers from innovation but a lack of sufficient or timely financial support from provincial or federal policymakers, utility regulators may exercise the tools at their disposal to ensure that such utility innovation is appropriately funded.

Regulators should charge the industry consortia tasked with administering innovation efforts with fully exploiting all available co-funding from government programs, private sector firms, or other sources (e.g., other industry associations). Public-private partnerships, where government funding complements investments made by private firms, are particularly relevant in the case of large-scale demonstration projects where new technologies are still too risky to rely solely on private sector funding but too close to commercialization for normal government R&D support.[43] Utility industry consortia focused on innovation can coordinate industry efforts to identify and exploit opportunities for co-funding or public-private partnerships.

THE BENEFITS OF COLLABORATIVE RDD&D EFFORTS

There are multiple ways in which utility RDD&D efforts can be collaborative. Utilities can collaborate among themselves and with relevant technology vendors, particularly via industry RDD&D consortia. In addition, innovation efforts can be collaborative insofar as utility customers across multiple states or provinces can pool their financial contributions to fund consolidated RDD&D efforts. A collaborative approach to utility innovation offers several advantages.

Collaboration is warranted by the fact that the benefits of innovation will spillover to customers across many service territories and jurisdictions.[44] In addition, certain innovation efforts are too expensive for a single utility to fund on its own.[45] A single utility is likely to have an interest in a wider portfolio of innovation efforts than it can fund itself, and a given innovation project is likely to have value to many firms.[46] Collaborative innovation spreads the cost of high-risk projects and helps participants stay on top of technology

developments. Pooling resources on collaborative RDD&D efforts leverages the collective funding, intelligence, and experience of program members to efficiently resolve technical and market barriers.[47] The International Gas Union observed that collaboration improves innovation by "bringing together different minds and points of view, revealing actual scientific and technological issues."[48] Moreover, the nature of collaboration and co-funding of innovation allows utilities to prioritize funding for areas where there is overlapping interest and need.[49] As such, collaborative innovation efforts provide regulators with added confidence that innovation projects have value for customers.[50] Unique to the regulated utilities industry, willingness to collaborate is generally high because utilities do not compete with one another as firms in unregulated industries do. As a result of this willingness to collaborate and lack of guardedness about proprietary knowledge, utilities can be more open about sharing RDD&D results with their peers and vendors and thus maximize the value of innovation investments.[51,52] Having surveyed the success of various energy RDD&D efforts, some analysts have concluded that collaborative research has proven more successful in producing outputs of real commercial value.[53]

Utility collaboration via a dedicated research entity (e.g., EPRI or ETIC) provides particular benefits, while maintaining in-house innovation capabilities ensures utilities can fully exploit the outputs of collaborative innovation efforts. Innovation-focused organizations can maintain centralized bodies of expertise and technical capabilities to support RDD&D efforts that few individual utilities could maintain internally. In surveying international utility innovation projects, KEMA found that the involvement of partners (e.g., EPRI) was generally evident when utility RDD&D progress moved smoothly and noted that such entities "helpfully act as an interface with other network operators, manufacturers and research organisations."[54] Collaboration with universities and government laboratories also facilitates technology transfer.[55] R&D collaboration via a centralized industry consortium has the value of fostering a common technological "vision" to guide innovation for a given industry.[56] Firms that rely on external innovation organizations usually have significant internal capability as well in order to exploit external results.[57,58]

Allocating funding to an innovation-focused entity (e.g., an industry consortium) provides a venue to attract additional public and private investment. Such an entity is more likely to have the capacity to engage with technology vendors and to fund projects of sufficient magnitude to garner taxpayer cost-sharing.

One possible drawback to collaboration is the dilution of a utility's unique needs and interests in setting an innovation agenda. This suggests the need for flexibility in the allocation of innovation funding between internal utility innovation efforts, Canadian utility industry programs, and international innovation activities. In many cases, Canadian-focused programs may best serve Canadian utilities' innovation needs. However, Canadian utilities and regulators should not ignore opportunities to benefit from international collaboration, especially collaboration with the U.S. utility industry through such entities as EPRI and GTI. Such large-scale international innovation collaboration likely involves a trade-off between the benefit of leveraging more total innovation funding for each Canadian ratepayer dollar and sacrificing control over the innovation agenda and the ability to specifically tailor innovation programs to Canadian circumstances and policy goals.

A collaborative approach to innovation and a pooling of funding (e.g., via an industry consortium) offers particular benefits to smaller Canadian utilities. For example, Ontario has over 70 small electric utilities.[59] Through a collaborative approach, such small utilities could invest in projects that would be too expensive for them to pursue on their own. The same holds true for smaller provinces whose utilities that may lack a sufficient customer base to fund large-scale innovation efforts without collaborating across provinces. Attachment B profiles the American Public Gas Association Research Foundation and the National Rural Electric Cooperative Association Cooperative Research Network; both of these entities pool funds from small utilities to fund innovation projects that would otherwise be too large for the members to pursue individually. These entities also work to ensure that the new technologies and other learning that these innovation projects yield flow through to all of the member utilities, since not each small utility can directly participate in every innovation project.

GOVERNANCE AND OVERSIGHT OF UTILITY INNOVATION

The survey of utility innovation funding models revealed a variety of approaches to the governance and oversight of innovation efforts. The common theme, though, is an important role for regulators in guiding innovation efforts. However, regulators also recognize the value of granting utilities discretion and not being overly prescriptive in their oversight given the necessarily uncertain and creative nature of innovation.

Where regulators approve the remittance of customer funds to industry consortia focused on innovation, those industry consortia generally have substantial roles for regulators and other public interest stakeholders on boards or advisory councils (e.g., see the examples of EPRI and GTI in Attachment B). When utilities contribute customer funds to government-chartered research entities (e.g., the California Energy Commission and the New York State Energy Research and Development Authority), regulators tend to wield ultimate approval authority over at least high-level innovation programs if not specific projects. In many cases, regulators require public input from a variety of stakeholders to inform innovation agendas.

The survey of innovation funding models also highlights the critical role of robust justifications for utility innovation's benefits to customers and society at large in relation to the costs of innovation. Often regulators set forth explicit criteria that utilities or other project sponsors must address to justify investments in innovation, and chief among those criteria are likely benefits to customers. Such benefits can span multiple dimensions (e.g., reliability, safety, cost savings, environmental goals, job creation). Given the primacy that regulators and other stakeholders put on the affordability of utility service, utilities should strive to quantify innovation programs' benefit-cost profiles. Because some innovation efforts prove highly successful and others less so, regulators should take a portfolio approach to judge utilities' innovation performance, rather than weighing the outcomes of individual projects too heavily.[60] Affirming the findings from this paper's survey, an evaluation of energy innovation programs recently conducted by the Mowat Centre similarly highlighted "explicit, measurable public-benefit maximizing goals" and "a cross-cutting portfolio approach" as two hallmarks of successful programs.[61]

There is a balance to strike between rigorous innovation program justifications and allowing utilities the flexibility to pursue innovation

activities most aligned with customer needs and with emerging technological and industry developments. For example, the California Public Utilities Commission explicitly noted this balance when considering the California 21st Century Energy Systems Research Project ("CES-21", see Attachment B for details). A utility innovation funding model should limit excessive burdens related to justifying investments on a project-by-project basis and rather allow sustained investments to be guided by certain principles and criteria established with regulators. A utility innovation model should be nimble enough to continually optimize its portfolio of investments, identifying and exploiting new opportunities and abandoning less successful ones.

One of the primary rationales for taxpayer and ratepayer support for innovation is the knowledge spillover benefits from RDD&D activities. As such, ratepayer-funded innovation activities should be subject to information-sharing requirements (e.g., as in the case of the U.K.'s innovation stimulus program). Moreover, enhanced information sharing is an advantage of collaboration through an innovation-focused entity, like an industry consortium.

Moving from ad-hoc utility innovation efforts often reviewed in base rate cases to coordinated, industry-wide innovation programs with formalized regulatory oversight provides benefits in terms of national scope (a factor reportedly key to the success of Sustainable Development Technology Canada) and a comprehensive view of utility innovation efforts that can avoid duplication and optimally allocate utility investments across Canada.[62]

MAGNITUDE AND STABILITY OF FUNDING

Stability and sustainability of funding and adequate commercial and technical (rather than political) direction can promote more successful innovation. Because successful innovation efforts often play out over several years, regulators should promote approaches that ensure stable, predictable funding over several years so that utilities and their partners can plan and execute multi-year innovation projects.

