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Energy-efficiency and renewable energy options for risk management and insurance loss reduction

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Abstract

This paper identifies a spectrum of risk management opportunities associated with technologies and procedures that use energy more efficiently or supply renewable energy. While the economic benefits of these measures have long been of interest to energy consumers seeking to reduce their energy expenditures, we have found that they also offer a novel and largely untapped pathway for achieving traditional risk management objectives. These technologies have many benefits, including insurance loss reduction and prevention. Early examples of research in energy efficiency and renewable energy technologies conducted by insurers are described, and new interdisciplinary collaborative applied research is proposed. These technologies should be of interest to the insurance and risk management communities (e.g., researchers, insurance companies, government, energy service companies, facility owners, and utility companies). © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

The promotion of technologies and services for insurance loss reduction and loss prevention is as old as the fields of insurance and risk management. Examples include the early fire departments established by insurance companies, the creation of the almost century-old Underwriters Laboratories, and more than 160 years of property loss prevention experience by the Factory Mutual Research Corporation. Today, automotive air bags, sophisticated security systems, fire sprinklers and alarms, and environmental monitoring equipment are familiar risk management technologies promoted by insurers. In some cases, insurers are involved with the fundamental research and development of such technologies.

This paper identifies a spectrum of risk management opportunities associated with technologies

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and procedures that use energy more efficiently or supply renewable energy [1–4]. While the economic benefits of these measures have long been of interest to energy consumers seeking to reduce their energy expenditures, we have found that they also offer a novel and largely untapped pathway for achieving traditional risk management objectives. For example, some of the technologies discussed in this paper might make a marginal risk acceptable to insurers, given proper controls or monitoring: from high value risks where machinery and equipment monitoring devices are critical in affecting loss performance, to homes with proper equipment that can prevent fires from furnaces or wood stoves. These technologies should be of interest to the insurance and risk management communities (e.g., researchers, insurance companies, government, energy service companies, facility owners, and utility companies).

2. Methodology

The energy-efficiency and renewable energy technologies described in this paper are primarily funded by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and are being studied at DOE's national laboratories.[1] Due to resource constraints, we limited the scope of work to technologies and services that affected energy use in the residential and nonresidential sectors, and did not examine technologies in detail in other sectors (e.g., transportation and agriculture).

We first contacted EERE's Deputy Assistant Secretaries and their staff in the Office of Building Technologies and State and Community Programs, Office of Utility Technologies, and the Office of Industrial Technologies, and solicited the names of projects and researchers at the national laboratories. We then contacted the national laboratories and asked each project manager to complete a survey form on their project. We collected the following type of information on each project: contact information, description of technology studied, avoided insurance losses, research capabilities and skills, research facilities, publications, standards/guidelines/protocols/software tools, links to World Wide Web sites, demonstration projects, international activities, future work, collaborations with the insurance industry, and suggestions for insurance-related research in their project.

A few caveats are in order. First, we tried to be comprehensive but realize that we have not covered all of the projects at the national laboratories. We did not interview all of the staff at DOE (due to resource limitations), and not all of our national laboratory contacts completed the survey. Second, the insurance and risk management communities have yet to systematically quantify the types of losses considered here. Third, because the concept of avoided insurance losses via energy-efficiency and renewable energy technologies is relatively new, most of the national laboratory researchers had never considered how their technologies would reduce insurance losses and, therefore, most analyses of insurance losses are qualitative. Fourth, as an initial step, we focused our research on the residential, commercial and industrial sectors and did not look at

[1] The national laboratories participating in this study were Argonne National Laboratory, Brookhaven National Laboratory, Idaho National Engineering and Environmental Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories.

other sectors, such as agriculture and transportation. And fifth, we have tried to be nonrestrictive if we thought a research project could be useful for reducing insurance losses: we have eliminated purely speculative cases, however, much research still needs to be undertaken for many products and services to illustrate their usefulness to the insurance industry.

3. Energy-efficiency and renewable energy technologies

Certain energy-efficiency and renewable energy technologies have the potential of reducing insurance losses involving property, health, life, or liability in the residential and nonresidential sectors. In Table 1, we summarize the energy-efficiency and renewable energy technologies that

Table 1
Physical perils and insurance coverage addressed by energy-efficiency and renewable energy technologies and strategies

	Number of measures offering benefit[a]
Physical perils	
Extreme temperature episodes	16
Fire and wind damage	38
Home or workplace indoor air quality hazards	38
Home or workplace safety hazards	21
Ice and water damage	17
Outdoor pollution or other environmental hazard	17[b]
Power failures	35
Theft and burglary	6
Insurance coverage — commercial lines	
Boiler and machinery	15
Builder's risk	4
Business interruption	21
Commercial property insurance	36
Completed operations liability	14
Comprehensive general liability	45
Contractors liability	14
Environmental liability	12
Health/life insurance	39
Product liability	5
Professional liability	19
Service interruption	21
Workers' compensation	35
Insurance coverage — personal lines	
Health/life insurance	35
Homeowners insurance	26

[a] The numbers in this column refer to unique technologies and cover all (i.e., including non-national laboratory) technologies studied in this paper. For example, if two national laboratories are conducting research on fuel cells, this is "counted" only once under Service Interruption.

