National Regulatory
Research Institute

New Technologies: Challenges for State Utility Regulators and What They Should Ask

Ken Costello, Principal

The National Regulatory Research Institute

January 2012

12–01

Acknowledgments

The author wishes to thank Peter Bluhm of Rolka, Loube, Saltzer Associates; Chairman Travis Kavulla of the Montana Public Service Commission; and Johannes Pfeifenberger of The Brattle Group. Any errors in the paper remain the responsibility of the author.

Online Access

This paper can be accessed online at www.nrri.org/pubs/multiutility/NRRI_New_Technologies_Jan12-01.pdf

Executive Summary

Innovation has enormous potential for enhancing the performance of public utilities. It can help improve utility services, lower their costs, improve reliability, add valuable services, and achieve other regulatory objectives.

Technology improvements in the electricity industry have made thermal and renewable power generation more efficient, cleaner, and safer, and increased the carrying capacity of transmission lines. New technologies in the natural gas sector—better inspection tools and improved data integration—have improved gas-pipeline safety and its cost-effectiveness. Hydraulic fracturing of fossil fuel deposits is making natural gas supplies more abundant and will continue to do so, assuming environmental issues can be resolved.

While this paper focuses largely on technological innovation, institutional innovation—by regulators, utilities, and third parties—has also advanced social objectives, such as implementing energy efficiency, increasing competition, protecting the environment, and diversifying energy supplies.

Unregulated firms innovate and invest in new technologies to improve their prospects for earning profits and increasing market share. But economic theory says that all firms, utilities included, will innovate if they receive adequate compensation, given the risks they face.

To put matters into perspective, much of the innovation in utility industries results not so much from utilities as from the work of vendors, from industry-wide research organizations like the Electric Power Research Institute and Gas Technology Institute, and from national governmental research laboratories under the aegis of the Department of Energy. Yet there remains a crucial need for utilities to innovate, for example in the areas of energy efficiency, distributed generation, and deployment of a smart grid.

What regulators can do

Regulatory policies can discourage or stimulate a utility's commitment to innovation. How regulators use the tools at hand—ratemaking, regulatory mandates, and performance objectives—will affect a utility's choices. By placing bounds on utility profits and risk, regulators can either constrain or encourage innovation. Utility failure to invest in new technologies can impose costs on their customers and on society at large that regulators should seek to avoid. Balanced regulation will create appropriate incentives for utilities to investigate and keep abreast of promising new technologies that utilities under their jurisdiction should consider.

Regulators must deal with questions of risk mitigation and risk allocation between utility customers and shareholders. Reducing investment risk may encourage a utility to pursue new technologies. But shifting too much investment risk to customers would violate principles of fairness.

Why utilities may shun innovation

New technologies may be disruptive, creating risks for utilities. Regulatory risk, the main focus of this paper, can arise in several ways. If a new technology performs poorly and provides minimal benefit to utility customers, regulators might declare the investment imprudent or not "used and useful." The consequence would be reduced cost recovery by the utility. Utilities can also face long delays in recovering costs, aggravating uncertainty and creating cash-flow problems. Depreciation policies might leave the utility with "stranded costs" if technological obsolescence makes the economic life of an asset shorter than its book life. Even if an investment performs well, a utility may not know what portion of its benefit would go to shareholders.

Other reasons may exist for a utility's suboptimal investment in new technology. The benefits of the technology may be too low relative to risk. Moreover, traditional utility regulation restricts the threat of competitive entry, reducing the utility's incentive to innovate. Finally, reducing utility sales through innovation can also reduce earnings, absent the regulator's decoupling of earnings from sales or some comparable policy. Contrariwise, there are also reasons why a utility might invest in new technology prematurely or excessively, if only to increase the rate base on which it may see a return on investment.

Challenges for regulators

Several challenges confront the regulator seeking to maximize the public good while protecting the interests of the utility and its shareholders. First, the regulator must become sufficiently informed about new technologies in order to avoid—or at least seek to balance out—the information asymmetry that inevitably exists between the regulator and the regulated companies. Reliance solely on information from utilities would not adequately safeguard the public interest. Next, the regulator must allocate the risk of technology or other innovation costs between the utility and its customers. It must also seek to align utility rewards with utility risks.

A deeper challenge for the regulator lies in addressing issues of risk allocation as between customer classes. When a technology benefits only a portion of a utility's customers, the regulator should consider the potential responsibility and benefits of all customer classes. Should all customers bear the risk of a technology that benefits only one class of customers? Should all residential customers pay the same costs, even though some users benefit more than others?

Once the above issues are addressed, the regulator must assure that the utility remains accountable. Accountability requires that utilities not receive guaranteed cost recovery, that they satisfy an acceptable level of performance, and, for technologies depending on demand-side response, that they have sought to educate and communicate with customers in a reasonable way.

Most utilities today assume roles that vary, to a greater or lesser degree, from being mere providers of a commodity to providing a range of service offerings, including actively promoting new technology that promises to improve customers' benefits. A subset of the above issues arises in the case of a demonstration project, which may not benefit customers for several years, or perhaps ever. Under what circumstances should regulators approve such a project? What degree of certainty should a utility have in recovering its costs, assuming that it has acted prudently and in accordance with the regulator's tacit or explicit approval of the project?

Traditional rate-of-return regulation may not induce the desired degree of utility innovation, but a modified approach might serve quite well. For example, allowing a utility to earn an incentive rate of return on innovation—one that takes account of the risks and the nature and extent of its performance based on predetermined metrics—might well induce the utility to be more enterprising. Such an approach seems consistent with the framework of traditional regulation, permitting higher returns for technology investments that carry higher risks.

Regulators might also consider evaluating new technologies in the context of integrated resource planning. A well-crafted utility IRP, vetted if not approved by a regulatory body, may reduce risk for the utility. The regulator may find a utility's IRP that includes innovative technology quite acceptable but still avoid the trap of committing to full cost recovery before the plan has been executed. Any imprudence in construction or other utility activities should still be subject to cost disallowance.

Regulators may want to consider establishing a separate commission policy on utility innovation and new technology. Such a policy might include general principles on what would constitute acceptable "innovation" investments. It would be most beneficial if it should also articulate criteria for cost recovery, risk allocation, and consideration of external benefits in evaluating a utility's proposal.

Finally, this paper suggests future research projects worth pursuing. One would be to design a general regulatory framework that addresses the concerns raised here, particularly as they relate to balancing utility incentives to innovate and fair risk allocation to and among customers. Such a framework should consider depreciation rules, regulatory commitment, targeted incentives, mitigation of asymmetric information, and abolition of undue barriers to innovation. A comprehensive, holistic approach could be most helpful in creating a new regulatory paradigm for stimulating utility innovation.

Table of Contents

New Technologies: Challenges for State Utility Regulators and What They Should Ask

I. Why Innovation Is Important

"Innovation" broadly refers to the creation of better products, operating processes, technologies, or even ideas that improve a utility's performance. Innovation simply improves matters over what they were previously. Put another way, innovation is a social-welfare-enhancing investment.

For the economy as a whole, innovation drives economic growth. As one author noted:

> Since the 1950s, economists have understood that innovation is critical to economic growth. Our lives are more comfortable and longer than those of our great-grandparents on many dimensions. To cite just three improvements: antibiotics cure once-fatal infections, long-distance communications cost far less, and the burden of household chores is greatly reduced. At the heart of these changes has been the progress of technology and business.[1]

In many economic sectors, innovative new technologies have had revolutionary effects. In the agricultural sector, the Green Revolution and other major innovations have made it possible for the world adequately to feed millions of people who otherwise would starve or suffer malnutrition. In education, new technology is "shaking colleges to their foundations."[2]

Innovation has enormous potential for enhancing the performance of public utilities. It can help improve utility services and lower the cost of existing services. Innovation can also advance regulatory objectives. New technologies, for example, have increased utility reliability and safety or made it possible to achieve these goals at a lower cost. Technology improvements have made new nuclear and coal generating plants more efficient, cleaner, and safer.[3] In the natural gas sector, new technologies in the form of better inspection tools and improved data

---

[1] Josh Lerner, *Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed—and What to Do about It* (Princeton, NJ: Princeton University Press, 2009), 43.

[2] "Schumpeter: University Challenge," *The Economist*, December 10, 2011, 74.

[3] *See*, for example, Build Energy America, *States' Best Practices Attracting Baseload Investment*, Research Report 2011:2, May 5, 2011, 12 at http://www.buildenergyamerica.org/BuildEnergyRep2.pdf.

integration have increased gas-pipeline safety and the cost-effectiveness of safety initiatives. Innovation can also advance social objectives relating to energy efficiency, competition, a clean environment, and diversity of electric generation.

This paper focuses on innovation chiefly in the form of new technologies. New technologies usually involve large, risky investments.[4] Analysts often refer to innovation as "technology that goes from the laboratory to the marketplace."

This paper also applies to other kinds of innovations, which can include (1) new products and services, (2) new operating processes, and (3) new internal "utility organization" structures. All innovations share the feature that they improve the utility's performance in one or more dimensions over several years.

In the energy sector, utility companies have adopted a large number of new technologies over the past several years. These include clean-energy technologies, including fuel cells and systems that manage carbon emissions; broadband telecommunications and real-time communications systems; improved measurement methods for pipeline corrosion; advanced vehicles; smart electric meters and advanced substation software; advanced heating and cooling systems including combination water/space heaters; super-efficient LED lighting; and efficient windows.[5]

Innovation in the energy sector has not ceased. Daniel Yergin recently explained that the energy sector "has never seen such a focus on innovation and technological change."[6] He also said that the emphasis on innovation across the energy spectrum is "greater than ever before."[7]

---

[4] Utilities can spend either large or small amounts of money on innovation. This paper focuses on large investments, such as new technologies that cost tens or hundreds of millions of dollars or even more.

[5] For examples of new technologies for natural-gas distribution operations, *see* Ron Edelstein, "Technologies of the Future for Natural Gas Operations," presentation at the NARUC Annual Meeting, November 15, 2011 at http://www.narucmeetings.org/Presentations/The%20Future%20is%20Unwritte%20Tuesday%202.pdf.

[6] Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World* (New York; The Penguin Press, 2011), 549.

[7] Ibid., 5.

II. How Utility Regulation Affects Innovation

Unregulated firms innovate and invest in new technologies to improve their prospects for earning handsome profits. Incentives are essential to induce firms to innovate. In unregulated sectors, a high proportion of new firms fail economically, a risk that entrepreneurs understand. Even with established firms, because innovative activities are intrinsically risky, unregulated firms generally expect larger benefits from innovative investments.

Unregulated firms also innovate to compete with their rivals, a fact that tends to spread innovation throughout unregulated industries. One firm's innovation or investment in new technology will often encourage other firms to innovate as well.

Economic theory says that all firms will innovate if they receive adequate compensation given the risks they face. This theory applies equally to utilities, although regulated utilities have different kinds of risks and compensation and hence different incentives. Regulatory policies can discourage or stimulate utility investments in innovations, thereby affecting the amount that utilities spend on innovation, the speed at which they innovate, and the nature of the investments. The regulatory tools that affect innovation are ratemaking, mandates, and performance objectives. By placing bounds on utility profits and risk, regulation can constrain innovation. Regulated utilities face more severe profit constraints than their unregulated counterparts, which generally diminishes their willingness to innovate. Analysts have criticized traditional rate-of-return (ROR) regulation for providing utilities with weak incentives to innovate.[8]

The general perception is that regulated utilities are slow to innovate. They may be more risk averse by nature and therefore less willing to invest in innovation. As one study noted:

> Although new technologies have been introduced, long equipment lifecycles, standardization, and utilities' aversion to risk have tended to limit the implementation of innovative transmission and distribution system technology.[9]

---

[8] The weak incentives not only affect utilities' unwillingness to apply known innovations that would improve their performance but also their search for innovations yet to be discovered. The last point is discussed in Dennis L. Weisman and Johannes P. Pfeifenberger, "Efficiency as a Discovery Process: Why Enhanced Incentives Outperform Regulatory Mandates," *The Electricity Journal*, vol. 16 (January/February 2003): 55-62.

