Securing Buildings and Saving Energy: Opportunities in the Federal Sector[1]

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1. INTRODUCTION

Since September 2001, most public agencies and many private firms have focused (or sometimes re-focused) attention on security issues, especially in high-visibility public gathering places and government workplaces. For DOE's Office of Energy Efficiency and Renewable Energy (DOE/EERE), this new focus on security may create both opportunities and challenges for its primary mission to advance the use of energy-efficient and renewable energy technologies. The EERE Buildings Program recently commissioned a White Paper on the implications of building security assurance for efficiency and renewables in buildings (Hadley 2002). The DOE/EERE Federal Energy Management Program (FEMP) is beginning to explore the relationships between security and energy efficiency/sustainability in public buildings. This paper presents some initial results of this FEMP work, suggesting possible avenues for government and industry collaboration in technology development, demonstration, and deployment activities that view building security upgrades also as opportunities to improve energy efficiency.

2. THE FEDERAL INTEREST IN ENERGY SECURITY

Federal agencies, and energy managers in particular, have a special interest in the relationships between building security and energy. Although federal government buildings represent less than 2% of the country's commercial building stock, they are far more likely to be at risk as potential targets for terrorist attack, especially for agencies such as DoD, Justice, DOE, the Postal Service, and the Department of State, with high-profile or symbolically significant facilities. For the same reason, it's also likely that federal facilities will receive a disproportionate share of the nation's total investments in upgrading security. Finally, while larger federal facilities are more likely to be targeted than smaller ones, they also offer more significant opportunities for piggybacking energy efficiency measures on security-driven investment projects.

With government buildings considered likely targets for terrorist attack, there has been a recent upswing in the number of interagency working groups and guidance documents on building security. Earlier, following the Oklahoma City bombing, the federal government created an Interagency Security Committee (ISC) in October 1995, under

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Executive Order 12977. GSA chairs this group, which has established guidelines for security in all federal facilities, including criteria for new construction and renovation.

Individual agencies and professional associations, including DARPA, the military services, FAA, Department of State, GSA, NIBS, and ASHRAE have also issued building security guidelines[4], some of which predate the events of September 2001 (and even predate October 1995). In most cases, these federal guidelines focus on security issues, with little attention to how building security may relate to the agencies' underlying missions – except for a common concern that there be minimal disruption to key facilities in the event of an attack or threat. Thus, the specific links between building security and efficiency or sustainability have received relatively little attention up to now.

3. EFFICIENCY AND SECURITY - SYNERGIES AND TRADE-OFFS

From a national perspective, energy efficiency clearly contributes to U.S. domestic security by lowering our dependence on imported oil and gas. Reducing U.S. net imports also helps ease world market demand, to the overall benefit of other oil-importing nations. At a regional or community scale, the reliability of the electricity grid and natural gas distribution system is generally enhanced, to the extent that building systems monitoring and control enable their operators to respond to external price signals or other system requirements. Grid reliability can also be enhanced through the availability of dispatchable on-site power, especially if the on-site power source is clean-burning enough to meet emissions restrictions – and ideally, fueled by local renewable resources. Finally, at the scale of the individual building, the same sensing and control capabilities needed to manage the building in an emergency can provide enhanced energy-efficient operation to meet normal, day-to-day needs. In fact, the capability to manage building systems in response to an attack or threat (especially the rapid system responses needed for airborne threats) will require far more reliable and effective controls than are now commonly used for daily building operation. Designing and maintaining heating, ventilation, and air conditioning (HVAC) systems for effective threat response almost inevitably creates huge spillover benefits in the form of improved energy management capabilities. Conversely, energy management and control capabilities, either for single facilities or groups of facilities (such as GSA's Western Region pilot project with the GSA Energy Management Network, GEMnet) can provide a backbone for remote monitoring and operation of federal buildings under emergency conditions.

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[4] The Defense Advanced Research Projects Agency sponsors a research and field demonstration program on "Immune Buildings" (DARPA 2001). The "Whole Building Design Guide" (NIBS 2002), co-sponsored by DOE, GSA, and NAVFAC, is an on-line resource with advice, examples, and links to other sites addressing a wide range of building design and operating issues, including energy efficiency/sustainability and building security. ASHRAE's recent publication on "Risk Management Guidance for Health and Safety" offers practical measures for design and operation of larger buildings (ASHRAE 2002). Lawrence Berkeley National Laboratory has published advice for building operators and "first responders" on managing HVAC systems in response to an airborne chem/bio attack. This work, sponsored by DOE/NN, also addresses some implications for HVAC design and operation in non-emergency conditions, including energy efficiency (LBNL 2002). Private sector resources include on-line magazines such as "Security Solutions On-Line" http://industryclick.com/magazine.asp?magazineid=119&siteid=24. A list of other Websites on building security and the indoor environment is at http://www.epa.gov/iaq/ohs.html.