[b] The environmental benefits of improving the outdoor air and reducing greenhouse gases by renewable energy resources (e.g., solar, wind, etc.) are not included in this table. We considered only localized environmental issues, such as hazardous waste reduction.

were examined in this study and that reduce these losses. In this section, we present examples of these technologies.

Insurance losses are related to eight types of physical perils (hazards):

1. *Extreme temperature episodes*: e.g., freezing temperatures can result in broken water pipes, while very hot temperatures can lead to “urban heat catastrophes” and loss of life. As an example, over 5300 summer heat deaths have occurred from a dozen urban heat storms in U.S. cities.
2. *Fire and wind damage*: e.g., malfunctioning heating or lighting equipment can lead to fires, severe property damage, and loss of life, and high winds can also lead to severe wind or roof failures and associated property damage. Approximately $2 billion in insured losses occurs annually from fires attributed to heating or electrical equipment in buildings.
3. *Home or workplace indoor air quality hazards*: e.g., carbon monoxide from improperly installed ducts and malfunctioning appliances can cause illness or death. Each year, about 1500 deaths result from CO poisonings in the U.S. Radon, a naturally occurring radioactive gas in homes, is responsible for about 12 000 deaths annually in the United States.
4. *Home or workplace safety hazards*: e.g., energy-efficient lighting often leads to fewer fixtures being installed as well as fewer changes in fixtures and lamps, thus reducing the safety hazards associated with lamp and fixture replacement. As an example, compact fluorescent lamps last ten times as long as incandescent bulbs, and LED exit lights are known to last much longer than incandescent exit lights, and can provide better visibility in smoky conditions.
5. *Ice and water damage*: e.g., repeated melting and re-freezing of snow can cause the formation of icicles and ice dams on roof eaves. Melting water tends to pond on the rooftop, behind the ice dam, often damaging the roof and the building interior. As another example, losses from frozen water pipes in the U.S. resulted in losses of $450 million/year during 1985–95. These losses occur during average seasonal temperatures (differentiating this physical peril from the first hazard associated with extreme temperatures).
6. *Outdoor pollution or other environmental hazards*: e.g., oil from transformers, mercury from lamps, and heavy metals from metal processing can harm both the environment as well as the workers handling these materials. In the U.S. steel industry, approximately $150 million is spent each year for environmental compliance.
7. *Power failures*: e.g., when power service is disrupted due to storms or other events, service interruptions often result. Losses from service interruptions can account for 20–40% of total insured losses following natural disasters.
8. *Theft and burglary*: e.g., poorly designed windows can facilitate theft and burglary in homes.

As seen in Table 1, the most common physical perils addressed were those associated with power failures, fire and wind damage, and home or workplace indoor air quality hazards.

Given our understanding of the relevant perils, we examined the types of associated risk and the types of energy-efficiency and renewable energy technologies and services that could reduce insurance losses associated with these risks. We focused primarily on buildings-related examples, but similar opportunities are no doubt to be found in industry and transportation. Some of these links are strong and have been demonstrated in practice, while others are less certain and need to be examined in greater detail.

3.1. Boiler and machinery risk

This form of insurance provides important mechanical breakdown coverage generally not available under any other insurance policy. A Boiler and Machinery policy can protect an insured against the effects of catastrophic property loss, such as steam boiler explosion or an expensive breakdown of machinery and equipment. Mechanical breakdown coverage encompasses much more than just boilers and pressure vessels. It also can include refrigeration equipment, air-conditioning equipment, various types of piping, turbines, engines, pumps, compressors, blowers, gearing, shafting, electric motors, generators, transformers and assorted other types of mechanical and electrical equipment. In fact, many policies are written for insureds who do not own or operate boilers or pressure vessels, but yet have sizable mechanical and electrical exposures.

One of the best ways of avoiding mechanical breakdowns is making sure the equipment is designed and installed properly and that any equipment is in compliance with existing standards or guidelines, the focus of building code development and compliance. Attention to such issues also tends to enhance energy efficiency.