[9] Navigant Consulting, *The 21st Century Electric Utility: Positioning for a Low-Carbon Future,* v. The report commented that attention has increasingly centered on improving the reliability and resilience of the electric grid to handle major equipment outages, severe weather conditions, and potential terrorist attacks. New technologies can play a crucial role in meeting these objectives.

Utilities might not view certain technologies and other innovations favorably. Some of them neither generate additional revenues nor reduce costs for a utility. New technologies can also jeopardize the natural-monopoly feature of utility sectors by facilitating competitive entry. We have especially seen this outcome in the telecommunications industry.[10]

Utility failure to invest in new technologies can impose costs on utility customers and society at large. This has consequences for regulatory policy. As explained in a previous NRRI report:

> If innovative technologies merely have the same expected costs as conventional technologies, nothing is lost if utilities eschew them; in fact, society is presumably better off if unnecessary risks are avoided. If innovative technologies, however, have lower expected costs or other benefits, then regulations that bias utilities toward conventional technologies may be undesirable.[11]

On the other hand, regulatory policies can also encourage innovation, sometimes with poor results. Electric utilities historically invested aggressively in new technologies when their economic incentives were strong.[12] In the past, some of those new technologies have performed poorly, burdening utility customers with recovery of excessive costs.

Few studies have looked specifically at the cause-and effect relationship between regulatory policy and innovative behavior. This paper argues that well-balanced regulation finds a middle ground between the extremes described above, creating incentives for utilities (1) to review promising new technologies, (2) to invest in good technologies without further

---

[10] *See* Sherry Lichtenberg, "Embracing the Future: Four Key Trends in Telecommunications," NRRI 11-19, November 2011 at http://www.nrri.org/pubs/telecommunications/NRRI_Telecom_Trends_Nov11-19.pdf. New telecommunications technologies often create new services or enhance services, while new technologies in the energy utility sectors tend more often to reduce costs, increase reliability, or support some social objectives, such as a cleaner and safer environment.

[11] Mohammad Harunuzzaman et al., *Regulatory Practices and Innovative Generation Technologies: Problems and New Rate-Making Approaches*, NRRI 94-05 (Columbus, OH, The National Regulatory Research Institute, 1994), 78, available at http://nrri.org/pubs/electricity/94-05.pdf.

[12] *See* H. Stuart Burness, W. David Montgomery, and James Quirk, "Capital Contracting and the Regulated Firm," *American Economic Review*, vol. 70 (June 1980): 342-54. During the 1960s to the mid-1970s, for example, utilities found nuclear power attractive because of the potential to earn high rates of return and the low risks involved during this period of rare retrospective review. *See also* Paul Joskow, "Productivity Growth and Technical Change in the Generation of Electricity," *The Energy Journal*, vol. 8, (1987): 17-38.

inducements, and (3) to refrain from investing in bad technologies that may be profitable but do not benefit customers.

Regulators must also deal with questions of risk mitigation and risk allocation between utility customers and shareholders. Reducing the risk to a utility will encourage the utility to invest in new technology. On the other hand, shifting too much risk to customers might violate the regulator's sense of fairness and create a "moral hazard" problem in which the utility lacks adequate incentive to act prudently. Achieving the proper allocation of risk between utilities and ratepayers is perhaps the most difficult task for regulators.[13]

This paper focuses on the question "What incentives do utilities have to 'buy' new technologies?" Even if industry-level research produces new products and technologies, would utilities tend not to invest in them when they are found to be financially untenable? Could such decisions deprive utility customers and society of the potentially significant benefits from these technologies?

This paper also addresses different regulatory actions that include revamping the traditional ratemaking model and eliminating "undue barriers" to innovation. It examines whether state utility regulators should tinker with the traditional ratemaking model to induce more innovation, and if so, how. Should the traditional model be scrapped and replaced with a new model, such as price cap regulation, to stimulate more utility innovation? Specifically, how can a new model be more accommodating to new technologies that benefit customers?

III. What Are the Features of New Technologies and Their Risks to Utilities?

A. Features

The following features characterize new technologies in the utility sector:

1. *New technologies can affect many aspects of utility operations.* Some new technologies improve a utility's long-run cost efficiency, reliability, or safety. Others create new services or enhance the value of current services.[14] Still others advance social objectives, such as

[13] Some analysts have contended that over the last several years risk has shifted from utility customers to shareholders. They point to evidence showing that the credit ratings of utilities have diminished over this time period. *See*, for example, H. Edwin Overcast, "Restoring Financial Balance," *Public Utilities Fortnightly*, November 2011: 12-15; and Navigant Consulting, *The 21st Century Electric Utility: Positioning for a Low-Carbon Future*, a report prepared for Ceres, July 2010, 25.

[14] This last outcome better reflects innovation in the telecommunication sector than in the energy or water sectors.

those relating to energy efficiency, competition, the environment, and electric-generation diversity.

2. *New technologies can bolster other new or existing technologies.* The smart grid, for example, can increase the market penetration of distributed photovoltaic and plug-in electric vehicles. Many technologies are interdependent with other technologies in that the development of one aids the development of the other.

3. *New technologies can generate large short-term benefits.* Unregulated firms that invest in innovations and new technologies do so largely because they expect to earn supernormal profits, at least until rivals catch up.[15] For example, a firm that creates a cost-saving innovation can, for a time, have temporary market power and enjoy supernormal profits. A monopolist would tend to achieve higher profits from a new technology for a longer period of time, since by definition it faces few or no rivals.[16]

4. *The inventor or developer of a new technology may incur all the cost but not all the benefits.* Many new technologies can be easily appropriated by other firms. Knowledge innovation is especially subject to this spreading effect. Knowledge innovation often can be viewed as a public good, or what economists call an "external benefit" that spills over onto other "free-rider" firms. This inadvertent creation of a public good blunts a firm's incentive to invest in innovation and represents a kind of market failure that provides a rationale for government funding of research and development, demonstration projects, and even government-distributed financial subsidies.

5. *New technologies are seldom discovered and developed by individual utilities.* The technologies are often created at the industry level by research organizations such as the Electric Power Research Institute (EPRI)[17] and the Gas Technology Institute (GTI).[18] New

---

[15] The firm can increase its profits for two reasons. The first source is an increase in the spread between its average cost and the market price. The second source comes from the firm's reducing its price below the market price, thereby increasing its sales and revenues. *See*, for example, Luis M. B. Cabral, *Introduction to Industrial Organization* (Cambridge, MA: MIT Press, 2000), 291-95.

[16] This likely outcome explains why some analysts believe that unregulated monopolies have the strongest incentive to innovate.

[17] EPRI's research activities cover the environment, generation, nuclear, and power delivery and retail. Retail technologies include energy-efficiency hardware, smart appliances, electric vehicles, demand-response devices, and distributed energy resources. The EPRI website expresses that "RD&D [research, development and deployment] drives innovation…Innovation drives progress." The website also says that:

technologies have also been developed by private entities like Westinghouse and General Electric or by government laboratories like the National Renewable Energy Laboratory (NREL).[19] Utilities are more often customers than creators of new technologies. At most, utilities may participate in joint ventures, partnerships, and informal cooperative arrangements with other utilities, industry-level research organizations, vendors, and government entities.

> EPRI's Technology Innovation (TI) organization has been integral in leading the development of key technologies that have benefited the electricity industry in numerous ways. The organization focuses on stimulating innovation and developing enabling electricity technologies for adoption in a 5-10 year period. (*See* http://my.epri.com.)

One major challenge that EPRI sees is transforming the power system to become more economical, environmentally benign, efficient, secure, reliable, and sustainable. Some of these objectives conflict with others, making it difficult for regulators and other decisionmakers to determine the appropriate balance.

[18] GTI's research activities cover climate change, energy efficiency, energy supply, utility operations, and safety. GTI describes itself in the following terms:

> We're a research organization with "the energy to lead." We solve important energy challenges, turning raw technology into practical solutions that create exceptional value for our customers in the global marketplace. We are driven by three primary objectives, which span the energy industry value chain. They provide both the focus and enduring opportunity for our business endeavors. These objectives are: (1) expanding the supply of affordable energy, (2) ensuring a safe and reliable energy delivery infrastructure, and (3) promoting the efficient use of energy resources. (*See* http://www.gastechnology.org.)

[19] The NREL website says that:

> The National Renewable Energy Laboratory is the nation's primary laboratory for renewable energy and energy efficiency research and development (R&D). NREL's mission and strategy are focused on advancing the U.S. Department of Energy's and our nation's energy goals. The laboratory's scientists and researchers support critical market objectives to accelerate research from scientific innovation to market-viable alternative energy solutions. At the core of this strategic direction are NREL's research and technology development competencies. These areas span from understanding renewable resources for energy, to the conversion of these resources to renewable electricity and fuels, and ultimately to the use of renewable electricity and fuels in homes, commercial buildings, and vehicles. (*See* http://www.nrel.org.)

6. *Some new technologies benefit the general public but are of little value to utility customers and shareholders.* New technologies can foster state and federal energy objectives and policies, provide environmental benefits, or reduce the nation's dependence on foreign energy. These kinds of broadly distributed external benefits raise questions about appropriate cost recovery. Should a utility's customers pay for a new technology that is economically justified only because of external benefits? Should the rest of society be allowed to become "free riders" who receive the benefits but do not pay any of the costs? Similarly, some new technologies benefit only a portion of a utility's customers. Should all utility customers pay for a new technology when some customers receive no benefits?[20]

7. *Firms typically invest in new technologies at different times.* The diffusion of a new technology is often slow and highly unpredictable, even after its initial commercial application.[21] Established firms with older capital assets and firms with newly purchased assets face different economic conditions when deciding to scrap old capital assets and purchase new capital assets that embody state-of-the-art technology. Not all firms should invest in "best practice" technologies at the same time. What is a "best practice" for one firm may not be "best practice" for another firm. Regulators should, therefore, not expect all utilities immediately to deploy the newest or the same technologies.

8. *New technologies create more risk than conventional technologies.* New technologies can fail in a number of ways: low operating performance, high cost overruns in construction, and (for optional demand-side technologies) low penetration or customer acceptance. Assets based on new technologies may have shorter economic lives than those assumed under a regulator-approved depreciation schedule.[22] Overall, new technologies carry higher risk, and

[20] Alternatively, in the example of smart-grid technology not all customers would receive the same benefits, so should not what they have to pay relate to those benefits?

[21] Observations across industries have shown that the diffusion of new technologies is a gradual process. The fraction of potential users that invests in a new technology typically follows an S-shaped path over time, rising only slowly at first, then experiencing rapid growth, followed by a slowdown in growth as the technology reaches maturity and most potential adopters have switched. One explanation is that potential technology adopters face different conditions so that the economics of a new technology differs across potential users. Another explanation relates to the intrinsic risk associated with investing in a new technology; this risk requires a potential user to acquire much information on both the generic features of the new technology and its use in the particular application under consideration. *See*, for example, Adam B. Jaffe et al., *Technological Change and the Environment*, RPP-2001-13 (Cambridge, MA: John F. Kennedy School of Government, October 2001), 41.