If these are all examples of positive interactions between energy efficiency and building security there are also trade-offs to consider, both at the level of specific building components and overall systems. For example, reduced glass area can limit options for conventional daylighting and passive solar design, while improved filtration has the potential to increase energy requirements. The objective, however, should be to carefully evaluate these potential trade-offs and encourage RD&D on new technologies and practices that can help improve the terms of the trade-off.

Another common concern is the competition for funds. While it may seem that investing in improved security will inevitably divert resources and attention away from investments in energy efficiency, these security-driven projects can also create opportunities to upgrade the efficiency of mechanical equipment, lighting, ducts, envelope components, on-site power, etc. Where equipment and systems must be substantially modified or replaced in order to install security measures, energy cost savings from improved energy efficiency can reduce the net cost of the security measures. New construction often provides the best opportunities to jointly optimize security along with energy efficiency/sustainability, but other options may arise when renovating or retrofitting existing facilities (see the Appendix checklist).

It is important that we identify barriers that make it difficult to integrate energy efficiency measures with security upgrades, and find ways to bridge these barriers. The economic argument for packaging efficiency along with security upgrades is often straightforward; it may be institutional issues, not technical ones, that pose the greatest challenge. How compatible are the objectives, time-frames, and distinct "cultures" of the security community and the energy efficiency/sustainability community – or how can they be made *more* compatible with the right effort and communication? For example, even the most basic information-sharing between building security specialists and energy management personnel can be seriously affected by the requirements to safeguard key information about the building; this is evident in a recent GSA order restricting the release of potentially sensitive but unclassified information (GSA/PBS 2002).

4. LINKING ENERGY-SAVING TECHNOLOGIES AND PRACTICES TO BUILDING SECURITY

This section describes in more detail some of the positive links between assuring security and improving energy efficiency, as well as areas where trade-offs may be required – at least with today's technology. Both lists are indicative rather than comprehensive; the further mapping of these relationships (along with examples and quantification where possible) deserves more attention.

4.1 Symbiotic Relationships

Examples of positive interactions between security and efficiency measures include:

- Improved operational control of building air distribution systems – including event monitoring and trending, periodic calibration of sensors, adjustment of dampers, and other system maintenance – is essential for rapid response to an emergency while also contributing to energy-efficient operation under normal conditions.

- Numerous opportunities for improvements in thermal and fresh-air distribution can contribute to both energy efficiency and building security (faster detection of a threat and better control of the entry or spread of airborne toxins). Examples include increased zoning of distribution systems, higher-quality sensors and controls, better system commissioning and calibration, training of operating personnel, and reduction of uncontrolled air leakage from distribution ducts.

- Tighter building envelopes also have the dual benefit of reducing energy losses from infiltration while making it easier to pressurize a building and thus reduce entry of airborne hazards released outside the building.[5]

- Improvements to particle air filtration have benefits in addition to helping protect building occupants from biological agent attack. Reducing indoor particle concentrations from routine sources can help improve occupant health (and productivity), as well as reduce HVAC coil fouling and in turn improve the efficiency of heat exchange.

- Similarly, ultraviolet (UV) lights installed in air handling systems could perform the dual function of controlling mold growth and providing a degree of protection against some bacteria and other deliberately introduced biological agents.

- Periodic inspections of HVAC and other building systems to assure security might be combined with inspections related to energy performance and indoor air quality, etc. For example, when inspecting ducts and air-handling systems for suspicious objects, it is also easy to check for mold growth – and vice-versa.

- Daylighted spaces are easier to evacuate quickly (in the daytime) even if the power is interrupted due to an attack on the building or the electricity grid; in normal operation daylighting designs can significantly reduce electric lighting while creating interior spaces that are more pleasant and visually appealing.

- Window replacements or add-on films to improve blast-resistance in existing buildings also offer the opportunity to upgrade thermal performance at the same time – provided that the window system or add-on film is carefully selected for that building application. For example, in planning for a recent retrofit project, DOE evaluated several blast-resistant films with varying thermal and optical properties and then pilot-tested the samples on windows in several offices. The Department of State, among others, is actively pursuing advanced materials and design concepts for dynamic (yielding rather than rigid) blast-resistant structures and window systems for new construction.

- Occupancy sensors to control exterior security lighting may actually provide better security than lights always kept on at night, since an occupancy-triggered light is an

[5] Conversely, of course, tight buildings can increase the hazard to occupants from an intentional airborne release inside the building.

obvious alert to security personnel. One concept called “active illumination” involves the design of building security lighting so that it senses and responds to intrusions and other security-related events. The idea is to reduce the energy required for constant high lighting levels while enhancing security by focusing the attention of facility operators and security personnel on unusual events.