Once a building has been constructed and the equipment is operating, "integrated information technologies" are needed to assure building performance by carefully examining the process by which buildings are designed, built, commissioned, and operated. The key elements of integrated information technology are software tools, building commissioning protocols, data, and energy management and control systems, i.e., products and services that can be used in buildings to reduce insurance losses. These procedures will result in the collection, documentation, and communication of important information about the building's design, the state of its operations, and its intended and actual performance. These tools will also allow their users to detect and diagnose discrepancies between intended and actual performance, and feed lessons back to building designers about design and operations problems.

Key integrated information technologies include: energy management and control systems (EMCS), building commissioning, architectural and infrastructure surety, and measurement and verification protocols. EMCS control energy use, building comfort and other factors and can be used to optimize factors that affect the energy use and productivity of employees in commercial buildings. Building commissioning is a process by which a building's energy service systems are tested and calibrated to make sure the building system is in full working order. The principles of architectural and infrastructure surety can be used to avoid mechanical breakdowns by applying risk management approaches to facility designs through the process of identifying, assessing, analyzing and mitigating risks in residential and commercial equipment. Measurement and verification protocols provide a uniform method of determining how much energy is saved by energy-efficiency measures. These protocols collectively encourage that the equipment is installed properly and that the building will be constructed as designed.

EERE technologies offer other tools that can help to reduce these kinds of losses. For example, infrared thermography is an energy management tool that is also used by some insurance companies to detect leaks in working fluids in refrigeration systems. And explosion prevention technologies can prevent significant damage to property and buildings.

3.2. Builder's risk

Builder's risk insurance indemnifies for loss of, or damage to, a building under construction. Insurance is normally written for a specified amount on the building and applies only in the course of construction. Coverage customarily includes fire, extended coverage, vandalism, and malicious mischief. One of the best ways for reducing builder's risk is through building code development and compliance, as well as many of the integrated information technologies described in Section 3.1.

3.3. Business interruption coverage

This form of insurance provides loss of income coverage for a business by replacing operating income during the period when damage to the premises or other property prevents income from being earned. It is by means of the operating income that a business meets its expenses of payroll, light, heat, advertising, telephone service, etc., and from which a profit is derived. If business interruption is suffered and one has to close for even a brief period of time or operate at a reduced pace because of fire or other perils, this income will cease or be reduced. Business interruptions are due to fire, lightning, water damage, etc. If the business interruption is due to an interruption in "incoming services" (e.g., electricity and gas), then this is classified as service interruption (see Section 3.12).

Several technologies can be used to reduce insurance losses from business interruptions. Explosion prevention technologies offer the potential for dispensing with the use of coatings for sensitive surfaces. Energy savings will be achieved by avoiding energy expenditures in the manufacturing and application of the coatings. Furthermore, these technologies can prevent significant damage to property and buildings, avoiding business interruptions. Energy-efficient ultraviolet water purification can produce emergency potable water during disaster situations, so that businesses can still operate. Refractories in glass production furnaces can maximize the service life and minimize the down time of these kinds of furnaces. Similarly, the reduction of cracking in recovery boilers in pulp and paper mills will also maximize the service life and minimize the down time of these mills.

3.4. Commercial property insurance

Commercial property insurance policies provide indemnification to the policyholder for direct damage to insured structures and business personal property. Direct damage to insured structures and business personal property includes payment for the repair or replacement of the damaged property.

Many of the integrated information technologies and services described in Section 3.1 help to reduce commercial property insurance. Other examples of energy-efficient technologies that can reduce commercial property insurance include: efficient heating and air-conditioning duct systems, light-colored roofs, explosion prevention technologies, wind-resistant building envelopes, durable roof coating materials, and efficient motors.

As an example, halogen floor lamps (torchieres) are extremely energy intensive (300 Watts) and operate at very high temperatures (~1000°F), creating a significant fire hazard in buildings.

They have been the source of 350 reported house fires, 30 deaths, and 114 non-fatal injuries in recent years. An additional 100 fires occurred at U.S. colleges and universities in 1996 and 1997. A safer, energy-efficient torchiere has recently been developed and can be used as a replacement for the halogen floor lamp based on compact fluorescent technology. This replacement lamp consumes only 60–80 Watts to provide the same amount of light output, and operates at significantly lower temperatures (only 100°F), virtually eliminating the fire hazard.

3.5. Completed operations liability

This form of liability insurance provides coverage for bodily injury and property damage arising from completed or abandoned operations, provided the incident occurs away from premises owned or rented by the insured. The best way of avoiding these problems is making sure the equipment is designed and installed properly, the focus of building code development and compliance as well as standard measurement and verification protocols. Furthermore, once a building has been constructed and the equipment is operating, several of the integrated information technologies described in Section 3.1 can ensure that equipment will not result in bodily injury or property damage: integrated information technology, energy management and control systems, and building commissioning.