[22] One reason for a shorter-than-expected economic life is the unexpected market development of newer technologies that make the previous technology economically obsolete. A second reason is the failure of the technology to live up to expectations. Problems may have arisen that caused its performance to be lower than what was expected at the time the utility

unforeseen problems commonly occur. The failure of firms to invest in new technologies because of uncertainty does not necessarily constitute a market failure; instead, it may reflect the economic reality that the technology has a high market risk that deters all rational investors.[23]

9. *Early adopters can face additional costs or derive additional benefits.* Both regulated and unregulated firms are unlikely to invest in a new technology unless a large payoff from success is likely. Typically the costs, benefits, and risks of new technologies are unknown or at least uncertain. Also, initiators or first adopters frequently pay higher costs than later adopters because they make mistakes that later adopters avoid.[24] In unregulated industries, early adopters usually receive greater benefits than later adopters of new technologies.[25] In regulated markets, the benefits of early adoption are less clear. When utilities do invest in new technologies, many of the benefits go to the utility's customers rather than shareholders. Under typical conditions, regulated firms see minimal benefits but added risks when they take on the early-adopter role.

---

made the investment. These outcomes are not uncommon across different technologies deployed by both regulated and unregulated firms.

[23] Uncertainty about future returns creates what analysts call an "option value" to deferring or postponing investment in the technology. A firm may rationally wait because it wants to acquire new information before making a decision that involves large amounts of money. "Real options theory" says that when the future is uncertain, it pays to have a broad range of options available and to maintain the flexibility to exercise those options. Applying real options theory to smart meters, a preferred policy might involve a pilot program rather than installation of smart meters in all homes over a designated period of time. An excellent discussion of real options theory is contained in Avinash K. Dixit and Robert S. Pindyck, *Investment Under Uncertainty* (Princeton, NJ: Princeton University Press, 1994); and Robert S. Pindyck, "Irreversible Investment, Capacity Choice, and the Value of the Firm," *The American Economic Review*, vol. 78 (December 1988): 969-985. The origins of real options theory traced back to the work of Myron Scholes, Robert Merton, and Fischer Black in the early 1970s. This work developed a theoretical framework for pricing financial options.

[24] "Learning by doing" means that over time firms make fewer mistakes, with production costs falling as a consequence. Because first movers may not capture all of the benefits from this experience—with some of those benefits going to rivals—this "spillover" effect would tend to underallocate resources to research and development as well as commercialization activities. This outcome provides a rationale for government-funded financial incentives.

[25] See, for example, Luis M. B. Cabral, *Introduction to Industrial Organization*, 294-95.

10. *The business case for new technologies may be weak.* Firms that adopt new technologies often must make substantial up-front investments but do not see enhanced revenues for several years. Such timing differences can create a cash-flow problem for the firm. Also, some new technologies neither create new revenues[26] nor reduce costs[27] but improve safety, environmental effects, or reliability. For regulated utilities, these technologies may require special cost-recovery treatment.[28]

11. *The benefits of new technologies to utility customers may not be certain, immediate, or apparent.* Short-term benefits may be small, relative to the long-term benefits.[29] As well, benefits to existing customers may be conjectural, or they may not flow directly to the utility's customers.[30] Finally, future benefits may depend on other developments. For example, customer benefits from the smart grid depend, among other things, on new rate structures and appropriate customer responses. Benefits also depend on whether customers use plug-in electric vehicles and distributed generation. The public understandably tends to resist technologies that have such an unfavorable short-term benefit-cost ratio or that have such uncertain or indirect benefits.

B. Regulatory risk

New technologies create several risks for utilities. These risks include *regulatory*, *demand*, *cost*, and *performance*. Regulatory risk is the main focus of this paper, and it can arise in five ways. *First*, if an innovation or new supply-side or demand-side technology performs poorly, and if it provides minimal benefits to utility customers, regulators might declare that the technology is not "used and useful." The consequence might be less-than-full cost recovery by the utility.

---

[26] New energy-efficiency technologies can reduce utility revenues more than they save in costs.

[27] These technologies may address new safety and environmental requirements.

[28] One example would be an infrastructure surcharge that allows a utility to recover its costs outside of a general rate case and thus in a more timely manner.

[29] *See*, for example, Charles Goldman, "Measuring Consumer Benefits and Accounting for Risks of Smart Grid Investments: Major Issues and Challenges," presentation before the NARUC Staff Subcommittee on Electricity and Electric Reliability, November 2011 at http://www.narucmeetings.org/Presentations/Goldman~Measuring%20Consumer%20Benefits~NARUC~v9~20111112.pdf.

[30] Uncertain benefits may require utilities to express them qualitatively rather than numerically. It is unclear how a cost-benefit analysis would consider those benefits in conjunction with quantifiable benefits in the overall review of a technology.

Second, a poorly considered decision to invest in a new technology or the unsatisfactory construction or operation of the technology can trigger a regulatory declaration of imprudence. Construction problems and poor management decisions can be evidenced by cost overruns, long delays, subpar operation, or low penetration of a demand-side technology (e.g., natural gas vehicles). A regulator who concludes that a utility has been imprudent will usually disallow recovery of some costs. Utilities often see advance commitment by regulators as a way to minimize this risk. Without that kind of commitment, utilities sometimes feel vulnerable to regulatory "hold-up" or "opportunism."[31] The regulator, for example, might disallow a utility to recover certain costs because of an outcome that was less than desirable even though the utility was not at fault.

Third, utilities can face a long delay in recovering costs. This delay aggravates the uncertainty that already exists and can create a cash-flow problem for utilities.

Fourth, depreciation policies can leave the utility with "stranded costs" if technological obsolescence makes the economic life of the asset shorter than the book life. State utility regulators universally use book depreciation because it is intuitive and easy to measure.

Fifth, utilities might not know in advance what portion of the benefits from using new technologies will be captured by their shareholders. A regulator, for whatever reason, might later decide to distribute more of the benefits to customers. For example, a regulator might rule that a utility receives too much benefit from a smart grid investment and that some benefit should flow to customers. Since aggregate benefits are uncertain, even if the regulator guarantees the utility a specified percentage of those benefits, the utility cannot know the amounts it will receive.

For all of these reasons, utilities might find new technologies too risky in relation to expected returns. Under this condition, regulators should then expect utilities to be wary of new technologies.

IV. Reasons for Suboptimal Investments in New Technologies

A. Factors in underinvestment

Utilities have real reasons to ignore or even resist investing in new technologies. *First, the payoff might be too low relative to the risks.* This is the primary reason why both regulated

---

[31] Analysts relate this condition to "asset specificity." It includes investments that have an alternative value much lower than their value in its original use. This condition makes investments vulnerable to "hold-up" or "opportunism" by the regulator.

and unregulated firms hesitate to innovate. The implication for policy is that if utilities are underinvesting in new technologies, adjusting the risks that utilities bear and the benefits that they receive can improve the investment rate.

Second, traditional utility regulation restricts the threat of competitive entry. Unregulated firms often innovate to maintain their competitiveness with other firms. Otherwise, they risk lagging behind other firms and losing market share and profit opportunities. Unlike unregulated firms, a utility operates in monopoly markets where it can often fail to innovate without fear of losing market share to its more modern rivals.

Competition has complicated this traditional picture. New technologies can erode a utility's monopoly status by reducing entry barriers for newcomers. For example, combined-cycle gas turbines have eroded utility monopolies on generation, and new telecommunications technologies have eroded telephone monopolies. A utility, therefore, might not only reject new technologies but also oppose any innovation that jeopardizes a highly valued monopoly position. On the other hand, the possibility of competition might increase a utility's interest in exploiting a new technology, especially if the new technology makes competitive entry less likely.[32]

Third, reducing costs through innovation can reduce prices and profits. Tight regulation constrains the profits that a utility is able to earn from innovation, but it also reduces the risk that a loss of competitiveness will harm the utility. If a utility lowers its cost through innovation, eventually it may return all the savings to customers in the form of lower rates. In an extreme case, frequent rate adjustments can deprive the utility of the benefits, even in the short term, from cost-saving technologies.[33]

Fourth, depreciation policies can delay retirements of obsolete plant. To retire an asset not yet fully depreciated can mean that the old capital asset becomes "stranded," leaving the utility with the potential to lose future cost recovery from the asset. The utility may then decide not to invest in the new technology until the old asset has fully depreciated.

---

[32] *See*, for example, Johann J. Kranz and Arnold Picot, "Toward an End-to-End Smart Grid: Overcoming Bottlenecks to Facilitate Competition and Innovation in Smart Grids," NRRI 11-12, June 2011 at http://www.nrri.org/pubs/telecommunications/NRRI_End_to_End_Smart_Grid_june11-12.pdf

[33] Regulatory lag has a mixed effect on utilities' willingness to innovate: On the one hand, lengthening the time allotted for utilities to recover their costs increases their financial risk; on the other hand, lengthening the time allotted for utilities to retain the benefits improves their financial condition.

B. Factors in overinvestment

A utility might prematurely or excessively invest in new technologies for several reasons. *First, inflating the rate base may generate higher profits.*[34] Regulators often allow utilities to capitalize their expenditures, even for new technologies. Some new technologies are also more capital-intensive than conventional technologies. These incentives can induce a utility to invest in a new technology even though it may not pass a cost-benefit test for customers or perform well in achieving output goals.[35]

Second, the utility might incur little or no risk. Regulatory policy might allow the utility to pass all costs promptly through to customers with a special "rider" or "tracker" mechanism. The regulator might also fully commit to a new technology, which can amount to an assurance of complete cost recovery irrespective of project performance and management. Regulatory policy might also limit downside risk but impose no limits or weak limits on upside returns.

Third, the utility might receive government assistance in funding a new technology for a limited time. This kind of assistance may hasten a utility's investment in the technology even when it would be more economical to wait.[36]

---

[34] This incentive assumes that the utility's rate of return at least equals its cost of capital. When a utility expects to earn a return greater than its cost of capital, it may want to invest in new technologies if they are more capital intensive than conventional technologies. What analysts call the Averch-Johnson (A-J) effect says that a utility would invest excessively in capital when it faces a binding rate-of-return constraint on its rate base and its allowed rate of return exceeds its actual cost of capital. *See* Harvey Averch and Leland L. Johnson, "Behavior of the Firm Under Regulatory Constraint," *American Economic Review*, vol. 52 (December 1962): 1052-69.

[35] Desirable new technologies tend to pass a cost-benefit test in which customers and society are willing to pay more for the innovation than it costs. Such a test is relevant whether the new technology promotes cost efficiency, safety or reliability. An acceptable new energy-efficiency technology, for example, should cause the utility to avoid more costs than the cost of the technology itself.

[36] Waiting to invest creates what analysts call an "option value." This value results from the flexibility that a utility has to make better decisions when conditions vary from the expectations in earlier periods. The option value increases with the level of uncertainty and the length of the time horizon for new investments and other actions. It relates to the opportunity for a utility to reduce the cost of over-commitment to an investment that turns out less well than expected. If a utility is uncertain about the future, it might hesitate to commit to investing large amounts of money in a new technology. It might instead want to wait for new information that could reduce the uncertainty about the technology's benefits and costs. This decision can be rational and in the best interest of the utility's customers.