- Site planning that provides a wide buffer zone to keep vehicles away from the exterior of a public building can also provide opportunities for better solar access and for climate-appropriate landscaping, including trees to directly shade the building itself, lower on-site temperatures through evapo-transporation, and channel prevailing summer breezes toward the building or temper the effect of cold winter winds on space heating loads.

- While on-site power systems are sometimes difficult to justify economically based on electricity or peak demand cost savings alone, they may be much more attractive where they also provide reliable power during utility system outages (whether natural or human-caused). This is especially true for systems with low pollutant emissions that can be operated year-around in urban areas, and for systems that make economic use of the waste heat.

4.2 Potential Trade-offs

While there are many positive opportunities for linking energy efficiency and renewables to building security, other measures may pose potentially serious trade-offs:

- A “fortress” approach to design of public buildings may reduce the opportunities to use glass to provide daylighting and passive solar gain – unless innovative light pipes, light shelves, or skylights are used.

- Buildings in temperate climates, that might otherwise be designed with operable windows for natural ventilation and cooling, may be constrained by security needs to use sealed envelopes with filtered mechanical ventilation and cooling.

- Some high-performance air filtration systems increase energy use by air-handler fans, but this energy penalty can be mitigated by selecting low pressure drop filters, high-efficiency motors and fans, and better overall system design, including larger-diameter (and straighter) ducts, system commissioning, and preventive maintenance.

- Some high-performance air filtration systems may increase air-handler energy use – but this effect can be mitigated with careful selection of filters and better system design (high-efficiency motors and fans, larger and straighter ducts) and maintenance to reduce energy penalties.

- Security system sensors and controls, as well as security lighting, may add to building electrical loads, especially where these systems use excessive amounts of standby power or may duplicate sensors and controls already installed for building management, smoke/fire safety, etc.

- Finally, as noted above, building security concerns may restrict the flow of information on federal facilities, including information that would support energy efficiency initiatives or tracking energy use over time.

4.3 Examples in Federal Buildings

While many agencies are beginning to take advantage of these and other positive relationships between energy efficiency/sustainability and building security, the Pentagon renovation project offers some of the clearest examples. According to Pentagon sources, a spray-on wall coating being considered to improve blast-resistance would also help improve air-tightness of the building envelope. This saves heating and cooling energy while at the same time providing added protection against airborne chemical or biological agents released outside the building (or helping to contain interior releases until they can be dealt with safely). DoD also reports that the new blast-resistant windows chosen to replace the original ones at the Pentagon are 50% more energy efficient, while photoluminescent signs to mark evacuation routes not only draw no standby power but are often easier to see than conventional, ceiling-mounted "Exit" signs under smoky emergency conditions. A final example from the Pentagon project is the use of zoned climate control systems that improve indoor air quality and reduce heating and cooling energy use, but also make it easier to control smoke and manage the spread of chemical or biological toxins.

5. CONCLUSION

In summary, while federal buildings account for only a small percentage of total U.S. building stock and an equally modest fraction of all U.S. industrial facilities, they represent a disproportionately high share of potential terrorist targets due to both their functional importance and symbolism. Thus, in the years to come, Federal investment may account for much more than their proportionate share of spending to upgrade building security in existing facilities and add protective features to new construction. The Federal sector, in effect, will serve as a real-life laboratory for enhancing building security through measures that improve threat detection, reduce vulnerability of people and property, and speed the process of recovery after a possible attack. If energy efficiency is ignored in the process, however, we will miss an important opportunity.

The challenge to federal agencies is to recognize and use this surge of public investment in improved building security as an opportunity to address energy efficiency at the same time, to contribute to the larger goals of an economy less vulnerable to energy supply and infrastructure disruptions and to generate long-term energy cost savings that will in turn lower the net costs of essential security improvements.