Because indoor air quality illnesses can result in large insurance losses [6,7], reducing the strength of indoor pollutant sources is commonly the best (i.e., the simplest, most effective and economical) method to reduce indoor air pollution. For example, radon is a naturally occurring radioactive gas that is responsible for about 12 000 deaths annually in the United States. Radon-resistant housing reduces the liability of the builder and the real estate owner from exposing occupants to high levels of indoor radon. Relative to current practice, new radon mitigation technology saves energy.

3.6. Comprehensive general liability

Under this form of insurance, the insurance company will pay all sums the insured becomes legally obligated to pay as damages due to bodily injury and property damage. Comprehensive general liability provides coverage for damages incurred by third parties (individuals, companies, firms, corporations, etc.) when the insured is legally liable, but does not cover property damage in commercial buildings to the insured. The technologies included under commercial property insurance are also good examples for this type of insurance (see Section 3.4).

3.7. Contractors liability

Contractors are liable for damages resulting from bodily injury and/or property damage caused by an insured peril and arising out of the ownership, maintenance, or use of premises and operations. They are also liable for bodily injury and/or property damage after their work is completed and they have left the job site. This type of insurance covers people who are working on a particular construction site, in contrast to professionals (e.g., architects and engineers) who may not be at the construction site (see Section 3.11).

Many of the integrated information technologies and services described in Section 3.1 help to reduce contractors liability, as well as reduction of indoor air pollution, and radon-resistant housing. In the area of combustion (oil or gas), appliance installation, repair and sizing are important: improper sizing and specification, improper installation, negligence, improper maintenance procedures during service, etc. can lead to carbon monoxide poisoning. As more and more unvented gas heaters enter the market (sales approaching a million/year in the U.S.), the long-term safety of these appliances is problematic, since they do not vent their combustion products outside of the living space. Carbon monoxide sensors would help warn people about safety problems with these appliances.

Geographic information systems (GIS) can also be used to make contractors aware of certain types of risk (e.g., water-pipe freeze damage or ice dam formation in insufficiently insulated roofs). Finally, the principles of architectural and infrastructure surety can be used by applying risk management approaches to facility designs through the process of identifying, assessing, analyzing and mitigating risks in residential and commercial construction.

3.8. Environmental liability

Several energy-efficiency technologies and services help to reduce environmental liability risks. By replacing oil-filled transformers with superconducting transformers, there may be fewer liability concerns with the handling and leakage of oil, as well as problems with transformers that are cooled with oil. Similarly, the replacement of chlorofluorocarbons (CFCs) by advanced thermal insulation (e.g., evacuated panel superinsulations and non-HCFC-blown plastic foam insulation) will reduce potential liability claims related to the handling and/or leakage of CFCs in buildings. The energy-efficient process of recovering zinc from galvanized scrap metal results in cleaner scrap metal that can be recycled, purified zinc that can be resold, and a reduction in the amount of heavy metals and caustic solutions that need to be handled and disposed. Installing composite wall systems reduces the exposure of children to lead poisoning hazards in residential housing. Finally, high-efficiency sulfur lamps do not use mercury, thereby eliminating insurance claims related to the handling or disposal of mercury.

3.9. Health/life insurance (commercial)

Examples of technologies and services that reduce losses under health/life insurance include the following: building commissioning and building code enforcement, light-colored roofs and surfaces, daylighting, technologies for clean rooms, radon resistant housing, composite walls, and energy-efficient torchieres. Other technologies not previously described include the improvement of oil-fired combustion systems, including the reduction of fouling and corrosion of heat exchangers, as well as the training and certification of oil-fired heating system service personnel to make sure the equipment is operating as designed.

3.10. Product liability

Product liability is the liability for bodily injury or property damage incurred by a merchant or manufacturer as a consequence of some defect in the product sold or manufactured, or the liability incurred by a contractor after he has completed a job as a result of improperly performed work. Building commissioning is a process that should reduce product liability claims by making sure that equipment (and the building) is operating as designed. Energy-efficient torchieres (instead of halogen torchieres) represent a specific technology that will significantly reduce product liability claims, since halogen torchieres account for about 10% of residential lighting use in the United States and create a significant fire hazard in buildings (see Section 3.4).

3.11. Professional liability

Professional liability insurance is coverage for liability resulting from errors or omissions in the performance of professional duties. This is applicable as a general rule to professional business activities, typically not at the construction site (see Section 3.7). In addition to the integrated information technologies described in Section 3.1, several energy-efficiency technologies and services help to reduce contractors liability: reduction of indoor air pollution, radon-resistant housing, and geographic information systems.