Multi-year authorizations among those surveyed ranged from three years (i.e., Louisiana's gas utility RDD&D authorization) to eight years (i.e., California's Electric Program Investment Charge). Ongoing funding mechanisms like these can provide for a stable funding stream for a portfolio of innovation investments.

The Mowat Center's recent survey of energy innovation programs found that "continuity of support" was a critical success factor.[63] Industry executives have criticized certain government-funded innovation programs for favoring technologies with the most political appeal but not necessarily the best commercial and technical potential.[64] Regulators can avoid this pitfall via extensive involvement in setting innovation agendas from utilities and other stakeholders with relevant expertise.

The magnitude of innovation funding approved by legislators and regulators varies considerably, as shown in Attachment C. California currently directs about $16.50 and $2.20 per customer annually to public interest RDD&D for electricity and natural gas programs, respectively.[65] On the lower end of funding levels, a basic membership in Utilization Technology Development ("UTD") and Operating Technology Development ("OTD") for gas utilities costs $0.90 per meter annually in total. The range of funding levels identified via the utility innovation funding model survey suggests that approximately $3-5 per customer annually would be a reasonable

initial funding level for both electric and natural gas innovation programs. That range is generally consistent with the range of funding levels found in all but the most aggressive jurisdictions surveyed. While many of the jurisdictions surveyed provide higher levels of funding for electricity than for natural gas utility innovation programs, natural gas plays a larger role in the Canadian end-use energy mix, suggesting a greater level of funding in the Canadian context. Regulators could increase the level of funding over time as the Canadian utilities industry develops greater innovation capacity and as utilities and regulators create more extensive long-term innovation roadmaps and more detailed quantifications of innovation benefits and costs.

RATEMAKING AND REGULATORY ISSUES

Balancing accounts for innovation program costs incurred by utilities are a common mechanism for cost recovery, and some regulators (e.g., in California) have employed specific surcharges to fund innovation. Such cost recovery approaches that provide for a reconciliation of actual innovation costs and funds collected from customers offer two advantages. First, they limit the risk to utility shareholders of under-recovering costs, providing a greater incentive for utilities to undertake the inherently uncertain task of innovation. Second, without reconciling cost recovery mechanisms, the pressures of a rising-cost environment could lead utilities to shift revenues initially earmarked for innovation to other O&M or capital needs, especially where revenue requirements are established via "black box" settlement agreements. Such shifting of funds would short-change the need for longer-term innovation to meet immediate pressures to minimize costs.

As with all aspects of utility regulation, regulators must strike an appropriate balance between risks borne by utility shareholders and those borne by customers. In the case of innovation, the goal is to reduce the inherent risks to shareholders to be more in line with the overall level of risk of the utility business model. Completely eliminating the risk to shareholders could overly blunt utilities' incentive to contain costs and carefully evaluate potential innovation projects.[66] The U.K.'s approach under its innovation stimulus program requires shareholders to bear a portion of project costs subject, in effect, to refund upon meeting predefined success criteria, and this approach appears to be a unique one. In general, regulators satisfy their need to protect customers from excessive costs through substantial oversight of innovation programs and the traditional regulatory prerogative to examine a utility's books and management and potentially disallow imprudently incurred costs. The "used and useful" standard for regulatory cost recovery has generally not proven to be a barrier for utility investments in innovation with long-term and uncertain payback where regulators have taken a sufficiently broad view of the portfolio of innovation investments and the "used and useful" fruits of prior innovation efforts.

Incentive-based regulation (e.g., price caps with efficiency factors) may stimulate utilities to pursue small investments in very near-term innovations with near immediate payback in terms of lower operating costs since utilities stand to benefit from those savings under such regulation. However, the focus that incentive-based regulation puts on minimizing short-term costs is also likely to make utilities even less eager to invest in most innovation efforts absent a specific cost recovery mechanism for such investments (akin to the innovation

stimulus program under the U.K.'s incentive-based regulation). Italy also has incentive-based regulation and a noteworthy approach to spurring utility innovation by offering higher returns on invested capital for competitively selected innovation projects.

Regulators may consider whether innovation efforts could be carried out by non-regulated utility affiliates; however, utilities would still be reluctant to invest shareholder funds in innovation through unregulated affiliates since such affiliates would face the same basic market failures (i.e., externalities and spillovers) that make the private returns from RDD&D investments lower than the social returns and that lead to chronic under-investment in innovation. Moreover, to the extent that regulated utilities act as the ultimate customer for new innovations, utility incentives must ultimately promote adoption of these innovations.

CONCLUSIONS

Canadian electricity and natural gas customers and Canadian citizens at large stand to reap substantial benefits from greater levels of utility innovation that can deliver energy cost savings, safer and more reliable service, valuable new products and services, environmental benefits, and economic development (i.e., job creation and enhanced Canadian competitiveness). Challenging energy and environmental policy goals and the rapidly changing economics of energy supply options magnify the potential benefits from innovations that can make achieving policy goals more readily achievable and affordable and that can exploit increasingly affordable energy options in new ways.

Several evaluations of Canadian energy innovation efforts have called for improvements and highlighted the unique, strategic role that Canadian utilities and utility regulators can play. Utilities are uniquely positioned to drive RDD&D efforts related to technologies that work on their networks or that their customers use, particularly at the crucial demonstration stage.

A survey of utility innovation models from around the world points to a model for Canadian utilities and regulators that involves industry consortia that invest utility customer funds in innovation programs with rigorously evaluated customer and societal benefits under robust regulatory oversight and governance. An industry-wide, collaborative approach to innovation requires a unified approach among utilities and regulators to create or expand such consortia to maximize customer benefits.

ATTACHMENT A: EXAMPLES OF CURRENT CANADIAN FEDERAL AND PROVINCIAL SUPPORT FOR UTILITY INNOVATION

This section surveys several of the current efforts by the Canadian federal and provincial governments to support RDD&D projects relevant to the electric and gas utility industries. This is not an exhaustive list of such efforts but does illustrate the range of programs.

NATURAL RESOURCES CANADA ("NRCan")

NRCan has extensive involvement in energy innovation, directed by several groups within the broader umbrella organization.

CanmetENERGY is Canada's largest energy science and technology organization working on clean energy research, development, demonstration, and deployment. CanmetENERGY works with the energy industry, academia, and environmental stakeholders on a cost-shared basis through in-house work and funding support.[67] For example, CanmetENERGY is working with gas utilities on a renewable gas project to address technical gaps related to biomass feedstock conversion to biogas.[68]

The NRCan Office of Energy Research and Development ("OERD") is the Government of Canada's coordinator of energy R&D activities, responsible for the Clean Energy Fund, ecoENERGY Innovation Initiative, ecoENERGY Technology Initiative, and the Program of Energy Research and Development ("PERD").[69] There are numerous recent examples of RD&D sponsored by NRCan offices. They include co-sponsoring a recent project to test highly efficient natural gas furnaces.[70]

The Clean Energy Fund has supported several demonstration projects that address utility-scale electricity storage using batteries; electricity load control; and cold climate air-source heat pumps.[71] These projects include:

- An $3.9 million investment in the City of Colwood, British Columbia to saturate the community with renewable and other technologies including installation of solar thermal and PV systems in the fire station and other public buildings, installation of solar- thermal, smart-grid, energy reducing, and energy monitoring technology in residential homes, and provide infrastructure to support the use of electric vehicles.[72]
- Application of a $978,000 grant to Great Northern Power Corporation to demonstrate new technology that would allow waste heat recovery to generate electricity from reciprocating engines that are used to process natural gas.[73]
- A $6 million project to test "smart grid" system control technologies that support optimization of Volt and VAR on Hydro Quebec's distribution network without any adverse impacts to power quality.[74]
- A $15.9 million load control demonstration project in New Brunswick that would rely on load shifting by 2,000 domestic and business customers to accommodate the integration of wind energy.[75]

- BC Hydro is investing $6.495 million to install large scale energy storage to study the impact on resiliency and reliability in an area of its system that is prone to weather-related outages.[76]

The ecoEnergy Innovation Initiative focuses on RD&D that improves the efficiency of energy use while contributing to a cleaner environment. Recent initiatives include a $1 million program, sponsored by the Pollution Probe foundation, to expand the use of electric vehicles in five municipalities of Toronto. They plan to do this by investigating the ability of distribution systems to keep up with increased power demand as EV use expands.[77] Striving to accomplish the same goals, BC Hydro has a $4.125 million grant that it is using to construct 300 public charging station and 30 fast charging stations.[78]

The ecoEnergy Technology Initiative focuses on research to promote cleaner air and to reduce greenhouse gas emissions. For example, the ecoEnergy Technology Initiative is directing two programs that focus on carbon capture and storage. The Fort Nelson Exploratory Project is being led by Spectra Energy Transmission and will examine the technical feasibility of injecting large volumes of sour CO2 into deep saline formations for permanent storage. Spectra's Fort Nelson natural gas processing plant will provide the carbon dioxide. A TransAlta Pioneer Project in Edmonton, Alberta will store carbon in deep saline formations for subsequent use in Enhanced Oil Recovery.[79]

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA ("SDTC")

SDTC is a not-for-profit foundation funded by the Government of Canada that finances and supports the development and demonstration of clean technologies which provide solutions to issues of climate change, clean air, water quality and soil, and which deliver economic, environmental and health benefits to Canadians.