Fourth, regulators might favor certain new technologies, such as those advancing renewable energy and energy efficiency, by offering utilities special incentives to promote them or mandating them to do so. Penetration of these technologies without adequate review—namely, a cost-benefit analysis—can lead to excessive investments costing customers more than the benefits they receive.

Some analysts contend that electric utilities operated in a favorable environment for new-technology investment before around 1970. A 1994 NRRI report concluded the following:

> From the 1960s through the mid-1970s, utilities invested in a variety of different technological innovations, many of which have produced disappointing results. This risk-taking behavior is consistent with the argument…that bounds on utility risks during the 1960s and early 1970s were low relative to the potential for utilities to earn high earnings from successful innovation.[37]

A combination of conditions motivated electric utilities to engage actively in innovative activities during this period.[38] "Regulatory lag" was a major factor.[39] The average cost of utility service declined during this period, but rates lagged. In some instances, rates did not decline until five to ten years after the cost decrease.[40] In this environment, a utility that reduced its costs through innovation could expect to earn more than its authorized rate of return for several years. One study observed that regulatory lag is crucial to the incentive for innovation, like new technologies.[41] If regulators respond immediately to a cost-saving technology by reducing price, the firm realizes no benefit. The study showed that longer regulatory lag could enhance the utility's incentive to reduce costs through innovation, although it delays the benefits to

---

[37] Mohammad Harunuzzaman et al., *Regulatory Practices and Innovative Generation Technologies: Problems and New Rate-Making Approaches*, 84.

[38] As explained in the 1994 NRRI report:

> Utilities had the perception prior to roughly 1970 that the profits they were able to earn, from the regulators' perspective, could not be too high but they could be too low. In this environment utilities had much incentive to adopt new technologies and innovate in other ways that lowered their cost of service. (Ibid., p. 64)

[39] "Regulatory lag" is the delay between an event that changes a utility's costs or revenues and the utility's subsequent change to its rates.

[40] See Paul Joskow, "Inflation and Environmental Concern: Structural Change in the Process of Public Utility Regulation," *Journal of Law and Economics*, vol.17 (1974): 291-327.

[41] *See* Elizabeth E. Bailey, "Innovation and Regulation," *Journal of Public Economics*, vol. 3 (August 1974): 285-95.

consumers. Utilities also faced minimal risks from innovation, as prudence reviews were rare during this period.

The incentives changed around 1970, when regulatory lag began to work against utilities and prudence reviews became more common. In this later period, utilities found the traditional ratemaking environment less favorable to innovation.[42]

V. Challenges for Regulators

This section discusses seven general goals or challenges for utility regulators as they seek to encourage utilities to innovate and apply new technologies.

A. Becoming informed about new technologies, information asymmetry

Regulators know less than utilities about the availability, risks, and benefits of new technologies. This "information asymmetry" arises in many kinds of regulatory work. It causes regulators to be uncertain about the commercial and social value of new technologies. Inadequate information might also make it difficult for regulators even to know when they have enough information to make a decision as to whether a new technology is in the public interest. Proactive regulators require parties to provide them with objective and adequate information. Especially if a regulatory commission is asked to pre-approve a new technology or the associated utility's expenditures, the commission should have a thorough understanding of the likely risks and benefits before allowing the utility to pass those risks on to customers.

Poor information might lead a regulator to reject a good utility "innovation" plan to employ a useful new technology. Perhaps more likely, though, a regulator would approve a bad plan that had been submitted with incomplete, inaccurate, or misleading information. Regulators

---

[42] The 1994 NRRI report observed that:

> Over the last several years, regulated firms have been less inclined to select projects involving innovative technologies whose cost and/or performance is uncertain. Bounds on earnings provide one explanation for the intuition that regulation inhibits the adoption of [innovative generation technologies] and for the decrease in generation innovation by utilities over the past several years.

Mohammad Harunuzzaman et al., *Regulatory Practices and Innovative Generation Technologies: Problems and New Rate-Making Approaches*, NRRI 94-05 (Columbus, OH, The National Regulatory Research Institute, 1994), 64.

need to distinguish between biased and objective information and be able to identify a "lemon" project when it comes before them.[43]

The pace of economic and technological change also complicates the task of remaining well-informed. The market for new technologies is dynamic, and opportunities can come and go quickly. Utility incentives can also shift rapidly with economic trends and changes in the pricing and availability of technology.

Obtaining information from the utility can also be more difficult when the utility has weak incentives to invest in a new technology either because it enjoys little of the benefits or incurs most of the risks of investment, or both. Especially when utilities are apathetic or indifferent, it may be necessary for the regulator to mandate proactively that the utility conduct a serious review of a new technology that has a potentially high social value.

For all these reasons, regulators should keep current on new technologies and know which ones offer the most promise for customers and society at large. Reliance solely on information from utilities is not adequate. Under real-world conditions, utilities may not fully inform regulators about what they have chosen to do and why, or about what they have refrained from proposing and why. Regulators should assume that utilities will not innovate at the socially optimal level.

The only practicable answer seems to be that regulators must do their own homework on new technologies. Commission staff can brief commissioners on new technologies. Commissioners and staff can attend workshops and other information forums to learn more about new technologies. By acquiring the best available information, regulators can lessen information asymmetry, although realistically they can never eliminate it. The better informed regulators are about new technologies, the more likely they are to make good decisions.

B. Evaluating technologies

As mentioned in Part III, many new technologies have potentially significant but uncertain benefits to consumers. Regulators might have to evaluate a new technology project or other innovation in a variety of contexts ranging from prudence reviews to rate cases. Yet the benefits and costs of new technologies are often uncertain. It is often difficult for regulators to know with a high degree of confidence whether a new technology passes a cost-benefit test.[44]

---

[43] A "lemon" project could have benefits that turned out to be much smaller than those the utility had projected for its regulator. It could also include a project with large cost overruns during construction or other unexpected outcomes that reduce the net value of the project to below zero.

[44] Regulators would want the projected benefits of a new technology to be as accurate as possible. They can require utilities to use the best data and analytical approaches in their forecasting.

Regulators must inevitably determine how to account for this risk in deciding whether to approve funding for a new technology or other innovation. It can be particularly difficult to account for the inherently higher risks of new technologies in an economic analysis of different alternatives. Assume, for example, that a new technology has lower expected levelized costs than a conventional technology but has higher cost risk. It is no simple matter for a regulator to make the two technologies "comparable."

In determining cost recovery for a new technology project and the proper scope of utility involvement, regulators should evaluate the merits primarily in terms of the new technology's likely effects on customers. They will need to:

- Identify and measure the likely benefits of the new technology.
- Identify and measure the costs of the new technology.
- Measure the risks to customers and utility shareholders.
- Evaluate the proper market structure for deploying the technology. Some new technologies, for example, are better provided in an unregulated market. Other markets have natural monopoly features, with the technology better provided in a regulated market.
- Evaluate how different cost-recovery mechanisms would affect the utility's financial condition and the risks to customers.

For some new technologies, particularly new demand-side technologies, evaluating the likely benefits requires evaluating market penetration, which in turn depends on a number of other factors such as customer education,[45] marketing, transaction costs, income level, customer discount rate, and financing costs. These extra variables affecting customer acceptance make the cost-benefit calculations more uncertain. For example, smart grid improvements, smart meters, and dynamic pricing will have greater benefits if customers actively respond to dynamic price signals. Customer education therefore affects the scope of the benefit from the technology.

C. Aligning utility rewards with utility risks

One important task for regulators is to adjust the utility's risks and benefits so that it takes an appropriate attitude about innovation in general and new technology in particular. As a first-order rule, any firm will find innovation and new technologies financially attractive when it expects a profit to compensate it for the risk it bears. Together, lower-end and upper-end profit boundaries will affect a firm's incentive to innovate.

---

[45] Education can help, for example, to increase the effectiveness of customer response to dynamic pricing, which is potentially a large component of the benefits from smart meters.

In unregulated markets, firms tend to shoulder all the risks of innovation and capture all the benefits, at least in the short term.[46] Unregulated firms will invest in new technologies only if they are looking to improve their profits and financial condition. If the firm is also an early adopter, it accepts the risk of higher costs, expecting that they will be matched with higher profits. Unregulated firms enjoy benefits until other firms in the industry invest in the same technologies, at which point the first firm's advantage may dissipate. Once a cost-reducing technology has been widely disseminated, the market price for the product or service falls, and the benefits shift back to customers.

Utilities are a different case because regulators, rather than competitors, control the extent to which risk is borne and shared with customers. Ideally, a utility should have incentives to:

1. Review promising new technologies;

2. Select and invest in new technologies that serve the public interest; and

3. Refrain from investing too early in untested innovations, and refrain from investing in bad technologies that may be profitable but that are not beneficial to customers.

To achieve these incentives, regulators must decide what constitutes adequate compensation for the utility and whether that compensation is acceptable from the perspective of customers and society. Tools that regulators commonly employ include granting advance approval to risky capital investments, changing the utility's authorized rate of return, and shifting costs or benefits to customers, all topics that are discussed in more detail below.

Creating optimal incentives is harder than it might seem. The author is unaware of any real-world experience in which a regulated utility has optimal incentives to invest in new technologies and innovate in general. Even the theorists have not succeeded in coming up with a completely satisfactory answer. Regulators must use a large dose of judgment in solving this problem.

---

[46] The author found few studies that examined the effects of utility regulation on investments in new technologies and other innovations. It seems obvious, however, that regulation would affect innovation through the allocation of the benefits and risks. One factor is regulatory lag; if a utility, for example, retains for a longer period the benefits from a cost-reducing technology, it would have more incentive to invest in the technology. Regulatory lag highlights the conflict between strengthening the incentive for innovation and allocating the benefits to utility customers in the short term. Another factor involves cost recovery: When a utility can recover its costs for a new technology more quickly and with more certainty, it will likely be more receptive toward the technology.

D. Allocating risk between utilities and ratepayers

In competitive markets, the risk of a new technology's failure always falls on the firm that makes the investment. (Table 1 at the end of this paper illustrates this principle.) Likewise, the benefits in a competitive market fall, at least initially, on the firm. In regulated markets, however, regulators not only balance the risks and benefits of innovation for utilities but must also assign a reasonable share of risks and benefits to customers. Indeed, balancing the risks and benefits of innovation between customers and utilities is perhaps the regulator's greatest challenge.

Two untenable extremes exist. At one extreme is to "socialize the benefits and privatize the costs." Obviously a firm's worst-case scenario is when it retains no benefits from an innovation but bears all the risks. This scenario is not only unfair to the utility but also creates incentives to resist innovation. A utility that cannot recover any benefit from a new technology is unlikely to spend capital on that innovation unless specifically required to do so.

The other extreme is to "privatize the benefits and socialize the risks."[47] Here the firm retains all the benefits but bears none of the risks. This scenario would tend to motivate firms to overspend on innovation and is unfair to the customers (or taxpayers) who bear the risks. This scenario would meet with protest from consumers, and rightfully so. Transferring too much risk to ratepayers also raises a moral hazard in which the utility has little incentive to perform well because its risks have been transferred to ratepayers.