3.12. Service interruption coverage

Similar to business interruption coverage, this form of insurance provides loss of income coverage for a business by replacing operating income during the period when damage to the premises or other property prevents income from being earned. It is by means of the operating income that a business meets its expenses of payroll, light, heat, advertising, telephone service, etc., and from which a profit is derived. If business interruption is suffered and one has to close for several months or operate at a reduced pace because of fire or other perils, this income will cease or be reduced. The service interruption is due to an interruption in "incoming services" (e.g., electricity and gas). If the interruptions are due to fire, lightning, water damage, etc., then this is classified instead as business interruption (see Section 3.3).

Energy-efficient technologies consume less energy than their counterparts and, therefore, can operate more effectively under minimum power conditions, reducing the negative impacts of service interruptions. For example, light-colored roofs reduce air-conditioning requirements during peak power periods lessening the risk of power failures. Similarly, cool storage systems are used in commercial buildings to shift the cooling load of a building to offpeak periods during the day; if a building's chiller or refrigeration system were to fail and the storage system could provide more than 12 hours of air conditioning without chiller operation, this would provide time for the chiller to be repaired or for alternative cooling arrangements to be completed. Any insured losses associated with building operation might be avoided. If the storage system provides less than 12 hours of air conditioning without chiller operation, benefits would still accrue, as uninsured or self-insured losses would be less. Efficient food or pharmaceutical refrigeration equipment reduces the risk of product destruction during power interruptions.

Renewable energy technologies can provide power to a building when grid service is disrupted-examples include flywheel storage, fuel cells, advanced batteries, photovoltaic systems, parabolic troughs for solar electric power, and, where available and appropriate, wind, geothermal, and biomass. For example, fuel cells can convert the chemical energy of nonpetroleum fuels (e.g., hydrogen, methanol or ethanol) to electricity with little or no pollution and with greater efficiency than heat engines and can provide this power continuously and reliably. Solar heating and cooling technologies also reduce a building's reliance on the conventional power grid, reducing the impact of business interruptions when power service is down. Grid-independent solar electric (photovoltaic) cells are already widely used to support traffic lighting, communications, and other critical services during natural disasters.

3.13. Worker's compensation

Workers compensation insurance protects the employee and the employer from the expenses and liabilities associated with a work-related accident. The legal requirements for obtaining this insurance vary widely from state to state, with wages paid or hours worked usually the defining item. Many energy-efficiency technologies and services help to reduce worker's compensation claims: for example, building commissioning and energy management and control systems ensure that equipment is operating as designed and that a healthy, comfortable indoor environment is achieved and maintained. The reduction of indoor pollutant sources should reduce worker's compensation claims by improving the indoor air quality and health of workers. Specific technologies also should reduce this type of insurance claims. For example, a lightweight ventilated vest intended for workers in spray booths and walk-in fume hoods reduces a worker's exposure to paint and chemical fumes and should result in fewer worker's compensation and health insurance claims. New technologies can be used to control particles in cleanrooms (which are used extensively in the manufacturing of integrated circuits, in the biological and pharmaceutical industries, and in medical facilities), keeping contaminants to a minimum; the air quality may be the same, but with lower energy use, or air quality could improve, but with level energy use. The use of organic coatings may prevent the onset of explosions in the metals casting industry which can lead to the loss of lives and serious injuries. Recovering zinc from galvanized scrap metal results in a reduction in the amount of time that people are in contact with heavy metals and caustic solutions.

3.14. Health/life insurance and personal liability (residential)

Many of the energy efficiency technologies and services that reduce commercial lines of coverage also reduce exposures under personal lines of coverage, especially with respect to health and life insurance and personal liability. Examples include the following technologies and services: building commissioning and building code enforcement, light-colored roofs and surfaces, daylighting, technologies for clean rooms (see Section 3.12), radon resistant housing, composite walls, energy-efficient torchieres, and the improvement of oil-fired combustion systems, including the reduction of fouling and corrosion of heat exchangers.

3.15. Homeowners insurance

Several energy efficiency technologies and services can help reduce homeowners' insurance claims: e.g., light-colored roofs and surfaces and energy-efficient torchieres. Duct systems in houses typically leak 15–30% of the air passing through them, impacting safety, energy use, indoor air quality, personal comfort and the environment. Improving the performance of duct systems and using aerosol sealing for internally sealing air leaks in heating and cooling ducts can avoid fires caused by furnace flame roll-out. The training, testing and certification of service technicians has aided in the safe long-term operation of oil-fired heating equipment.