SDTC portfolio projects include: utility energy storage; advanced renewable electricity generation (e.g., tidal power, concentrated photovoltaic systems); highly efficient LED lighting; microgrid applications; highly efficient combined home ventilation and space/water heating system. [80]

The most recent SDTC portfolio projects include solar power generation, oil sand exploration and production, hazardous waste disposal, and de-polymerization of recycled plastics. SDTC is investing $10 million total in these projects. [81]

The CGA recently formed the SD Natural Gas fund in a partnership with SDTC that will invest $30 million over a three-year period in emerging clean end-use technologies that are being developed by small and medium-sized enterprises. The SDTC announced its first application period in February 2014 looking for projects relating to downstream natural gas technologies such as residential space conditioning, commercial space conditioning, industrial steam generation, power generation (remote fuel switching), transportation technologies, and renewable gas. The projects have "proof of concept" but are not yet commercialized. As project manager for the fund, SDTC will select the projects to fund using pre-established criteria. Canada's natural gas utilities can elect to participate and thereby provide critical market exposure to potential technologies.[82]

ATLANTIC CANADA OPPORTUNITIES AGENCY ("ACOA")

ACOA supports programs designed to stimulate the development and commercialization of new technologies in Atlantic Canada, including the

Atlantic Innovation Fund, which provides R&D funding made possible through a Government of Canada initiative. [83]

ALBERTA INNOVATES ENERGY AND ENVIRONMENTAL SOLUTIONS ("AI-EES")

AI-EES is the lead agency for energy and environmental research in Alberta, providing funding and technical assistance. Projects include supercapacitor energy storage for wind power and carbon capture and storage. More recently AI-EES announced that it would be providing $35 million over a five- year period that could "prove one person's garbage is another person's energy source."[84]

ALBERTA INNOVATES TECHNOLOGY FUTURES ("AITF")

The iCORE program provides grants and education for Alberta citizens that have the potential to be future innovators. The high school and undergraduate program is known as the geekStarter program and assists students in preparing for international competitions and collaborations such as the Microsoft Imagine Cup. There are also grants and awards provided for graduate students in all field and especially in doctoral programs.[85]

ATTACHMENT B:
SURVEY OF UTILITY INNOVATION MODELS

This section presents the results of a survey of (primarily) utility innovation models conducted to inform the recommendation for an optimal approach for Canadian utilities and regulators. An innovation model refers to the source of funding and the method of program administration and governance (e.g., collaboration, project selection). While not exhaustive, the survey examines models applied to utility (and, in some cases, energy more generally) innovation in Canada and throughout the United States and internationally in order to identify best practices.

In the interest of grouping similar utility innovation models together, the table below describes a set of basic model descriptions that differ in such ways as who funds innovation, the degree of coordination and collaboration, and the level of utility involvement. The survey uncovered many variations on the basic types, and the remainder of this section explores those variations in more detail and calls out the key aspects most relevant for a new approach to utility innovation in Canada.

Table 3: Taxonomy of Utility Innovation Funding Models

Funding Model	Description	Examples
"Laissez Faire"	A purely free-market approach to innovation that leaves it entirely in the hands of the private sector is a theoretical option for the energy industry but not one apparent among any major economies (e.g., Canada, the United States, Europe).	None
Taxpayer Financing	In this model the government funds innovation directly (e.g., via grants) or indirectly (e.g., via tax credits). Such support can be provided by national or subnational governments and may include cost-sharing with companies or other research entities. This approach is widespread, especially in the case of higher-risk R&D.	Canadian Clean Energy Fund; Sustainable Development Technology Canada; Ontario Centres of Excellence Special Energy Fund; U.S. Department of Energy
Ad Hoc Utility Programs	Utilities pursue RDD&D projects at their discretion with regulatory oversight and cost recovery akin to traditional utility activities. In some cases, there may be particular regulatory guidance for utilities' innovation efforts and for cost recovery. In general, utilities recover the costs of innovation since they are reluctant to engage in RDD&D without cost recovery.	Hydro-Québec's IREQ; Ontario natural gas DSM guidelines allow utilities to propose R&D and pilot projects.
Voluntary Industry Consortium	Utilities and other firms voluntarily contribute to an industry consortium tasked with RDD&D activities. Utility members seek cost recovery for their contributions.	ETIC; EPRI; Utilization Technology Development ("UTD") and Operations Technology Development ("OTD"); NYSEARCH; Pipeline Research Council International, Inc.

Funding Model	Description	Examples
Mandatory Industry Consortium	Governments or regulators require utilities or other firms to contribute to an industry consortium tasked with innovation activities.	Central Research Institute of Electric Power Industry (Japan); Gas Research Institute (now defunct); Propane Education and Research Council
Surcharge / Tracker to Fund Utility-Directed Programs	Regulators approve a surcharge or balancing account to create a dedicated funding stream for utilities' RDD&D activities with funds collected from customers spent on programs administered by the utilities and on projects largely chosen by the utilities subject to regulatory oversight.	California 21st Century Energy Systems Research Project; Montana Universal System Benefits Program; New York Millennium Fund
Surcharge / Tracker to Fund Public Interest RDD&D Entity	Regulators or legislators mandate a surcharge collected from utility customers and remitted to a stand-alone, public-interest RDD&D entity that may be a government or non-profit entity. In this case, utilities typically have limited say in how funds are spent.	Brazil's CT-Energ; California Electric Program Investment Charge and Natural Gas Public Purpose Program; Delaware Energy Office; Iowa Energy Center; New York System Benefits Charge; U.K. RIIO Innovation Stimulus

The sections below explore salient features of surveyed innovation programs, with programs grouped by general funding model.

TAXPAYER FINANCING

There are many examples of taxpayer-financed energy innovation. This section highlights two that offer useful lessons.

U.S. Department of Energy ("DOE")

DOE spends substantial amounts of money funding energy-related innovation ranging from basic science research to full-scale energy technology demonstration projects. Of particular note, the Energy Policy Act of 2005 mandated cost-sharing for future DOE RDD&D programs, with the minimum non-federal share set at 20 percent for R&D programs and 50 percent for demonstration and commercial application programs (with the potential for DOE waivers in certain circumstances).[86]

Sustainable Development Technology Canada

SDTC is a not-for-profit foundation funded by the Government of Canada that finances and supports the development and demonstration of clean technologies which provide solutions to issues of climate change, clean air, water quality and soil, and which deliver economic, environmental and health benefits to Canadians.[87]

A recent report from the Mowat Centre found that:

> *Sustainable Development Technology Canada (SDTC) is a noteworthy exception in the federal [energy R&D] framework, in terms of both its longevity and its high degree of effectiveness as measured by outcomes. The organization has a clear mandate to develop the most promising pre-commercial clean technologies, an independent governance structure, and operates arms-length from the*

> *government. National scope is a strong advantage giving it a unique perspective and awareness of diverse regional capabilities and existing projects, thereby avoiding duplication. The program is widely applauded by stakeholders.*[88]

The national scope that has reportedly contributed to SDTC's success is currently lacking from Canadian utility innovation but could be provided by innovation-focused industry consortia and a coordinated approach by utility regulators.