Once a project is built or an innovation implemented, costs and benefits seldom turn out exactly as expected. For large investments, cost overruns may have to be assigned between customers and utility shareholders. One possible tool is for regulators to set a prospective cap on capital costs, above which the utility would have to demonstrate prudent management. If the expected capital cost for a new technology is $500 million, for example, the regulator might specify a cap of $550 million, allowing for the possibility of certain uncontrollable events. If actual costs rise above the cap, the utility would have to show the costs' reasonableness before it is granted full cost recovery.[48]

In practice, the anticipated benefits from a project may have been overstated. One option is to assign some of that risk to the utility. Assume that actual benefits turn out, *ex post*, to be

---

[47] For example, in 2008 the U.S. government offered bail-outs to banks, but the banks were allowed to retain all of their profits during good times.

[48] In California, the Public Utilities Commission requires utilities to absorb 10 percent of cost overruns up to $100 million for smart-grid projects. Cost overruns over this amount are subject to a prudence review for rate recovery. (Charles Goldman, "Measuring Consumer Benefits and Accounting for Risks of Smart Grid Investments: Major Issues and Challenges," 11.)

below the expected level (possibly even so far that the new technology fails a cost-benefit test). In that event, both the utility's shareholders and customers could share in the net cost, rather than having customers alone absorb all the costs of a new technology.

Some regulators believe that regulatory lag provides an important incentive for efficient utilities operations. Utilities, on the other hand, contend that regulatory lag can limit their ability to raise capital for new investments and to remain financially viable. There is no clear answer to the question of optimal regulatory lag. Regulators have generally been favorable toward cost trackers, infrastructure surcharges, and other ratemaking mechanisms that shorten regulatory lag by allowing utilities to recover investment costs, including those for new technologies, outside of a rate case.[49] These decisions reflect the regulators' belief that traditional ratemaking practices might not serve the public interest in special circumstances.

Risk-allocation issues also arise between customer classes. When a new technology benefits only a portion of a utility's customers, the regulator may have to consider the responsibility of separate customer classes. Should all customers bear the risk of a new technology that benefits only residential customers? Should all residential customers pay the same costs for the technology even though some benefit more than others? The answer might lie with how utilities allocate the costs for other activities. For example, customer groups who benefit the most should perhaps pay more of the costs.[50] In some jurisdictions, utilities recover the costs of new smart meters through the customers' distribution charges. Complaints have come from customers who see little benefit from these meters.

Regulators historically have tried to create incentives for utilities to innovate while maintaining fairness for customers. Reasonable people can disagree on where that alignment is found. Fairness is a subjective concept, and the minimum incentive a utility would require to innovate is a debatable matter.

If a regulatory system happens to assign all the risks of innovative activities to customers, it is tempting to say that customers should also receive all of the benefits. Symmetry and fairness would seem to require that result. But any such system would likely make the utility indifferent to innovation,[51] or even opposed to innovation, since it receives nothing in return.

---

[49] *See* Ken Costello, *How Should Regulators View Cost Trackers?* NRRI Paper 09-13 (September 2009), at http://nrri.org/pubs/gas/NRRI_cost_trackers_sept09-13.pdf.

[50] Regulators can allocate what analysts call "common costs" on a customer, demand, or energy basis. Common costs are costs incurred jointly for two or more operational areas or the provision of two or more services—for example, the capital cost of a new distribution main serving residential, commercial, and industrial customers.

[51] A utility might find it tempting in this low-risk environment to experiment with innovation even if such experimentation is not expected to be profitable. It might, for example, try to attract engineers by portraying itself as an innovative company. Although this point is

Regulators would then have to assume the role of innovation evaluator by initiating a review of whether a utility should at least consider certain innovative activities such as investments in new technologies. As a general rule, the regulator should push utilities toward innovative activities when utilities themselves lack the incentive to innovate.

One general regulatory approach would be to create a symmetric risk/reward system in which utilities have good incentives to innovate but customers bear most of the risks and capture most of the benefits. Specific features of such a system could include (1) prompt recovery of costs (e.g., via a surcharge), (2) regulatory commitment to the innovation, (3) prudence review of the utility's management in spending the money, and (4) a guarantee that customers will capture most of the benefits. If a regulator wants to shift more of the risks to the utility, the regulator should also consider allowing the utility to receive more of the benefits. Criteria for cost recovery should have as their primary concern the balancing of utility and customer interests.

E. Maintaining utility accountability

Utility accountability is crucial for avoiding a "moral hazard" situation in which one party bears the risk and another manages that risk. Accountability requires that utilities (1) not receive guaranteed cost recovery, (2) satisfy some minimally acceptable performance (e.g., keeping construction costs below 125 percent of the projected costs), and (3) for demand-side technologies, educate and communicate with customers. For example, utilities could educate customers on the benefits of a new technology. Education and outreach are particularly critical for those demand-side technologies not widely understood by the general public.[52]

Utility accountability lies at the core of good regulation. The challenge for regulators is to make utilities accountable for their actions but, at the same time, also be fair to them and their shareholders. Repressive regulatory practices jeopardize a utility's incentive for innovation, which ultimately can harm both utility customers and society.

F. Inevitable trade-offs

Like many other matters regulators face, new technologies require them to make difficult judgments in which one good is traded off against another. Examples of trade-offs are:

1. *Timely utility recovery of costs versus tolerable customer risk:* Trackers and riders allow utilities to recover their costs more quickly and with more certainty, but they might also

---

conjectural, it reasonably assumes that utilities might innovate for reasons other than making a profit.

[52] Whether a utility should disseminate information on the merits of a new technology depends on its incentive to distribute unbiased information. Instead, it might be preferable to have the regulator or some other government agency (e.g., the state energy office), if they deem the growth of a new technology to be in the public interest, disseminate this information.

create (a) added risks to customers, especially when regulators fail to adequately scrutinize those costs; and (b) incentive problems.[53]

2. *Fuel diversity of electric generation versus the lowest possible utility rates:[54]* Regulators might want utilities to include a certain percentage of renewable energy in their generation portfolio; this policy would likely increase electricity prices over what they would otherwise be. Justification for establishing a floor on renewable energy is that utilities, for whatever reason, would tend to underinvest in this technology.

3. *Carbon reductions versus the lowest possible utility rates:* Regulators may want utilities in invest in low- or zero-carbon technologies, even in the absence of state or federal requirements. These technologies will gain faster market penetration; in the short term, however, they are likely to increase electricity prices above what they otherwise would be.

4. *Jobs versus the most economical technology:* Regulators may favor certain technologies because they create jobs. Job-creating technologies may, however, have higher costs. Regulators should be wary of arguments claiming that development of a certain technology will create hundreds or even thousands of new jobs. Many of the estimated new jobs might simply reflect a transfer of jobs from one sector of the economy to the sector linked to the technology.

---

[53] *See* Ken Costello, *How Should Regulators View Cost Trackers?*

[54] Most electric utilities have historically relied to some extent on fuel diversity to hedge against fuel-price spikes, to maintain system reliability, and to deal with emergency situations. There are examples, however, in which individual utilities heavily relying on one fuel source have produced good results, while others arguably have not. The fundamental economic question for fuel diversity is whether the benefits of fuel diversity are expected to outweigh the costs. As with any activity, the justification for fuel diversity must come only after reviewing both the benefits and the costs. It cannot be taken for granted that achieving a higher degree of fuel diversity would automatically have net benefits or be socially desirable, especially if the policy is not carried out intelligently. Fuel diversity, *per se*, should not be perceived as an end but only as a means that has the capability to produce benefits that are less costly than other alternatives in achieving the same objectives. The costs associated with diversity, at least at first glance, are more difficult to comprehend than the benefits. These costs might include lost scale economies resulting from the suboptimal operation of certain technologies requiring intensive use to exploit their full benefits. Another cost from diversity comes from a utility's incurring higher transaction costs as a result of the need to seek additional information about a wider array of fuels and generation technologies. Many utilities have acquired, through time, specialized expertise in a particular generation technology, allowing them to exploit fully the benefits of the technology. Learning about other technologies demands time and resources, adding cost to a utility's operation.

5. *More competition versus fostering social-benefit programs such as low-income energy assistance:* New technologies may increase competition but, in the process, reduce available utility funding (i.e., subsidies) for activities that serve social objectives.[55]

G. Distinguishing between due and undue regulatory barriers to innovation

Advocates of specific technologies often ask regulators or other government entities to redress allegedly unfair or excessive obstacles to their market success. Their advocacy might seek subsidies or other forms of financial incentives or the explicit lifting of particular restrictions that apply to other market participants.

Regulators should exercise caution, however, in taking action that favors one technology that is believed to better serve utility customers and the general public. Regulators should distinguish between what we call here "undue barriers" and "due barriers."[56] For example, a new technology might appear superior to a conventional technology in performance and cost but be only slowly adopted in the market. A key question is whether that slow diffusion is caused by (1) a "due barrier" such as the utility's rational response to risk, evaluated in light of its financial and regulatory incentives, or (2) an "undue barrier" created, for example, by a poorly adapted reward structure.

An "undue barrier," by definition, would cause a utility not to seek and develop socially desirable innovations. Undue barriers can arise from market or regulatory failures such as flawed prices for utility services. As an illustration, electricity prices that do not fully reflect the environmental costs of production could be an undue barrier to investment in clean-energy technologies. Similarly, if retail electricity prices are below marginal costs, that could be a barrier to optimal investment in energy-efficiency technologies. Also, an asymmetric risk/reward relationship can discourage a utility from making socially beneficial investments in new technology. Regulators should try to eliminate or at least mitigate these barriers to the extent possible.

Subsidies or other promotional practices funded by utility customers or shareholders can offset undue barriers. Appropriate offsets might include providing consumer education and (for

---

[55] In the telecommunications sector, for example, new technologies that promoted entry and competitive conditions contributed to making subsidies and monopoly prices unsustainable.

[56] For a thorough description of the barriers to the development of one technology, *see* Anna Chittum and Nate Kaufman, "Challenges Facing Combined Heat and Power Today: A State-by-State Assessment," a report by the American Council for an Energy-Efficient Economy, September 2011 at http://www.aceee.org/research-report/ie111. Without identifying them, the reader can judge for herself which barriers identified in the report are "undue" and which are "due." The report groups the barriers into four categories: economic, financial, political, and regulatory.

demand-side technologies) offering the utility or customers a financial incentive. Regulators should be cautious of counterproductive results when they seek to offset a problem at a high cost. Even in the face of an undue barrier to innovation, doing nothing may be preferable to creating a costly offset.[57]

"Due barriers" to innovation protect customers from imprudent and uneconomical utility actions such as excessive utility risk-taking and poor investment choices.[58] It would also be a due barrier to prevent a utility from assigning costs to all customers for an innovation that benefits only some customers. Regulators should ensure that utilities treat customers fairly, for example, by requiring funding for new technologies only from customers who expect to benefit. Some utilities may consider risk shifting to their shareholders an "undue barrier" when in fact it reflects a fair and appropriate regulatory response that corrects an imbalance in utility incentives or distorted risk sharing.

H. The proper role of utilities

Utilities can assume different roles. These roles range from merely providing a new commodity to actively promoting new technologies.[59] Another matter for regulators is to determine the proper role of utilities in developing and deploying new technologies.

According to the late economist Josef Schumpeter, the market penetration of a new technology requires three stages: *invention, innovation,* and *diffusion*.[60] After the invention of a new product or process, innovation involves commercialization. Diffusion means the wide use

---

[57] *See* Clifford Winston, *Government Failure versus Market Failure: Microeconomics Policy Research and Government Performance* (Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies, 2006); and Charles Wolf, Jr., "A Theory of Nonmarket Failure: Framework for Implementation Analysis," *Journal of Law and Economics*, Vol. 22 (April 1979): 107-39.