3.16. Summary

As summarized in Table 1, the energy-efficiency and renewable energy technologies and services in the inventory benefit thirteen types of commercial lines of insurance and two types of personal lines of insurance (Health/Life and Homeowners). Of the commercial lines of insurance, the top four categories are Comprehensive General Liability, Health/Life, Commercial Property, and Workers Compensation. These were closely followed by Business Interruption and Service Interruption.

A detailed listing of the energy-efficiency and renewable energy technologies and services in the inventory and their links to reduced insurance losses can be found in Ref. 3. As noted previously, some of these links are strong and have been demonstrated in practice, while others are less certain and need to be examined in greater detail. Similarly, some of these technologies are still in the research and development phase (e.g., advanced batteries, fuel cells, flywheel energy storage), some are being actively demonstrated (e.g., ceramicrete, zinc recovery, composite walls), and others are ready to be commercialized (e.g., DOE's International Performance Measurement and Verification Protocols). Many of the projects in the inventory fall into the first two categories and are not ready to be commercialized. Readers are encouraged to look at each of the project descriptions in the World Wide Web () to gain a better understanding of these technologies and services.

4. National laboratory collaborations with the insurance industry

LBNL is leading a national effort to involve the insurance industry as a partner in the research and implementation of energy-efficient and renewable energy technologies. LBNL has developed partnerships with a number of insurance trade organizations and individual insurance companies. The key activities being conducted in this effort are [5]:

- Helping to implement and carry out a Memorandum of Understanding between DOE and the Institute for Business and Home Safety
- Conducting an inventory of DOE National Lab capabilities potentially transferable to the insurance industry
- Development of a research agenda based on Inventory task results
- Assembling data that help quantify the "insurance value" of EERE technologies
- Identifying new energy-efficient and renewable energy technologies that prevent insurance losses
- Data collection on the insurance industry as a player in real estate markets.

For example, LBNL conducted a demonstration project and training workshop at Northeastern University with Arkwright Mutual Insurance Company on the benefits of using energy-efficient torchieres instead of halogen torchieres (see Section 3.4). In support of the Memorandum of

Understanding between DOE and the insurance industry's Institute for Business and Home Safety (IBHS), LBNL is collaborating with IBHS to encourage the development and commercialization of UV Waterworks for disaster recovery. UV Waterworks is a small, simple, inexpensive device that uses ultraviolet light to quickly and cheaply disinfect water from the viruses and bacteria that cause cholera, typhoid, dysentery and other deadly diarrheal diseases. As a disaster relief technology, UV Waterworks could shorten periods of business interruptions for affected communities and reduce health care costs by ensuring an adequate clean water supply.

LBNL is exploring the merits of building commissioning with the two largest U.S. providers of professional liability insurance for architects and engineers (see Section 3.1). Building commissioning could improve indoor air quality (leading to reduced health claims and improved labor productivity), reduce system and equipment design and failure (leading to reduced property damages), and reduce professional liability claims for all participants in the design/build community.

In addition to these technology-specific activities, LBNL has been involved in a number of support activities for the insurance industry and DOE. LBNL recently completed a study on the costs of indoor air quality illnesses with significant input from the insurance industry [6]. LBNL is also assisting DOE in establishing an insurance industry advisory group for improvements to the IPMVP. The IPMVP is a consensus document for measuring and verifying energy savings from energy-efficiency projects and is being expanded to include indoor air quality issues [8].

We came across one other example of a national laboratory actively collaborating with the insurance industry. ORNL has a Cooperative Research and Development Agreement (CRADA) with the Roofing Industry Committee on Wind Issues (RICOWI) to investigate the durability of residential and commercial roofing systems after a major wind event strikes the U.S. RICOWI includes all major roofing trade associations in North America and various insurance partners (IBHS, State Farm Insurance, Chubb Insurance and insurance consultants). The aim of this cost-shared project is to analyze mechanisms of roof failure during severe windstorms, and one goal is to identify specific ways in which energy-efficiency detailing can enhance roof structural integrity in the face of such storms.

5. Early adopters within the insurance industry

A number of early insurer activities have demonstrated the largely untapped value of energy efficiency and renewable energy to the insurance and risk management communities. Some insurers are recognizing that involvement in the energy arena can open up new ways to touch customers and add value to their core business relationships. The approaches can be grouped into the categories of information and education, financial incentives, specialized insurance products, direct insurer investment to promote energy efficiency, value-added customer services, research and development, and in-house energy management.

5.1. Information and education

Insurers' well-established channels of communication with most property and business owners present a unique opportunity to disseminate information about risk management. The USAA

Insurance Company published a detailed extensive guide to energy conservation for homeowners, providing basic information on energy saving measures, a simple home energy audit procedure, and a tool for computing cost-effectiveness.