VOLUNTARY INDUSTRY CONSORTIA

Gas Technology Institute ("GTI"), Utilization Technology Development ("UTD"), and Operating Technology Development ("OTD")

GTI is an industry R&D laboratory established in 2000 in the United States. UTD and OTD are U.S. industry-led consortia created in 2003 to fund gas operations and end-use efficiency innovation, respectively. UTD and OTD have 14 and 19 member utilities, respectively. Most UTD- and OTD-sponsored R&D activities are performed by GTI, and GTI manages any projects performed by third parties for UTD and OTD. GTI also has a Sustaining Membership Program ("SMP") that allows gas utilities to fund longer-term, higher-payoff R&D projects via annual financial commitments; the SMP has 16 gas utility members. Technologies initially developed through the SMP can advance into the UTD and OTD innovation pipeline for further progress toward widespread commercialization. Twenty-five states currently permit one or more gas utilities to recover the RDD&D funding provided to GTI and/or OTD/UTD.[89] Gas utilities can choose to allocate their contributed funds across a set of portfolio projects managed by GTI or to devote money to their own projects through GTI using membership contributions. For UTD and OTD, membership contributions are calculated on a per-meter basis. For UTD, for example, the member utilities contribute $0.40 per meter for a minimum of $100,000 and a maximum of $250,000 per year; smaller utilities can pool contributions to meet the minimum investment level.

GTI, UTD, and OTD are examples where utilities leverage their innovation investments with the approval of their regulators and fund a mix of near- to long-term RDD&D projects. Moreover, utilities have discretion in how their financial contributions are used and can allocate them to the projects most relevant to their customers' needs.

GTI maintains active engagement with state regulators, including providing regular briefings to NARUC and supporting utilities with expert testimony in regulatory proceedings. GTI's governance model includes a mechanism for guidance from public-interest and other non-utility stakeholders. GTI maintains a Public Interest Advisory Committee made up of public utility commissioners, consumer advocates, and environmental, economic, and academic experts.[90]

American Public Gas Association ("APGA") Research Foundation

APGA is a non-profit trade organization that represents the interests of American publicly owned natural gas utilities (i.e., municipal gas systems). The APGA Research Foundation serves as the "bank" for the voluntary R&D contributions from more than 150 contributing public gas systems and directs funds to UTD to advance projects in its members' interest.[91,92]

Electric Power Research Institute ("EPRI")

Created in 1972, EPRI is an independent, non-profit industry consortium focused on research,

development, and demonstration activities that span the full spectrum of the electricity system from generation to end use with innovation efforts that are both long-term and short-term in focus. EPRI is a voluntary membership organization with more than 1,000 member organizations, with extensive participation among U.S. electric utilities and engagement by certain Canadian utilities and other entities around the world. EPRI offers "base" and "partial" membership options depending on the breadth of members' research interests, and EPRI devotes a portion of membership funds to its Technology Innovation Program, which leads early-stage innovation aimed at potential breakthrough technologies. EPRI also focuses on innovation activities that cut across specific vendor technologies and that can complement R&D activities undertaken by manufacturers—e.g., activities that can help members pick the best new technologies, apply them effectively, and operate them efficiently.

EPRI's utility members recover their membership dues from ratepayers with regulatory approval, and EPRI maintains a close relationship with NARUC, conducting regular outreach and education.[93]

EPRI's governance model includes substantial input from a wide array of stakeholders with a central role for utility regulators. EPRI established a public Advisory Council to oversee its public interest mission. The Advisory Council consists of 30 individuals from academia, government, business (non-utility), and environmental organizations, as well as 10 state public utility commissioners appointed by the president of NARUC.[94]

National Rural Electric Cooperative Association – Cooperative Research Network ("NRECA-CRN")[95]

The NRECA-CRN monitors, evaluates, and applies new technologies for its members. The NRECA-CRN reports an R&D budget of $5 million funded by a $0.55 per meter voluntary contribution from its members. A six-member advisory board ensures that CRN members have a voice in research-project selection, funding, and organizational policy. Research efforts include renewable and alternative energy and end-use technologies.

Pipeline Research Council International, Inc. ("PRCI") [96]

Formed in 1952, PRCI is supported by voluntary contributions from 51 pipeline companies and vendors (2009 budget of $13 million supported 150 active projects) to support R&D related to pipeline operations. The U.S. Department of Transportation provides substantial co-funding of projects. PRCI allocates its members' contributions to the projects of greatest interest and need through an annual, iterative voting process, and all member companies share the R&D project results.

MANDATORY INDUSTRY CONSORTIA

Gas Research Institute ("GRI")

GRI eventually evolved into the Gas Technology Institute. For roughly two decades from its creation in 1976, however, GRI's RDD&D programs were funded by a surcharge on interstate gas sales approved by the Federal Energy Regulatory Commission ("FERC"). At its peak year in 1995, GRI had a budget of $321 million (in current dollars).[97] GRI was a planning and funding organization managed by a public board of directors. FERC annually reviewed GRI's funding on a project-by-project basis, which led GRI to develop a project assessment methodology that combined objective criteria, probabilistic assessments, and quantified subjective judgments by independent experts.[98] In 1997, gas industry restructuring led the pipeline companies to

withdraw their support for the GRI surcharge, which was phased out over seven years. Subsequent to the withdrawal of mandatory funding, GRI evolved into GTI and its current voluntary funding model (described above).

GRI's governance model included an industry-led board of directors that represented gas producers, pipelines, and utilities. GRI also had an advisory council of non-industry stakeholders whose purpose was to help ensure that GRI's funding decisions aligned with the public interest.[99]

Japan's Central Research Institute of Electric Power Industry ("CRIEPI")

Founded in 1951, CRIEPI is a non-profit foundation funded through a 0.2 percent surcharge levied on all electricity sales by Japan's 11 privatized utilities.[100] CRIEPI engages in primarily basic, longer-term R&D related to energy and the environment. CRIEPI has three main research areas—i.e., nuclear power technology, stable power supply technology, and environmental energy technologies—and three major project themes that cut across those areas—i.e., promotion of electrification, energy conservation, and use of low-carbon power sources.[101]

Propane Education and Research Council ("PERC")

PERC was created by the U.S. Congress in 1996 and established subject to a two-thirds approval in a referendum of propane industry members. Once established, the PERC was authorized to impose a mandatory assessment on propane sales, part of which funds are devoted to research projects.[102] The mandatory assessment is $0.004 per gallon of propane, which provided more than $33 million in 2013.[103] PERC's innovation funding covers projects to develop efficient propane utilization equipment, and RDD&D constituted 53 percent of PERC's 2013 budget for operating programs.[104]

The statute creating PERC also set forth certain governance requirements. PERC must publish its annual budget plan for public comment and submit it to the Secretary of Energy and Congress, and the Secretary of Energy may recommend programs and activities for PERC to pursue.[105]

Louisiana Gas Utility Research

Louisiana is a noteworthy case where state utility regulators required the state's gas utilities to join OTD and UTD and recover their membership contributions from customers. Whereas OTD and UTD are voluntary industry RDD&D consortia, Louisiana regulators, in effect, treated them as mandatory industry consortia for the state's gas utilities.

In 2008, the Louisiana Public Service Commission ("LA PSC") required the state's gas utilities to join the UTD and OTD and created the Louisiana Research and Development Committee ("RDC"), which includes a PSC staff representative and all gas utility companies.[106] Gas utilities are allowed to recover $0.90 per meter for innovation funding provided to UTD and OTD. GTI submits project proposals to the RDC which selects preferred projects to fund with Louisiana customer money. The PSC's 2008 order required a three-year review to reauthorize the innovation charge, which was renewed in 2011. In its three-year review report, Louisiana PSC Staff stressed that gas utilities are allowed to collaboratively choose projects for funding and that the utilities themselves are in a unique position to identify projects worthy of funding.[107] The PSC Staff also pointed to specific examples of in-state economic development spurred by innovation projects.[108]

SURCHARGE TO FUND UTILITY-DIRECTED RDD&D

California 21st Century Energy Systems Research Project ("CES-21")

California is a noteworthy case study because it has legislation that makes energy innovation a cornerstone of state energy policy.[109] California law explicitly authorizes the California Public Utilities Commission ("CPUC") to allow utilities to recover RDD&D costs and lays out guidelines for reviewing utility innovation projects that include: having a "reasonable probability of providing benefits to ratepayers," avoiding duplication of effort, and achieving objectives that include "conservation by efficient resource use or by reducing or shifting system load."[110]

In December 2012, the CPUC authorized $30 million per year in funding to be collected from customers for a 5-year research project between the state's three large electric investor-owned utilities ("IOUs") and the Lawrence Livermore National Laboratories ("LLNL").[111] The focus of CES-21 is on developing advanced modeling, simulation, and analytical tools—by leveraging LLNL's high-performance computing capabilities—to generate new data and insights into electric resource planning, smart grid operations, cyber security, and gas system planning and operations.[112] The substantial, long-term financial commitment required to fund such cutting-edge research and analysis would not be possible without this program. Without this program, California utility customers would never realize the benefits promised by leveraging high-performance computing capabilities to tackle emerging industry challenges.