[58] One example is retrospective reviews, which penalize utilities for imprudent decisions and actions that otherwise would burden customers with higher rates.

[59] For different utility roles in accommodating and promoting natural gas vehicles, *see* Ken Costello, "Natural Gas Vehicles: What State Public Utility Commissions Should Know and Ask," NRRI 10-16, 4-6, at http://www.nrri.org/pubs/gas/NRRI_natural_gas_vehicles_dec10-16.pdf. Although natural gas vehicles are not a new technology, they have an extremely low market share in the U.S., exemplifying an immature technology.

[60] Josef Schumpeter, *Capitalism, Socialism and Democracy* (New York: Harper, 1942). Another stage that could be included is basic research, which occurs prior to the invention stage. The public sector is a major source of basic research because of the tendency of private firms to underinvest in this activity.

of a successful innovation in the marketplace.[61] The three stages overlap with blurred boundaries, and they are not necessarily linear. Feedback can also occur from one stage to another. Results from a pilot project, for example, may cause a return to the invention stage to correct unanticipated problems.

What role do utilities play for each stage? They definitely play the role of a "buyer" of a new technology and, often through funding to an industry research group, participate in the innovation stage (e.g., via a demonstration project[62]) and, on rarer occasions, in the invention stage. One question for regulators relates to demonstration projects whose results may not benefit their customers for several years or, because of their intrinsically risky nature, never benefit them. Under what conditions should regulators approve demonstration projects? What degree of certainty should utilities have in recovering the costs for these projects?

VI. Evaluating Existing Regulatory Mechanisms

A. Traditional ratemaking

Traditional rate-of-return (ROR) ratemaking sets rates by imposing cost-based rates and limiting profits. ROR ratemaking also commonly includes constraints on competitive entry.

ROR ratemaking can fail to provide utilities with incentives to invest in new technologies that are in the public interest. ROR ratemaking removes many of the profit opportunities that induce unregulated firms to make technological improvements. ROR ratemaking also limits utility risk for unsuccessful new technologies, which at least partially compensates for the absence of potential profit. Overall, ROR ratemaking tends to socialize both the benefits and the risks of new technologies.

It is not clear theoretically whether ROR ratemaking leads to over- or underinvestment. In some past circumstances, ROR ratemaking has enhanced the deployment of new technologies

---

[61] Schumpeter contended that an unregulated monopoly market creates the best environment for innovation. His reasoning was that a high payoff would come to those who could successfully innovate to keep out potential competitors. The benefits of innovation to individual firms tend to be negatively related to the number of competitors. As the number of competitors increase, rival duplication of the innovation would be quicker and thus reduce the benefits to the innovator. Taken to an extreme, excessive competition could stifle the incentive of firms to innovate.

[62] A government-supported demonstration project helps (1) subsidize the cost for a first-of-a-kind project that is currently not competitive and too risky for the first adopter, (2) verify the benefits of a new technology and thus reduce the risk to later adopters, and (3) verify the performance of a new technology on a commercial scale.

because regulatory policy passed most of the risks to customers. Conversely, ROR ratemaking can discourage new technologies by allocating most of the benefits of lower costs to customers.

Regulatory lag can also encourage innovation. In periods before the late 1960s, when electric utilities had declining costs, infrequent rate cases allowed utilities to retain the benefits of new technologies over several years. Retrospective reviews of utility activities were also rare during this time. Not surprisingly, during this period the electric industry welcomed new technologies and other innovative activities.[63] Some analysts believe that there was actually too much investment.

> Utilities in the late 1970s/early 1980s should have been more attuned to the risks of investing billions of dollars in extremely complex technologies which were subject to large cost changes during construction. In this case, hindsight reviews may beneficially reduce overinvestment and curb utilities' pursuit of unnecessary risks.[64]

A summary of the effects of ROR ratemaking on utility innovation follows:

1. When regulation tightly controls the utility's prices and profits in addition to eliminating the threat of competitive entry, it removes much of the incentive for utilities to minimize costs. ROR ratemaking offers utilities insurance against the risks of innovation in return for lower expected returns to investors. In other words, compared to unregulated firms, utilities incur fewer losses from innovative failures but enjoy fewer of the gains from successes. In the extreme case, if prices are continuously adjusted to reflect changes in costs and revenues, utilities would not enjoy any benefits from cost-saving or revenue-enhancing innovations.[65]

2. ROR ratemaking can induce too much innovation. This is especially true if the utility has minimal risk to its cost recovery, if returns are above the cost of capital, and if there is a long regulatory lag in transferring the benefits of cost-reducing measures to customers.

3. Regulatory lag may not provide a sufficient incentive for cost-reducing innovations, especially those with long payback periods. Regulatory lag seems most effective for inexpensive innovations with short payback periods.

---

[63] *See*, for example, Paul Joskow, "Productivity Growth and Technical Change in the Generation of Electricity."

[64] Mohammad Harunuzzaman et al., *Regulatory Practices and Innovative Generation Technologies: Problems and New Rate-Making Approaches*, 76.

[65] Revenue-decoupling mechanisms or rate designs in which marginal rates correspond to marginal costs, for example, would tend to discourage utilities from investing in innovations that increase sales. The reason is that utilities would receive minimal or no profits.

4. The threat of cost disallowances may compensate for utilities' tendency to invest in overly risky assets, but it also can cause utilities to avoid risky activities.

B. Depreciation rules

Despite its reputation, depreciation can be an exciting subject during periods of rapid technological change. Depreciation rules aim to ensure that a utility can recover its expended capital funds over the economic life of an investment.[66] Utility regulators, though, generally have not taken account of technological progress in setting depreciation schedules. Most regulators use book depreciation, which relates annual depreciation to three factors: (1) the original cost of property plus the cost of removal less estimated salvage value; (2) the estimated service life over which the utility writes off the asset property; and (3) the method used to distribute value over this life, usually straight-line depreciation. Book depreciation keeps rates lower in the short term, which might account for its appeal. Utilities might also favor book depreciation when they can earn a return above their cost of capital.

An alternative to book depreciation is economic depreciation. Economic depreciation (D_e) can be expressed in relation to three component terms:

$$D_e = d - i + \sigma,$$

where d equals the wear-and-tear or physical depreciation rate, i equals the inflation rate (which affects the replacement cost), and σ is the technological change.[67] Under this formula, a decline in economic value depends primarily on trends in replacement cost and technological change, whose annual rates fluctuate and are difficult to predict. Book and economic depreciation can have substantially different values in any given year.[68]

When depreciation rates are too low, the depreciation period can extend beyond the economic life of an asset. In such an instance, the utility encounters "technology risk" by experiencing a financial loss if it were to replace the asset at the end of its economic life.[69] This frequently happens to utility assets depreciated using straight-line book methods.

---

[66] The economic life corresponds to the projected length of time that an existing physical asset is economical and not replaced.

[67] *See* Paul L. Joskow, "Regulation of Natural Monopolies," draft paper, August 29, 2006, 105.

[68] Economists have argued that book depreciation distorts the path of rates relative to the optimal path under economic depreciation.

[69] Alfred E. Kahn, *The Economics of Regulation: Principles and Institutions*, Fourth Printing (Cambridge, MA: The MIT Press, 1991), Volume I, 117-122.

One solution to this problem is to allow the utility to use accelerated depreciation. This allows the utility to improve its cash flow in the early years of an asset's life, which can help to finance a new technology. Accelerated depreciation, though, increases the burden on customers by increasing their rates. In other words, accelerated depreciation passes the risk of unrecovered depreciation entirely to customers, a transfer that some regulators might disapprove of.

C. Regulatory commitments

Over the past several years, regulators have been under intense pressure from utilities to approve cost-recovery mechanisms that shift more of the risks to customers. In many cases this pressure takes the form of requests for pre-approval (sometimes called "full commitment") of both an investment and its costs. The scope of a regulatory commitment affects the scope and nature of later retrospective review of the utility's performance.[70]

Regulatory commitments are controversial because they can assign to customers virtually all the risks of a costly new investment with uncertain benefits. Regulators are understandably reluctant to bet "customer" money on an innovation when they know the chances for failure are high.

The proper standard for regulatory commitments was aptly expressed in one article:

> For utility investors, it is not the tiny details that matter, but whether there is a *credible commitment* to treat both utility customers and utility investors *fairly*, over the short and long runs. Public utilities are regulated to protect utility customers from the consequences of the unfair exercise of market power.[71]

The key words here are "credible commitment" and "fairly." The challenge for regulators is to strike a balance between credibility to investors and fairness to ratepayers so as to best serve the public interest. In the extreme, a commitment to utility investors that the utility will recover all of its costs for a new technology would certainly be credible from the perspective of investors, but it would likely be unfair from the perspective of utility customers.

1. The benefits

Innovative activities may require regulators to make some commitment before utilities spend money. Utilities may feel that before investing in a risky activity that involves a large amount of dollars, they would need a long-term commitment from regulators. If there is an

---

[70] Prudence reviews exacerbate the risks of innovation. *See*, for example, Mohammad Harunuzzaman et al., *Regulatory Practices and Innovative Generation Technologies: Problems and New Rate-Making Approaches*, 268.

[71] Kenneth Gordon et al., "Targeting Attrition: Some Familiar Ratemaking Tools," *The Electricity Journal*, Vol. 24 (August/September 2011), 10-11. (Emphasis added.)

unexpectedly bad outcome, this commitment will preclude second guessing after the fact by regulators (or what some analysts call "hold-up.")

Bad outcomes can occur, however, even under high-quality and prudent management. Outcomes derive from two distinct factors: internal efficiencies and external conditions. The first factor encompasses the resources used and utility management skills that determine how to combine and deploy those resources. The second factor accounts for market and business conditions that are largely independent of an individual utility's control.

The challenge for regulators is to separate the effects of management from the effects of factors outside a utility's control. It would be unreasonable for regulators to use an "actual outcome" as the only information for evaluating whether a utility was prudent.[72] A poor outcome, however, can act as a "red flag" that suggests the need for further investigation into possible poor management.

2. The downside

When carried to an extreme, regulatory commitments can create a "moral hazard" in which the utility has little or no financial risk yet manages the assets and makes important decisions that affect risk. Customers bear the risk but have no control over its management. This combination creates poor incentives stemming from the separation of those who manage the risk (the utility) and those who bear it (customers). One remedy is to have utilities bear most of the risk and retain most of the benefits. But regulators may have reasons for opposing such a policy, such as the possibility of "excessive" utility profits from a highly successful outcome.

Commitments may also induce utilities to hesitate to change their plans or activities when warranted by new information and changed conditions. If a utility knows that it will recover all of the costs for a new technology project because of prior regulatory commitment, it may continue with the project even though conditions call for scrapping or modifying it. Changing plans midstream may generate scrutiny and increase the chance of a cost disallowance. Especially if the utility has already spent a large amount on a project, it may see substantial risk exposure from changing its plan.

It may also be legally or practically difficult for regulators to make a credible commitment. Some states may have legal constraints preventing the regulator from making commitments. Also, current regulators may not be able to bind future regulators, who may not feel bound by a past commitment.[73] Finally, it may be hard to get a regulatory commitment that

[72] *See* Ken Costello, *How Performance Measures Can Improve Regulation*, NRRI Paper 10-09 (June 2010), at http://www.nrri.org/pubs/multiutility/NRRI_utility_performance_measures_jun10-09.pdf..