6. REFERENCES

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APPENDIX:
Checklist of Opportunities to Upgrade Energy Efficiency with Building Security

Architectural Considerations			
Building Envelope	*Efficiency Opportunity*		*Security Issue*[*]
	Airtight barrier	Sealing appropriate to resist chem./bio. penetration also provides weather-tight seal	Air
	Insulation	Wall insulation may provide secondary barrier and provide thermal savings	Air, Ex
	Impact absorbing walls	Innovative walls systems (multiple layers, openings, crumple zones) designed to absorb blast effects can also reduce envelope heat transfer and control solar gain	Ex
	Thermal Mass	Earth berming for blast deflection can also provide thermal buffering	Ex
		High-mass (concrete) construction allows active or passive use of thermal mass to reduce heating/cooling loads	Ex
	Shading devices	Consider shading devices that can double as blast protection	Ex
	Vestibules	Consider vestibules to help control building access while reducing infiltration of unconditioned outside air	Con, Air
Windows	Laminate films	Apply blast-damage resistant laminate films to interior surface of windows with appropriate emissivity and visible light transmittance	Air
	Operable windows	Analyze appropriate response to threat (http://securebuildings.lbl.gov/)	Air, RR
	Protective screens	External protective screens may also control unwanted solar gain	Ex
	Storm Windows	Consider retrofit of storm window with efficient (low-e, solar control) films	Air, Ex
	Light shelves	Use light shelf integrated with blast wall	Ex

[*] Con = Control of access, Air = Airborne (Chem/bio) threat, Ex = Explosive threat, RR = Response and Recovery

HVAC Considerations			
Air Systems	System Design	Separate ventilation air systems from thermal distribution; use radiant cooling/heating for added efficiency	Air, RR
		Provide larger ducts and efficient fans for rapid venting and energy savings in normal operation	Air, RR
		Efficient ventilation systems (displacement ventilation, large ducts, etc.) reduce space and energy requirements for upgraded filters.	Air, RR
	Variable speed drives	Provide capability for normal operation and rapid venting. (VFDs also allow for dynamic braking to stop fans faster in an emergency.)	Air, RR
	Dedicated Exhaust	Provide separate additional exhaust for emergency venting or for economizer operation, especially in high-risk areas such as entry vestibules, loading docks, and mail rooms	Air, RR
	Whole-building ventilation	Consider dual use of building purging systems (for smoke and also chemical contaminants) to provide nighttime "free cooling" during normal building operation.	Air, RR
	Duct leakage	Specify, install, and commission (test) ductwork for low leakage	Air, RR
	Dampers	Provide dampers with rapid closure and low leakage	Air, RR
	Filtration	Provide low pressure drop filters, at the filtration level needed	Air, RR
		Provide tight seal around in-line filters	Air, RR
	Security barriers	Review impact of security barriers, such as additional doors, on normal air distribution	Con, Air
Water Systems	Physical layout	Provide secure enclosures and minimize run lengths of piping	Air, Ex
		Increase pipe size if making modifications	Air, Ex
Control System Considerations			
Windows	Operable window controls	Provide automatic and operator control for chem./bio isolation and thermal comfort	Air, RR
	Shading control	Provide automatic and operator control for blast protection and shading	Ex, RR
Integrated Systems	Interoperable systems	Integrate security controls with normal building controls using interoperable systems	Con, Air, Ex, RR
		Plan for future additions as new sensing capability is developed	Con, Air, Ex, RR
HVAC controls	Individual control of fans, dampers	Provide for pressurized safety zones when needed.	Air, RR

	Alternate filtration path	Provide parallel path through filter banks during chem./bio. attack.	Air, RR
Wireless systems	Remote monitoring and control	Provide secure and redundant control using wireless and web based systems.	Con, Air, Ex, RR
Monitoring	System status monitoring	Provide whole building system monitoring to improve maintenance, normal operation, and critical monitoring during events	Con, Air, Ex, RR
Elevator Controls	Integrate elevators with building systems	Integrate elevator controls for emergency response to fire or chem./bio events and provide for efficient operation, and controllable for peak load strategies.	Con, Air, Ex, RR
Lighting Considerations			
Interior/ Exterior Lighting	Security Lighting	Provide efficient lighting and lighting controls such as motion sensors.	Con
		Integrate lighting into overall building controls.	Con, RR
Interior	Daylight access	Minimize interior spaces without daylight access, to improve visibility in daytime emergency evacuations.	RR
Distributed Generation			
		For emergency back-up generation, consider upgrading from diesel to a gas turbine or other clean/renewable on-site power source with heat recovery to reduce power and fuel costs during non-emergency periods.	RR
Site Planning			
Building Site	Solar access, landscape to reduce heating + cooling loads	Added protective open space around buildings allows better solar access and building orientation. Trees and plantings can directly shade buildings, buffer or channel prevailing winds, and add evapo-transpiration cooling.	Con, Ex
Campus Layout	Sustainable site planning and management	Larger, multi-use sites to enhance security (e.g. Embassy compounds) create opportunities for efficient water use/recovery/recharge, ground-source heat pumps, better load matching for on-site combined heat and power, etc.	Con, Ex
Other			
Cyber Security	Computer standby energy	Physically shutting off power to PCs at night and during unoccupied periods saves energy even beyond low-power sleep modes, while reducing risk of unauthorized access to data and systems.	Con