The CPUC's decision approving the CES-21 and setting forth requirements for governance and program administration offers a unique look at how regulators can establish a framework for funding cutting-edge energy innovation. Noting the emerging needs of the utilities, the CPUC approved the use of "illustrative cases" of potential research projects in justifying the overall CES-21 research effort, rather than requiring specific, detailed project proposals that might lock the effort into ultimately unproductive projects given the "rapidly changing technologies and energy priorities" in California. The CPUC approved a 6-member board to govern CES-21, with half the members from utilities and half chosen by utilities from academia or research institutes. Research proposals must have the support of a majority of the board to be funded, and research proposals must include a "business case" with a benefit-cost analysis. Research proposals must also be approved by the CPUC annually via an advice letter process subsequent to a public workshop to review proposed research activities with stakeholders.[113] Advice letters seeking approval of CES-21 research projects must explain how the projects are not duplicate of other research (e.g., by EPRI, U.S. DOE). Importantly, the CPUC stressed the "inherent tension" between regulatory oversight and the "creative, sometimes unpredictable process" of R&D value creation. The CPUC also emphasized the stability provided by its five-year authorization of CES-21 funding. The three IOUs recover their CES-21 costs through balancing accounts.

In February 2014, CPUC issued a decision updating CES-21 in response to 2013 Senate Bill 96, which reduced funding levels that had previously been established by the CPUC. Responding to criticism from the Ratepayer Advocate and citing insufficient "peer review and oversight," the bill dramatically reduces the budget from $30 million per year, for 5 years ($152.19 total), to $35 million total over 5 years. The CPUC decision also restricted RDD&D projects to cyber security and grid

integration, and reduced the governing board of the program from six to three members (these member represent only the utilities).[114]

Massachusetts Department of Public Utilities ("MADPU") Decision Regarding Modernization of the Electric Grid[115]

The MADPU recently issued an order on electric grid modernization establishing a requirement that each electric utility file a Grid Modernization Plan ("GMP"). The order addressed the value of innovation specifically, establishing a "Process for Adoption of New Technologies." Electric distribution companies, as part of their GMP's, are required to propose a list projects that could include "smart inverter systems, energy storage vehicle to grid, and software and hardware tools that optimize system planning and management." The focus of these projects should be on testing, piloting, and deploying RD&D projects that explore new technologies focusing on modernizing the grid.

With respect to funding, the Order acknowledges that ratepayer funds will be applied, but explicitly directs the electric utilities to leverage outside funding and pursue collaboration to the extent possible. The MA DPU also recognized that not all RD&D projects would be successful but that cost recovery would still be allowed, as long as projects were managed appropriately. The electric distribution companies will be required to submit progress reports with their GMP's on funding, status, and results of the project as well as "lessons from collaborative efforts."

Montana Universal System Benefits Program ("USBP")[116]

Montana's electricity restructuring law created the USBP in 1997. The USBP surcharge collected from customers by utilities supports cost-effective energy conservation, renewable energy projects and applications, and research and development programs related to energy conservation and renewables. Utilities have discretion in spending the USBP funds collected and can fund internal or external programs.

The NorthWestern Energy-Renewable Energy Fund collects approximately $9 million annually under the USBP and funds public awareness and education of renewable energy ($1.2 million) and the rest to solar and wind incentives. [117]

New York Millennium Fund

In 2000, the New York Public Service Commission ("NYPSC") approved a gas R&D ratepayer funding mechanism to replace the expiring pipeline surcharge that had funded the GRI and GTI.[118] The surcharge (known as the Millennium Fund) supports medium- to long-term R&D (i.e., activities that are at least 2-years removed from becoming commercial products); NYPSC staff noted that R&D that is closer to commercialization tends to be lower cost and lower risk and thus more amendable to internal utility R&D activities traditionally funded through base rates or manufacturers' R&D efforts.[119] Millennium Fund money must be allocated 80/20 to co-funded and internal R&D projects, respectively, to ensure the benefits from co-funding (particularly that co-funding directs funds to areas with the most interest and need) while also allowing utilities the discretion to fund unique R&D work particular to their own businesses.[120] Millennium Fund money is spent with GTI, OTD, NYSEARCH, or other R&D entities at the utilities' discretion.[121]

The NYPSC specifically rejected funding end-use focused R&D, noting that gas appliances have national applications not limited to New York and should be researched by manufacturers.[122] However, this position is an outlier among those surveyed as regulators who approve substantial innovation programs

do generally support customer-funded end-use innovation, noting the benefits to customers and the lack of sufficient public and private investment in RDD&D. Moreover, the NYPSC's position on gas end-use RD&D seems to be at odds with the NYPSC's position on electricity end-use innovation given that the electric system benefits charge funds innovation specifically related to energy efficient products and services (see below for more details).[123]

SURCHARGE TO FUND PUBLIC-INTEREST RDD&D ENTITY

Brazil's Mandatory Electricity R&D Investments[124]

Brazil presents a hybrid funding model with money directed to internal utility programs and a public-interest research entity. By law, Brazil's electricity generation and transmission companies must invest at least 1 percent of their net operating revenue in R&D, and electricity distribution companies must invest at least 0.5 percent. Brazil's electricity regulatory, ANEEL, has set out guidelines for how those R&D funds must be spent. 40 percent of R&D funds are kept within the companies for internal projects, 40 percent are collected to fund the Energy Sectorial Fund (CT-Energ), and 20 percent are allocated to fund studies and research in energy system planning. One of CT-Energ's focus areas is development of highly energy-efficient technologies with social benefits.[125]

California Electric Program Investment Charge ("EPIC")

From 2002 through 2011, legislation in California directed the CPUC to order the state's three large IOUs to collect $62.5 million per year via a "special rate component" to fund research, development, and demonstration activities. These funds were directed to the California Energy Commission's ("CEC") Public Interest Energy Research ("PIER") program.[126]

This legislative authorization for an RDD&D surcharge sunset at the end of 2011; however, California Governor Jerry Brown wrote to the CPUC and urged it to use its existing authority to continue to fund electricity RDD&D. The CPUC initiated a proceeding that ultimately created the new EPIC funding stream for RDD&D of $162 million per year, which the CPUC authorized for the period 2013-2020. The CES reports that investments funded by EPIC include: next-generation end-use energy efficiency technologies for the building sector; new technologies for distributed generation; emerging utility-scale renewable energy generation; grid-level electricity storage; and advanced technologies to optimize the benefits of plug-in electric vehicles.[127]

EPIC constitutes a hybrid funding model with 80 percent of the funds collected by the utilities via customer surcharges remitted to the CEC to administer RDD&D activities and 20 percent retained by the utilities to fund their own innovation programs, with the utilities' efforts limited to the areas of technology demonstration and deployment.[128]

The CPUC authorized EPIC funding for the areas of applied research and development, technology demonstration and deployment, and market facilitation for clean energy technologies.[129] Each of the state's three large electric IOUs and the CEC submits triennial R&D program applications to be reviewed and approved by the CPUC. This process replaces the prior Commission review of utility innovation programs in general rate cases and allows the CPUC to take a comprehensive view of electricity innovation programs.

In reviewing the triennial applications, the CPUC explained that its focus is on "clear

electricity ratepayer and societal benefits."[130] R&D investment plans must quantify estimated benefits to ratepayers and to the state that can include: "Potential energy and cost savings; Job creation; Economic benefits; Environmental benefits; and Other benefits."[131]

Due to its recent creation, EPIC has yet to fund any RDD&D projects. As of late July, select projects under the $25 million funding category, "Technologies and Approaches for More Affordable and Comfortable Buildings" have passed Stage One and will soon be submitting formal funding proposals for Stage Two.[132] The projects that passed Stage One include attic design projects, direct current and energy storage projects, and commercial building efficiency projects.[133] There are also programs under the categories "Developing Advanced Energy Storage Technology Solutions to Lower Costs and Achieve Policy Goals" ($6 million) and "Advancing Utility-Scale Clean Energy Generation" ($9.5 million) that are currently submitting applications for Stage One.