Arkwright Mutual Insurance Company has promoted the risk-prevention benefits of compact fluorescent torchiere light fixtures, which replace high-temperature halogen versions known to be associated with hundreds of structural fires across the United States. The activity involved a technology demonstration in student housing at Northeastern University, a follow-up training workshop for risk managers, and several publications distributed to their customers nationally [9]. In a prime example of cross marketing between government and insurance activities, Arkwright included prominent mention of the ENERGY STAR labeling program for efficient (and fire-safe) torchiere fixtures, operated by the U.S. Environmental Protection Agency and the U.S. Department of Energy. Finally, the National Association of Independent Insurers and the National Renewable Energy Laboratory have recently collaborated to evaluate the potential for solar photovoltaic cells to serve as a risk management tool during natural disaster recovery situations.

5.2. Financial incentives

The "soft" insurance market of today makes it extremely difficult for insurers to grant premium reductions as an incentive for customers that implement risk management. There are, however, some notable exceptions. In the first such case we are aware of, the Hanover Insurance Company (c. 1980) gave a 10% reduction in homeowner property insurance premiums to energy efficient/solar homes, based on the reasoning that the heating systems operated fewer hours, resulting in a reduced fire hazard.

Insurers can also promote education programs for their customers, be they building owners or building professionals. Insurers in Massachusetts have offered 10% discounts to people who take a free six-hour course in weatherization, home repair and other subjects. Another notable example, pertaining to professional liability insurance for building professionals, is a one-time premium credit of 10% offered by DPIC Companies to architects and engineers who receive training in commissioning. The credit applies to the Professional Liability policies carried by architects and engineers, and is based on a closed-claims study conducted by the insurer which examined the role that building commissioning can play in preempting physical conditions that lead to claims against their insureds.

5.3. Specialized insurance products

Another tool available to insurers is to design new types of insurance policies and products that promote risk-reducing energy efficiency improvements. As an example, the Zurich–American Insurance Group offers specialized insurance policies for third-party energy service companies that implement energy-efficiency technologies in exchange for a share of the savings. The policies protect the installer or building owner against under-achievement of contracted energy savings targets, and thus help reduce business risks for this emerging service industry.

Other examples involve new products to help address indoor air quality problems, an issue integrally related to energy performance. While most such claims are settled out of court, three U.S. examples that we have identified resulted in payouts totaling $50 million [6]. Innovative approaches to preventing or recovering from IAQ problems are being crafted by the insurance industry, and insurers are expected to participate in the indoor air quality annex of the IPMVP.

5.4. Direct insurer investment to promote energy efficiency

Insurers are among the most significant players in world financial markets, and these involvements often touch on the energy sector. The recently founded Storebrand-Scudder Environmental Value fund is an early example of environmental investing, to which insurance companies (Swiss Re, Gerling, Trygg-Hansa) and individual investors have already contributed $110 million. Energy efficiency is one of the criteria used to evaluate securities being considered for inclusion in this fund.

5.5. Value-added customer services

The risk-management benefits of energy-efficient and renewable energy technologies and practices suggest possibilities for entirely new insurance products and services. Chubb has avoided claims thanks to the use of infrared cameras in detecting electrical and other risks. Some of the risks identified also correlate with energy inefficiencies, e.g. refrigerant leakage, water damage to roofs, eroded insulation in steelmaking furnaces, and ruptured underground district heating lines. Munich Re has recommended the use of infrared cameras as a loss-prevention tool, citing the prompt detection of broken hot water pipes as an example of how to minimize water damage losses and save energy. Hartford Steam Boiler has been the leader in mechanical equipment inspections, as evidenced by its eye-opening analysis of fire hazards in 200 New York City buildings [10]. Infrared inspections might also prove useful in other areas, such as identifying heat losses (and associated energy waste) in roofs that invite costly ice dam formation or poorly insulated pipes exposed to freeze damage. Finally, Storebrand has conducted several customer-focused programs in which they provide building inspections (commercial and residential) and provide advice on improving indoor air quality and energy efficiency.

5.6. Energy-efficiency codes and standards

Insurers have long been involved in the development and support of building standards, as an integral to the disaster-resilience of structures. To the extent that energy-efficient technologies can offer risk management benefits (e.g. reduction of ice damming risks or elimination of pilot lights), insurers could expand their involvement to this dimension of codes and standards. The insurance industry's IBHS has endorsed the improved enforcement of building energy codes. There are as yet no examples of individual insurers involvement in the energy code arena.