[73] Although the current commission cannot bind future commissions, current commissions can make it difficult for future commissions to nullify a past commitment.

eliminates all "hold-up." This is akin to the difficulty of parties' trying to negotiate a "complete contract" that minimizes contingencies and "wiggle room" for the parties. Eliminating such future risks simply might not be possible.

D. Summarizing the effects of existing regulatory practices

Having considered above the effects of some regulatory mechanisms on innovation, the broader question remains. What is the overall effect of regulation on utilities' willingness to invest in new technologies? This question is addressed in Table 2, which lists the main features of regulation and describes how they affect a utility's willingness to invest in new technologies. Some features of regulation encourage new technologies, while others discourage those technologies.

As discussed earlier, the allocation of risk and benefit is a key factor. Traditional ratemaking socializes most of the benefits and costs of new investment. Customers capture most of the benefits as well as bear most of the risks. This traditional allocation tends to make utilities neutral toward investing in new technologies. Overall, today's regulatory environment would seem not to create any strong inclinations by utilities to adopt new technologies. There are exceptions, of course, one being the smart grid, which has a time constraint on government funding under the American Reinvestment and Recovery Act (ARRA) in addition to potentially large benefits for utilities.

As shown in Table 2, several other features of traditional regulation make new technologies unattractive to utilities. These include the following: the presence of entry restrictions applicable to new firms,[74] the fact that most benefits are distributed to customers, cost-of-service rates that tightly link rates to actual costs, the use of book depreciation, the existence of prudence and "used and useful" tests, undifferentiated treatment of cost savings from conventional and new technologies, and the absence of rate-of-return differentials between different technologies.[75] Also, a regulatory emphasis on reliability and safety would tend to shift a utility's interest away from cost-saving new technologies.[76]

Although these regulatory practices tend to discourage new technologies, it does not follow that they should be abandoned or are contrary to customer interests. Regulators rightfully

---

[74] One explanation for the presence of more innovative activities in the telecommunications sector than in energy utility sectors is that telecommunications has robust competitive conditions, allowing firms to increase market share.

[75] The undifferentiated treatment would tend to favor conventional technologies and practices because they are less risky to the utility and the utility receives the same benefits as it would with new technologies and other innovations.

[76] This observation assumes that utilities have a fixed amount to spend on capital and will tend to allocate it toward activities that regulators prefer.

consider how these practices affect other regulatory objectives. Cost-of-service rates, for example, attempt to control utility profits and are generally perceived by regulators as a fair method for setting rates. Similarly, book depreciation is simple and avoids the complexities of measuring economic depreciation.

Table 2 also shows features of existing regulation that tend to encourage utility investments in new technologies. The principal measure that has this effect is the shifting of most risks to customers. Although this risk allocation may encourage new technologies, it also may run counter to regulators' perception of fairness. In addition, it can create an incentive problem or "moral hazard" for the utility that no longer has any risk from poor performance.

Regulatory favoritism toward a specific technology can bolster that technology but often does so at the expense of other technologies. Discriminatory treatment can lead to undesirable results, especially when conditions change, making the favored technology less economically attractive relative to other technologies.

VII. New Regulatory Approaches to Promoting Innovation

A primary objective of regulation should be to create incentives for utilities to invest in new technologies that benefit their customers. Regulators themselves should be innovative in contemplating new ways for giving utilities better incentives to innovate when in the public interest. The challenge here is to overcome what analysts call the "principal/agent problem"; namely, how to motivate a utility to achieve the objectives set out by the regulator. Without financial inducements, the regulator would have to (1) require utilities to undertake certain actions and (2) monitor utilities' performance to evaluate whether they effectively carry out those actions.

The discussion below provides a sample of regulatory approaches that have the ability to increase utilities' innovative activities. Few or none of these have yet been adopted by the majority of state utility regulators. A key question for each approach is whether its negative "side effects" are worth the benefits from more innovation.

1. Modified traditional ROR ratemaking model

The standard ROR ratemaking model could be modified to induce more innovative activities by utilities. But regulators should also address whether the benefits of getting utilities to innovate more than offset any negative side effects. For example, reallocating risks to customers might increase investment, but it would also weaken utility incentives for efficient cost management.

Another practice would be to allow more explicit risk-adjusted returns. For example, regulators can allow higher returns for investments, like new technologies, with higher risks.

A third practice would be to allow more timely and certain cost recovery. Infrastructure surcharges or cost trackers would help in this regard.[77] More timely recovery would also result from allowing construction work in progress (CWIP) in rate base.

A fourth practice would be to lengthen regulatory lag. This approach would allow utilities a longer time to collect the benefits of any cost-saving new technologies they install.

A fifth practice would be to replace book deprecation with economic depreciation, at least for large physical assets threatened by new technologies.[78] Book-depreciation policies can discourage utilities from replacing existing physical assets with new technologies because they can lead to "stranded costs."

A sixth practice would be to modify ROR policies by establishing a targeted incentive mechanism applicable to a new technology. A well-designed incentive mechanism would have several components. First, it would have a cost-overrun protection. If actual capital costs exceed the projected level by a certain percentage, for example, the utility would absorb a specified portion of the "cost overruns." Conversely, if actual costs fall below the specified level, the utility might be allowed to keep a part of the "cost savings." Targeted incentives can also share the benefits from a new technology.[79] Traditional ratemaking generally provides utilities with minimal benefits from new technologies, even when they are successful.[80]

A seventh practice would be to establish utility guidelines or "safe harbor" rules that articulate criteria for approval of new technologies and other innovations and their attendant costs. This action would reduce regulatory risk, which can induce utilities to take on more innovation.

---

[77] Regulators would still have the obligation to make sure that any cost recovered from customers reflects efficient and prudent management.

[78] See part VI.B for a discussion of this topic.

[79] The regulatory policy of favoring a certain technology might not advance the public interest. The regulator might have a bias toward the technology that is indefensible from an economic perspective. The point made here is that if the regulator wants a utility to do something, designing proper incentives rather than imposing a mandate would likely be a better choice.

[80] A properly structured incentive-based regulation, which allocates some risk to the utility but also allows the utility to benefit from "successful" outcomes, could create a symmetric benefit/risk relationship from both the utility and the customer perspective. As an example, for new energy-efficiency technologies, regulators might want to consider giving utilities an opportunity to capture some of the benefits. Regulators would have to first determine whether customers are benefitting and then establish some mechanism that would allow the utility to capture some specified share of those benefits.

2. Integrated resource planning

Regulators might also consider evaluating new technologies in the context of integrated resource planning (IRP). Several states require both electric and gas utilities periodically to submit integrated resource plans. As a prospective review, IRP allows the regulator and non-utility shareholders to compare new technologies, before the utility commits to them, with other options on a so-called "level playing field." IRP has particularly bolstered energy efficiency and distributed energy because it requires utilities to review, on an equal basis, these options along with traditional supply-side technologies.

A common technique in IRP is scenario analysis, incorporating a concept called a "loss function." A regulatory decision or investment is often based on a single forecast or range of forecasts. The loss function calculates the incremental cost if the forecast or range of forecasts turns out to be wrong in a particular way. For example, assume that a utility decides to invest in a clean coal technology, assuming it will pay wholesale natural gas prices above $6 per Mcf. If actual gas prices instead turn out to be $4 per Mcf, the utility's present-value revenue requirements for the coal plant would be $600 million higher than those for an equivalent gas plant.[81] Therefore, $600 million is the "loss function" if the forecast turns out to be wrong in this particular way. Forecasting risk is unavoidable when making capital allocations, particularly when dealing with something as dynamic and unpredictable as a new technology. To reduce this risk, however, regulators can require utilities to submit this kind of information on loss functions under a range of future market scenarios.

IRP can reduce a utility's risk from new technologies. IRP approval can represent at least a partial regulatory commitment to a utility's plan, which might include new technologies. As such, new technologies might be immune from later second-guessing by the regulator. The utility could still be investigated later for how it managed the investment and the actual cost, especially if there were cost overruns.

Integrated resource planning also mitigates information asymmetry. By having a separate proceeding to evaluate new technologies along with other options, regulators will more likely have the information that they need to make a sound decision that is in the public interest.

3. Partial commitments

As mentioned earlier,[82] commitment carried to an extreme can cause unfairness and can weaken a utility's incentives for efficiency. In other words, complete commitment can have negative implications for both equity and economic efficiency. The regulatory challenge is to balance the effects of a "commitment," some of which are positive and others negative, in a way that maximizes the public interest.

---

[81] The utility's second choice would be a combined cycle gas-fired generating plant.

[82] *See* Section VI.C.

An alternative is the "partial commitment." This kind of decision can offer regulators the balance they desire in allocating the risks of a new technology between utility shareholders and customers. A partial commitment can apply to any portion of the utility's innovation activities, including approving a general "innovation plan," approving the decision to invest in a kind of asset, approving the actual cost of an acquired asset, and approving how the asset will be managed.

A regulatory commitment affects the scope and nature of later retrospective review of the utility's performance. A commitment with a clear scope can avoid later controversies. A regulatory commitment to a plan gives the utility more certainty by reducing the likelihood of regulatory second guessing. Partial commitments can find a utility's "innovation" plan acceptable without committing to full cost recovery before that plan has been executed. Any imprudence in construction or other utility activities would still be subject to cost disallowance.

4. Price caps

In its purest form, a price-cap regulatory system regulates a utility's prices but not its profits.[83] Price caps generally allow utilities to earn higher profits.[84] Compared to ROR regulation, a price-cap plan also imposes higher risk on the utility. The focus shifts from "inputs" to "output," which should improve the utility's interest in using innovation to serve customers and society.[85]

Utilities under a price-cap system have incentives quite different from ROR regulation. For efficiency improvements, a utility can generally fully recover the costs of innovation, so long as implementation is successful.

Price caps encourage utilities to install only certain kinds of new technologies. Where an innovation neither saves costs nor generates revenues, the utility would need to recover the costs separately, as it would under ROR regulation.

---

[83] For a general discussion of price caps, *see* Wayne P. Olson and Kenneth W. Costello, "Electricity Matters: New Incentives in a Changing Electric Services Industry" *The Electricity Journal*, vol. 8 (January-February 1995): 28-40; and Mark Newton Lowry and Lawrence Kaufmann, *Price Cap Regulation of Power Distribution*, report prepared for the Edison Electric Institute, June 1998.

[84] Profit constraints depend on the length of regulatory lag. Compared to traditional ROR regulation, the length of regulatory lag is prespecified and thus more predictable to the utility.

[85] Under ROR regulation, for example, a utility could profit from merely placing the capital costs associated with an innovative activity in rate base without having to demonstrate any benefits. For this reason, regulators should hold the utility accountable for assuring customers that they will benefit from an innovation.

5. Explicit policy on innovation; regulatory mandates

Regulators may want to consider establishing a separate commission policy on utility innovations and new technologies. Such a policy can coexist with ROR ratemaking, price caps, or other ratemaking methodologies. It might include guidelines or general principles on what constitutes acceptable "innovation" investments. It can also articulate criteria for cost recovery, risk allocation to customers, and consideration of external benefits in evaluating a utility's proposal.[86] Since new technologies and other innovations are important for the future well-being of customers, special treatment for a particular technology might be warranted.

Regulators may consider issuing mandates that utilities invest in certain new technologies. A mandate can be justified if the regulator believes that a technology is cost-beneficial but, for whatever reason, utilities do not invest in it.