California Natural Gas Public Purpose Program ("PPP")

California legislation passed in 2000 (AB 1002) called on the CPUC to establish a surcharge on natural gas customers, which never sunsets, to fund public interest research.[134] The CPUC ultimately established the natural gas PPP surcharge to collect up to a maximum of $24 million per year and made the CEC the program administrator. Each year, the CEC provides a prioritized list of RDD&D projects to be reviewed and approved by the CPUC.[135] The CPUC, though, also encouraged utilities and other parties to provide input for this list noting their "unique knowledge regarding particular energy problems."[136] Notably, the CPUC adopted a broad definition of public interest gas R&D—i.e., "Public interest gas R&D activities are directed towards developing science or technology, 1) the benefits of which [sic] accrue to California citizens and 2) are not adequately addressed by competitive or regulated entities."[137] The CPUC also established criteria for such projects: "1) Focus on energy efficiency, renewable technologies, conservation and environmental issues, 2) Support State Energy policy, 3) Offer a reasonable probability of providing benefits to the general public, and 4) Consider opportunities for collaboration and co-funding opportunities with other entities."[138] Projects proposed to the CPUC must explain how they meet the criteria for public interest R&D and provide cost and benefit details.[139]

According to the 2014 CPUC Energy Division Report, the total 2013 cost of "gas related" Public Purpose Program projects was $552 million, an 11% decrease from the 2012 costs. However, most of the gas-related funds in this program are allocated to the CARE program that provides discounts to customers who need help paying their utility bills. Only $24 million of the 2014-15 budget is directed to gas R&D projects. The CPUC established a set of criteria the programs need to meet including:

1. "Focus on energy efficiency , renewable technologies, conversation and environmental issues
2. Support state energy policy
3. Offer a reasonable probability of providing benefits to the general public, and
4. Consider opportunities for collaboration and co-funding opportunities with other entities."[140]

The funds will be distributed among research in the areas of "Energy Efficiency ($8.6 million), Energy Infrastructure ($9.5 million), and Renewable Energy and Advance Generation ($3.5) million." Under the area of Energy

Infrastructure the CPUC has made a specific point to allot $2.5 million to pipeline integrity and safety. Although these categories and subcategories are detailed further in the order, there is no detail on specific projects to be funded in this fiscal year.[141]

Delaware Energy Office

Delaware's electricity restructuring legislation passed in 1999 established a public benefit funds collected from customers by electric utilities to support renewable energy incentives, energy efficiency education programs, technology and demonstration grants, and research and development grants administered by the Delaware Energy Office.[142,143,144]

The Green Energy Program and Fund provides incentives for renewable energy projects and is administered by the Delaware Energy Office, Delmarva Power, Delaware Electric Cooperative, and Delaware Municipal Electric Corporation (DEMEC). However, the program is currently being revised in to comply with the 2012 Delaware Energy Act.[145] This Act intended to make the Green Energy speed up the application and approval process, improve the clarity of program requirements, and allow for adaptation to changes in the industry.[146]

Each of the three sub-programs provide incentive rates or grants to technologies that focus on photovoltaics, solar water heating, wind, and geothermal systems. Delmarva Power's updated incentive rates for green energy were released as of July 2014 and are also currently accepting grant applications for new technologies.[147] Delaware Electric Cooperative's Renewable Resource Program accepted grant applications for the identical technologies as of January 2014.[148]

Iowa Energy Center

Created by state legislation in 1990, the Iowa Energy Center promotes energy efficiency and renewable energy R&D and is funded by an annual assessment of 0.085 percent of gross intrastate revenues of all natural gas and electric utilities in Iowa.[149,150] In 2012, the annual utility assessment provided $3.9 million.[151] The remaining funds from the 2012 utility assessment and the $3.9 million provided in 2013 created a total of $6.74 million available for utility grants.[152] The Iowa Energy Center has an Advisory Council that provides input on planning and budgeting issues; the council consists of members from the research and education, public, and utility sectors, including a member of the Iowa Utilities Board and a representative from the Office of Consumer Advocate.[153]

In the coming year, the grant funds will be distributed among various projects that help promote energy efficiency in Iowa such as the Innovative Energy Solutions Alternative Fuel Project which was provided $130,000 to research the conversion of "waste hydrocarbons into useful transportation fuels."[154]

New York Technology and Market Development ("T&MD") Portfolio

The NYPSC created a system benefits charge ("SBC") in 1996 with the funded programs administered by the New York State Energy Research and Development Authority ("NYSERDA") subject to oversight by PSC Staff; the SBC is reauthorized at 5-year intervals by the NYPSC.[155] As program administrator, NYSERDA consults with interested parties, prepares plans to fund programs within the categories established by the NYPSC, and evaluates and reports on funded programs.[156] The SBC funds a wide range of programs extending from R&D to subsidies for adoption

of energy efficiency measures. Describing the benefits of the SBC programs, the NYPSC explained that:

> *Since their inception, these programs have produced significant reductions in peak electric demand, helped numerous advanced technologies to reach commercial availability or market adoption, supported the start-up and growth of clean tech companies, expanded the availability of energy efficient products, and supported training of essential clean energy practitioners and educators.*[157]

In 2010, NYSERDA submitted to the NYPSC a proposal to "further extend the SBC with a renewed vision of the program," which became the T&MD program.[158] NYSERDA explained that the "vast majority" of its funding was "focused on expanding market adoption of commercially available technology" and proposed that the future SBC-funded efforts "should 'feed' new technologies and services" into the energy efficiency and renewable resource acquisition programs.[159] NYSERDA's new SBC-funded T&MD program is of particular relevance as a model for funding utility innovation. The T&MD program encompasses activities to:

> *Accelerate energy innovation through support for scientific research and market analysis, investment in technology development and demonstration, promotion of a clean energy economy through business and market development, acceleration of adoption of clean energy technologies and practices, and the incorporation of more rigorous energy-use standards in codes and industry best practices.*[160]

The NYPSC expressed the need for NYSERDA to provide rigorous justifications for the proposed T&MD programs and not to spread its dollars too thinly to be impactful, noting that the Commission's "central objective is that there is a high level of confidence that ratepayers will benefit from the T&MD expenditures."[161] Justifications for the NYSERDA T&MD program must explain, inter alia, why the projects will benefit New York ratepayers specifically and the likelihood of leveraging outside funding.[162] The NYPSC emphasized the important role of stakeholder input to the NYSERDA program plan to ensure it is "well-conceived, appropriately funded" and making use of available external funding.[163]

Under the New York SBC model, utilities collect SBC funds from customers but have no say in how those SBC funds are used by NYSERDA (aside from participating in NYSERDSA's stakeholder engagement process), but utilities can apply to receive funding from NYSERDA for their own innovation projects.[164]

After the closing of the 2006-2011 authorization period, NYSERDA reported that the annual project funding was approximately $154 million. About half of these funds were allocated to "energy efficiency resource acquisition" and half to TM&D activities. The expected budget for the current authorization period (2012-2016) is $98.8 million per year. Over the current authorization period, funds will be allocated to three main categories including Power Supply and Delivery (smart grid and CHP), Building Systems, and Clean Energy Infrastructure. [165]

As part of their Electric Power Transmission and Distribution Smart Grid Program, the TM&D fund is allocating Clarkson University $381,000 for their designs of a resilient underground microgrid. In the city of Potsdam, reliability is a constant challenge due to flooding and winter storms. The creation of an underground microgrid would provide efficient

and reliable electricity for Clarkson, SUNY Potsdam, Canton-Potsdam Hospital, and other local businesses.[166]

U.K. RIIO Model Innovation Stimulus

The U.K. Office of Gas and Electricity Markets ("Ofgem") recently completed its latest iteration of incentive-based ratemaking (termed the Revenue = Incentives + Innovation + Outputs, or "RIIO," model) for gas and electric transmission and distribution companies, and the most recent framework includes specific elements to foster innovation.[167] Ofgem recognized that even within the new incentive-based ratemaking framework, "research, development, trials and demonstration projects - the earlier stages of the innovation cycle - are speculative in nature and yield uncertain commercial returns."[168] Ofgem noted that the innovation stimulus is intended to "kick start" a cultural change at utilities.[169] Innovation funding is provided by customers since they will benefit from innovations.[170]

Ofgem created two distinct innovation funding programs. The Network Innovation Allowance ("NIA") is to fund smaller innovation projects that can deliver benefits to customers and is a set annual allowance available to each network operator.[171] For electricity distribution, Ofgem required utilities to define innovation strategies based on NIA funding of between 0.5 and 1 per cent of their base revenues.[172] The Network Innovation Competition ("NIC") is an annual competition to fund selected "flagship" innovative projects that could deliver low-carbon and environmental benefits to customers.[173] Compared to the NIA, Ofgem expects the NIC to be focused on funding larger scale, more complex innovative projects.[174] Illustrating the scale of funding for innovation, thirty million pounds (£30 million) will be available each year for the electricity NIC, adjusted for inflation.[175] Making funding available in these separate "pots" for different stages of innovation ensures funding across the spectrum of RDD&D.[176]

Unique among funding models surveyed, the NIC requires network operators bidding for innovation funds to cover 10 percent of the project cost themselves (deemed the "compulsory contribution"); however, 10 percent of NIC program funds are also set aside each year for "successful delivery rewards" that can be awarded to innovation project sponsors who meet project-specific success criteria to, in effect, refund their compulsory contributions. Ofgem reports that this mechanism was intended to incentivize well-managed and efficient projects.