5.7. Research and development

Insurance-related R&D organizations such as the Factory Mutual Research Corporation and Underwriters Laboratory evidence insurers' historic role in technology assessment and R&D. With a few modest exceptions, the resources of these organizations have yet to be focused squarely on the opportunities for combined energy and risk management. An early example of insurer partnerships in government energy R&D is the CRADA between various elements of the U.S. insurance and roofing industries and DOE's Oak Ridge National Laboratory (see Section 4). More recently, IBHS, focusing on natural disaster preparedness and recovery, is partnering with DOE in developing and deploying an extremely low-energy ultraviolet water disinfection system (see Section 4). The design is based on UV Waterworks, which utilizes small ultraviolet lamps to disinfect the water. The device will be manufactured by WaterHealth International, and can be operated with solar photovoltaic cells when grid-based power is unavailable. IBHS has also explored topics such as frozen water pipes and rooftop ice damming, for which some risk management solutions also yield energy savings [11,12]. Swiss Re has also investigated the dynamics of frozen water pipes, and has tabulated historical losses for two European countries [13].

5.8. In-house energy management

The insurance industry is one of the world's most important owners of real estate. Our survey of the ten largest insurance companies globally identified real estate assets amounting to $105 billion. We estimate the total floor area of these buildings at about one billion square feet, corresponding to an annual energy cost of $1.6 billion. Many insurers operate in-house energy management programs, with varying degrees of effort.

As large real estate owners, insurers also tend to purchase enormous volumes of energy-using equipment. Several European insurance companies (Delta Lloyd Verzekeringsgroup NV, General Accident, Independent Assurance, and Prudential Assurance) are now collaborating with the International Energy Agency to harness the purchasing power of large building owners to create new markets for energy-efficient photocopiers.

Lastly, U.S. insurers are beginning to look at the benefits of participating in the government's voluntary energy savings programs, such as Rebuild America and ENERGY STAR. Given the scale of insurer real estate ownership, the industry has an unparalleled opportunity to display leadership by example in the field of energy management.

6. Next steps

A number of promising technologies and services have been identified, including the development of energy-efficient and fire-resistant windows and light fixtures, improved indoor air quality monitoring devices, methods to reduce airborne disease transmission in office buildings, building commissioning, energy management control systems, and building code enforcement. While not technology development per se, there is a need for improved research on many fundamental building science issues, such as ice dam formation and mitigation, and the causes of Sick Building Syndrome. Other research opportunities include definitive studies on the connections between indoor environmental factors (e.g., air quality, lighting, and thermal comfort) and worker productivity and health.

The energy efficiency and renewable energy community and the insurance and risk management communities (e.g., researchers, insurance companies, government, energy service companies, facility owners, and utility companies) need to work together in the following ways:

1. Participate in strategic research, development and demonstration (RD&D) activities necessary to move new loss-reducing technologies into the marketplace.
2. For those energy-efficiency and renewable energy technologies that are commercially available, encourage insurance customers to employ technologies and practices that reduce the likelihood of insured health, property, and liability losses.

The focus of this paper has been on the development of new products and services. But basic market research is also needed on the particular types of losses potentially addressed by energy-efficient and renewable energy technologies. There is currently a remarkable lack of basic data on specific loss categories of interest for these technologies (e.g., fires caused by halogen light fixtures). New categories of insurance loss statistics need to be collected, so that it may be easier to quantify the potential loss reductions from the types of measures described in this report.

Most of the technologies described in this report were supported by government-sponsored RD&D programs over many years of effort. These technologies have many benefits, including insurance loss reduction and prevention and risk management. The insurance and risk management communities could take advantage of these technologies, either independently or in cost-sharing partnerships with existing R&D programs. Insurance industry support of strategic energy-related RD&D has been endorsed by the Reinsurance Association of America [14].

The cost for conducting research on the technologies and services described in this paper is significant. Accordingly, we recommend that representatives from the insurance and risk management communities, the national laboratories, and DOE develop a joint national insurance research agenda for the national laboratories in order to prioritize the type of research that needs to be conducted and to discuss potential collaborations.

Past experience in the energy sector could offer a model for interdisciplinary insurance industry R&D in this area. The Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI) spend $1 billion a year on technology and market research for energy utilities (about 1/500th of their members' revenues). They provide a common knowledge base for large and small energy companies and serve as an interface among the numerous energy utility companies, regulatory bodies, and providers of energy technologies. A research fund based initially on 1/10 000th of property casualty premium revenues would represent a $6 million annual program, which we suggest could be matched by DOE.

The activities of the Bermuda Biological Station for Research are also worth noting.[2] While this insurer-funded program focuses on global climate and natural disasters (rather than on energy issues), this is a good model for how insurers can pool resources in order to conduct research of strategic importance.

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[2] The World Wide Web page is http://www.bbsr.edu.urn

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