Mandates carry risk, however. Mandates requires regulators to "pick winners and losers," which is ordinarily a difficult task given the limited knowledge of most regulators. The problem is particularly difficult for new technologies with a high level of uncertainty. For example, a policy that mandates energy-efficiency technologies as a preferred resource can backfire if the price of natural gas falls sharply, causing the efficiency measure to become uneconomical. Another example is that some state utility regulators specify a "loading order" that requires electric utilities to prioritize future energy resources. Regulators may demand, for example, that utilities consider energy efficiency and renewable energy before acquiring other resources. Again, the problem is that utilities operate in a dynamic world where changed conditions can quickly shift the relative economic attractiveness of different technologies.

6. Spin-off of utility "innovation" activities to an unregulated entity

Regulators may ultimately decide that innovation best occurs outside the sphere of regulated activities. To give utilities adequate incentives to innovate may require assigning unacceptable risks to customers or unreasonably relaxing profit restrictions. An option in that case is to require utilities to establish an unregulated affiliate that invests in new technologies and other innovations. Regulators should give this alternative some consideration if they are unable to come up with other satisfactory mechanisms for allocating the risks and benefits of innovative activities. This kind of arrangement can help promote new technologies and other innovations that benefit utility customers in the long run.

Even if an affiliate succeeds in stimulating innovation, it creates another risk: An affiliate for innovation could be a way to cause captive customers to bear the risks of innovation while shareholders receive the rewards. To illustrate, assume that both the utility and an

[86] One external benefit is cleaner air than what federal and state regulations require. Another external benefit is the reduction of dependency on foreign oil caused by electric vehicles.

"innovation" affiliate are under the control of the same parent company. Both subsidiaries' resources are then held by a single corporation. To the extent that innovation is economically productive, the parent company would profit more than would the regulated utility.

VIII. Conclusion

This paper discusses the importance of utility innovation. One category of innovation—new technologies—has features that distinguish it from conventional technologies. This paper discusses eight challenges that innovation and new technologies pose for regulators. It then looks at widespread regulatory practices that either directly or indirectly affect new technologies. Some of these practices stimulate investments in new technologies while others hamper them. Finally, the paper recommends that regulators consider other practices, including targeted incentives, infrastructure surcharges, partial commitment to an innovation, economic depreciation, guidelines or "safe harbor" rules, and integrated resource planning.

Utility regulators always must balance different objectives to best serve the general public. With regard to innovation, they seek to (1) protect customers from excessive risks while at the same time (2) giving utilities adequate incentives to invest in new technologies when beneficial to their customers. Traditional regulation might not provide utilities with the right environment in which to invest in new technologies and other innovations that are in the public interest. A utility's incentives depend largely on regulatory commitments, risk allocation, and earnings constraints imposed by regulators.

Regulators are sometimes asked to allow utilities to use customer funding for new technologies that are not economical today but hold promise for the future. An alternative approach is for the government to subsidize these technologies through demonstration projects and other means. Some of these technologies might have external benefits that justify some taxpayer funding to supplement funding from utility customers. Regulators should exercise caution in using customer monies to subsidize new technologies that cannot pass muster from a cost-benefit perspective. Utilities should offer subsidies only for limited times and where there is convincing evidence that future benefits would otherwise be lost.

This paper has suggested some future research projects worth pursuing. One would be to design a general regulatory framework that addresses the concerns raised in this paper, particularly as they relate to balancing utility incentives to innovate and fair risk allocation to customers. The regulatory framework would consider depreciation rules, regulatory commitment, targeted incentives, mitigation of asymmetric information, and abolition of "undue barriers." A holistic approach could help create a new regulatory paradigm for stimulating utility innovation.

A second research project could focus on case studies of recent innovations in the electricity and natural gas sectors. The project would evaluate whether regulated utilities or unregulated entities have undertaken more innovations. Evidence showing, for example, that unregulated firms have dominated innovation (e.g., new electricity generation and transmission technologies) could suggest that regulation itself is a deterrent to innovative activities.

Table 1: Benefits and Risks of New Technologies in Different Markets

Type of Market	Benefits	Risks
Competitive	To the firm in the short term, to consumers in the long term	To the firm
Monopolistic	To both the firm and the consumer	To the firm
Oligopolistic	To the firm in the short term, to consumers in the long term	To the firm
Regulated monopolistic with ROR ratemaking	Largely to customers	Largely to customers
Regulated monopolistic with price caps	To the utility in the short term, to consumers in the long term	To the utility

Table 2: Effects of State Utility Regulation on New Technologies

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

Appendix: Questions that Regulators Should Ask

Regulators should ask several questions about new technologies. Answers to them might trigger different ratemaking practices and even a new general regulatory framework for accommodating new technologies. They might also lead to a regulatory policy on new technologies—for example, a requirement that utilities explain why they have not invested in a new technology that would seem to benefit their customers or criteria for cost recovery of investments in new technologies.

The author recommends that regulators ask themselves, utilities, and other stakeholders the following questions:

A. The role of utilities

1. Should utilities fund industry-wide research and development (R&D) that could create new products and production processes, technologies, and techniques for commercialization? What economic barriers do utilities face in conducting their own R&D?[87]
2. In addition to investing in new technologies, should utilities assume the roles of market facilitator, educator, coordinator, and leader?
3. Should utilities devote resources to promoting and marketing new demand-side technologies? Should they provide incentives to customers to increase the penetration of these new technologies?
4. Does the investment in a new technology by one utility mean that other utilities should also invest in the technology? Are "best practices" the same across utilities?

B. The role of utility regulators, state legislatures, and the federal government

1. Should state legislatures only provide regulators with guidance on new technologies (e.g., the general framework for evaluating demand-side new technologies) or should they prescribe more detailed regulatory actions (e.g., 15 percent of new generation capacity must be renewable energy)?
2. Should the federal government provide utilities with financial incentives when utilities are the first adopters of a new technology?[88]

---

[87] One possible barrier is the sharing of benefits with other utilities while the individual utility alone incurs the costs.

[88] First adopters usually face high risks, and often they incur higher costs than later adopters because of "learning."

3. What information should a utility provide to regulators so that they can make well-informed decisions on new technologies? How can regulators mitigate the problem of information asymmetry?
4. In addition to deciding on whether a utility should invest in a specific new technology based on a utility's proposal, what other functions should regulators assume?
    a. Should they provide utilities with guidelines or parameters for new technologies?
    b. Should they take a proactive leadership role by proposing or requiring that a utility invest in a specific new technology?
5. On what basis should regulators approve or reject new technologies? Should they, for example, require modular and flexible plans that reduce the risk of a long-term commitment? [89]
6. How should regulators identify barriers to utility investments in new technologies?
    a. Which barriers should they consider lifting? Some barriers prevent overinvesting in new technologies (i.e., "due barriers") while others hamper new technologies that are in the public interest (i.e., "undue barriers"). The former barriers act as protection against excessive risk taking and poor investment choices.[90]
    b. Should regulators eliminate only the latter barriers? If so, how should they do so?
7. Should regulators have a policy on new technologies?
    a. If so, what should be included and what would be its objective?
    b. Should regulators set guidelines for new technologies?
    c. Should regulators set parameters and establish a general regulatory framework for evaluating new technologies?
8. What regulatory forum is best suited for addressing questions on new technologies? Should regulators consider new technologies as part of resource planning, in a general rate case, or in some proceeding?

---

[89] Modular plans can reduce risk by dividing a single large project into a series of small sequential investments. For example, spreading investments over time allows a utility to respond to unfolding contingencies and new information. Modularity and flexibility are especially attractive for investments such as new technologies that have a high degree of uncertainty and lack regulatory commitment. Thus, a rational utility might want to avoid a large financial commitment by sequencing its investments over time.

[90] One example is uncertainty, which can hamper the penetration of a new technology. Uncertain outcomes are intrinsic to new technologies. Eliminating this uncertainty for a utility, say, through guaranteed cost recovery can cause the utility to take excessive risk. The problem is that the utility's customers would bear the full consequences of technology failure—a "moral hazard" outcome.

C. Ratemaking practices and regulatory incentives

1. What circumstances could lead utilities to overspend on new technologies, invest in the wrong technologies, and invest in them too quickly?
   a. Do they include risk-shifting to customers, rate-basing of costs, and government subsidies offered for a limited time?
   b. Can risk-shifting lead to a "moral hazard" situation in which the utility would be willing to take a chance on a new technology only because it would not suffer financially if the technology turns out to be unsuccessful?
2. Does traditional ROR regulation provide utilities with inadequate incentives to invest in new technologies that are in the public interest? Does it compensate the utility for bearing the risks intrinsic to new technologies?
3. Can incentive-based regulation better motivate utilities than ROR regulation to invest in socially beneficial new technologies? Would a mechanism such as price caps allow a utility to capture adequate benefits relative to the risks?
4. How can ratemaking be fair to both the utility and its customers while giving utilities good incentives to invest in new technologies?
5. What commitments should regulators make to new technologies?
   a. Should they pre-approve both the utility's investment in a new technology and all its costs?[91]
   b. Should they instead make partial or no commitment?
6. Who should bear the risks of new technologies?
   a. Who has more control over risk, the utility or its customers?
   b. Who is more likely to capture the benefits?
   c. Who can bear the risk at less cost?
7. How do depreciation practices affect the utility's incentive to invest in new technologies? Does straight-line book depreciation, for example, discourage replacement of existing physical assets that are not fully depreciated?
8. What role does regulatory lag play in stimulating utility investments in new technologies?

---

[91] For a more detailed discussion of regulatory pre-approval practices, *see* Scott Hempling and Scott Strauss, *Pre-Approval Commitments: When and Under What Conditions Should Regulators Commit Ratepayer Dollars to Utility-Proposed Capital Projects?* NRRI 08-12, November 2008 at http://nrri.org/pubs/electricity/nrri_preapproval_commitments_08-12.pdf.

9. Do some new ratemaking mechanisms discourage utility investments in new technologies? Does revenue decoupling, for example, discourage demand-increasing technologies because the utility would capture minimal benefits from increased revenues?

10. If regulators allow timelier and more certain cost recovery of new technologies, should they for the sake of fairness require that customers capture more of the benefits?

    a. If customers bear most or all of the risks, should they enjoy most of the benefits?

    b. Similarly, if all the benefits of new technologies go to customers, should they bear all of the risks?

    c. Is one factor in determining cost recovery the allocation of the benefits?

11. How should regulators treat cost recovery for new technologies that have large "external" benefits?[92] Should funding for these technologies come from taxpayers rather than from utility customers?

12. If a subgroup of customers directly benefits from a new technology, should only those customers be held responsible for paying the costs?[93]

13. How can regulators make utilities accountable for their actions that involve new technologies? Should they require risk-sharing (e.g., no guaranteed cost recovery), minimally acceptable performance levels (say, for construction and operation), and for demand-side new technologies, customer education and communication?

---

[92] These benefits accrue largely to society at large rather than to utility customers.

[93] When social benefits from a technology extend beyond those received directly by direct beneficiaries (i.e., social benefits exceed private benefits), regulators should ask whether it is appropriate to spread the costs to all customers. Assume that the benefits from a new technology include a cleaner environment for everyone and less dependency on foreign oil. Regulators might approve the recovery from all utility customers of costs associated with the technology. If, on the other hand, the direct beneficiaries—for example, customers who purchase electric vehicles—alone stand to benefit from the new technology, arguably the risks should not fall on the general ratepayer. In this instance, a policy of balancing the risks and benefits would require the direct beneficiaries, and perhaps the utility, to shoulder the entirety of the risks.