During the 2013 NIC, 60 million pounds of funding was awarded to six gas or electricity based projects. One winner under the natural gas category, receiving £6.5m, was Southern Gas Network's Robotics program. The goal of the project is to create a robot that can repair, reconnect, and monitor gas pipelines. The robot will also demonstrate sensor technology to report the conditions of gas pipeline while developing a methodology for bringing attention to iron gas pipes that need replacing.[177]

The first winner in the electricity category was Scottish HydroElectric Transmission's Multi-terminal Test Environment (MITTE) for HVDC Systems. Receiving £11.3m, Northern Gas Network is planning to investigate and experiment with gas preheating technologies that surfaced recently. They plan to test the efficiency and performance of these technologies by producing real-time data on both old and new preheating technology. They also plan to investigate the investment risk and potential cost savings for customers by looking into "whole life costs" for the technology. The second winner in the electricity category was

Scottish Power Transmission's Visor Program which they describe as "providing a new insight in the capability and dynamic performance of the system with the intention of improving network operation and planning." This will be achieved by using £6.5 million in RIIO funding to develop and test a Wide Area Monitoring system, try alternative ways of using Phasor Measurement Units, and design new techniques for operating and planning the transmission system.[178] The 2014 NIC is currently underway and full submissions have been submitted as of July, 25; the winners will be announced late November 2014.[179]

In its extensive examination of innovation funding, Ofgem offered several important observations about utility innovation. Ofgem recognized that even "failures" in terms of innovation attempts can provide useful information.[180] Recognizing the value of learning gained from innovation projects, Ofgem's innovation stimulus includes requirements for knowledge dissemination. Ofgem also concluded that allowing non-utilities to bid for competitive innovation funding would be beneficial for stimulating a greater number of innovative ideas.[181]

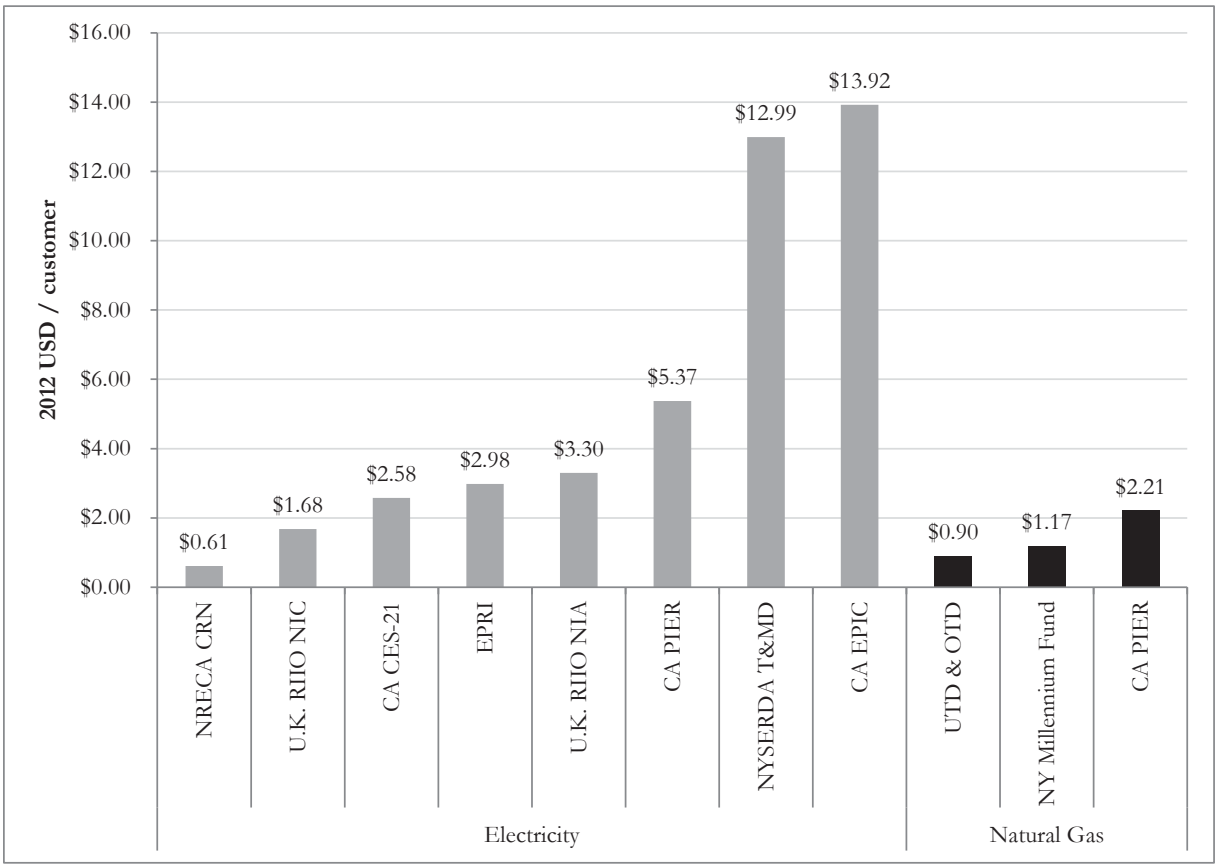
Italy's Return on Capital Adder for Innovative Demonstration Projects[182]

Italy's electricity regulation consists of a price-cap with efficiency factors applied to operating costs. To spur innovation, Italy introduced a competition to select a limited number of smart grid projects that would be eligible for an extra 2 percentage point return on invested capital for utility sponsors. The incentive for the added return was funded through the network tariff and awarded to eight project sponsors. Italian regulators recognized that real-world demonstration projects are a critical step in moving innovative technologies to full deployment but that the high cost of such projects necessitated careful project selection. The Italian innovation stimulus program defined specific performance criteria for smart grid demonstration projects and focused on quantifiable benefits from the projects.

ATTACHMENT C:
UTILITY INNOVATION FUNDING LEVELS

While a comprehensive survey of the levels of funding for utility innovation is beyond the scope of this paper, Figure 2 below summarizes the funding levels identified for several of the utility innovation programs described in Attachment B, where such data were readily available.

Figure 2: Examples of Utility Innovation Funding Levels[183]



Notes:

NRECA CRN - National Rural Electric Cooperative Association Cooperative Research Network

U.K. RIIO NIC – U.K. RIIO Network Innovation Competition

CA CES-21 – California 21st Century Energy Systems Research Project

EPRI – Electric Power Research Institute

U.K. RIIO NIA - U.K. RIIO Network Innovation Allowance

CA PIER – California Public Interest Energy Research

NYSERDA T&MD – New York State Energy Research and Development Authority Technology and Market Development Program

CA EPIC – California Electric Program Investment Charge

UTD & OTD - Utilization Technology Development and Operating Technology Development

[1] Khanberg, Tatiana and Robert Joshi, *Smarter and Stronger: Taking Charge of Canada's Energy Technology Future*, The Mowat Centre at the University of Toronto, September 2012, at 17.

[2] Benefit-to-cost ratios for the U.S. Department of Energy, Electric Power Research Institute and California Public Interest Energy Research are from California Energy Commission, *Public Interest Energy Research 2003 Annual Report*, at 27. The Gas Technology Institute benefit-to-cost ratios are from Ron Edelstein, Gas Technology Institute, Transcript of Hearing #10-11165 before the Public Service Commission of South Carolina, December 15, 2010. The benefit-to-cost ratio for the New York State Energy Research and Development Administration is from that organization's *System Benefits Charge in New York: Vision for the Future*, September 20, 2010, at 5.

[3] Ontario Energy Board Decision No. EB-2010-0002, December 23, 2010, 2010 LNONOEB 359.

[4] California Public Utilities Commission, Decision 12-05-037, May 24, 2012, at 27.

[5] Massachusetts Department of Public Utilities, "Investigation by the Department of Public Utilities on its own Motion into Modernization of the Electric grid," June 12, 2014 at 27-30.; Ofgem, creating Britain's Low Carbon future. Today, 2013; New York Public Service Commission, "Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision," April 25, 2014.

[6] Review of Federal Support to Research and Development, Views Provided by BC Hydro, 2011

[7] Louisiana Public Service Commission, Staff Report and Recommendation to Continue Research & Development Committee, Docket No. R-30479, August 25, 2011, at 8.

[8] Comments of Enbridge Gas Distribution Re: Ontario Energy Board Demand Side Management ("DSM") Guidelines for Natural Gas Distributors, April 21, 2011.

[9] Khanberg, Tatiana and Robert Joshi, *Smarter and Stronger: Taking Charge of Canada's Energy Technology Future*, The Mowat Centre at the University of Toronto, September 2012, at 37.

[10] The California Public Utilities Commission adopted the following definition of technology demonstration: "the installation and operation of pre-commercial technologies at a scale sufficiently large and in conditions sufficiently reflective of anticipated actual operating environments, to enable the financial community to effectively appraise the operational and performance characteristics of a given technology and the financial risks it presents." Decision 12-05-037, May 24, 2012, at 39.

[11] Such market facilitation is an explicit component of California's electricity technology demonstration and deployment framework. See, California Public Utilities Commission, Decision 12-05-037, May 24, 2012, at 61.

[12] For an analysis of the substantial induced employment benefits attributed to lower household and business energy expenditures due to energy efficiency and conservation energy savings, see Wei, Max, et al., "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S.?" *Energy Policy* 38 (2010): 919-931.

[13] One can see this dynamic by considering an unregulated affiliate that invested in an innovative technology that substantially reduces utility operations and maintenance costs. Regulated utilities would be the customer for this new technology, but the benefits from the technology (i.e., the cost savings) would flow through to ratepayers under traditional cost-of-service regulation, thus dampening the regulated utilities' interest in adopting a potentially unproven new technology and limiting the profitability of the investment innovation. In addition, even if utility shareholders invested their own funds in RDD&D through unregulated affiliates in order to earn unregulated returns on successful investments in innovation, those unregulated affiliates would still make less than socially optimal investments in innovation in the face of the externalities and knowledge spillovers discussed below. Moreover, such an approach would fail to exploit the benefits noted above of having regulated utilities undertake innovation efforts.

[14] Sanyal, Paroma and Linda Cohen, "Powering Progress: Restructuring, Competition, and R&D in the U.S. Electric Utility Industry," *The Energy Journal* Vol. 30, No.2 (2009).

[15] Office of Gas and Electricity Markets, *Decision and Further Consultation on the Design of the Network Innovation Competition*, September 2, 2011, at 19.

[16] Massachusetts Institute of Technology, *The Future of the Electric Grid*, December 2011, at 79, 185, 189.

[17] KEMA, *A Sample Survey of International Innovation Projects*, October 9, 2009, at 47.

[18] The recent report from the Ontario Distribution Sector Review Panel emphasized this issue, noting that "a number of [local distribution companies] say it can be difficult to be innovative in the current regulatory environment" and that "[t]he expectations and requirements of the [local distribution companies] and the [Ontario Energy Board] need to be aligned if innovation is to be encouraged in Ontario's distribution sector." *Renewing Ontario's Electricity Distribution Sector: Putting the Consumer First*, The Report of the Ontario Distribution Sector Review Panel, December 2012, at 25.

[19] See Sections 399-399.9 of the California Public Utilities Code.

[20] Office of Gas and Electricity Markets, *Electricity Network Innovation Competition Governance Document*, February 1, 2013, at 5.

[21] KEMA, *A Sample Survey of International Innovation Projects*, October 9, 2009, at 49.

[22] Jaffe, Adam et al., "A Tale of Two Market Failures: Technology and Environmental Policy," *Ecological Economics* 54 (2005) 164– 174.

[23] Jamasb, Tooraj and Michael Pollitt, "Liberalisation and R&D in Network Industries: The Case of the Electricity Industry," *Research Policy* 37 (2008) 995–1008.

[24] See, e.g., the Ontario Energy Board's *Demand Side Management Guidelines for Natural Gas Utilities*.

[25] Jaffe, Adam et al., "A Tale of Two Market Failures: Technology and Environmental Policy," *Ecological Economics* 54 (2005) 164– 174.

[26] Hargadon, Andrew, *The Business of Innovating: Bringing Low-Carbon Solutions to Market*, Prepared for the Center for Climate and Energy Solutions, October 2011, at 17.

[27] See http://www.hydroquebec.com/innovation/en/institut-recherche.html.

[28] Ontario Power Generation, Management's Discussion and Analysis, December 31, 2012, at 64.

[29] Ontario Power Generation, 2002 Annual Information Form, at 43.

[30] Ontario Energy Board, *Demand Side Management Guidelines for Natural Gas Utilities*, EB-2008-0346, June 30, 2011, at 11.

[31] Egan, Timothy M., Speaking Notes to the Standing Committee on Natural Resources Study on Innovation in the Energy Sector, February 26, 2013.

[32] Energy Technology & Innovation Canada Business Plan, December 15, 2011, at 5.

[33] Egan, Timothy M., Speaking Notes to the Standing Committee on Natural Resources Study on Innovation in the Energy Sector, February 26, 2013.

[34] Khanberg, Tatiana and Robert Joshi, *Smarter and Stronger: Taking Charge of Canada's Energy Technology Future*, The Mowat Centre at the University of Toronto, September 2012**.**

[35] Sterlacchini, Alessandro, "Energy R&D in Private and State-Owned Utilities: An Analysis of the Major World Electric Companies," *Energy Policy*, 41 (2012): 494-506.

[36] GDP figures from the World Bank, see http://goo.gl/htns2G.

[37] See the July 25, 2014 IESO Press Release at http://www.ieso.ca/Pages/Media/Release.aspx?releaseID=6857

[38] See http://www.greentechmedia.com/articles/read/ontario-contracts-34mw-of-all-of-the-above-energy-storage

[39] See http://www.hydrogenics.com/about-the-company/news-updates/2014/07/25/hydrogenics-selected-for-2-megawatt-energy-storage-facility-in-ontario

[40] Pennsylvania Public Utility Commission, Statement of Policy on Collection of Research and Development Funds by Natural Gas Distribution Companies, PA Bulletin, Doc. No. 01-987, June 8, 2001.

[41] National Association of Regulatory Utility Commissioners, *Resolution Recognizing the 40-Year Collaborative Relationship Between NARUC and the Electric Power Research Institute*, November 16, 2011.

[42] KEMA, *A Sample Survey of International Innovation Projects*, October 9, 2009, at 50.

[43] Anadon, Laura Diaz et al., *Transforming U.S. Energy Innovation*, Belfer Center for Science and International Affairs, Harvard University, November 2011, at 225.

[44] Gas Technology Institute, "R&D Advocacy: Finding Research Support through the States," *Gas Operations News*, April 2005.

[45] Gas Technology Institute, "R&D Advocacy: Finding Research Support through the States," *Gas Operations News*, April 2005.

[46] Cohen, Linda and Paroma Sanyal, "R&D Choice in Restructured Industries: In-House vs. Collaborative Research in the U.S. Electricity Industry," Working Paper, February 2008.

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[48] International Gas Union, 2006-2009 Triennium Work Report, Task Force: Research and Development, October 2009, at 10.

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[108] Louisiana Public Service Commission, Staff Report and Recommendation to Continue Research & Development Committee, Docket No. R-30479, August 25, 2011, at 6.

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[110] California Public Utilities Code §740.

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[112] See https://ces21.llnl.gov/about.

[113] California Public Utilities Commission, Decision 12-12-031, December 20, 2012.

[114] California Public Utilities Commission," Decision Modifying Decision 12-12-031 to Comply with Senate Bill 96," February 14, 2014, at 5-6.

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