GridWise® Architecture Council

Financial Benefits of Interoperability

How Interoperability in the Electric Power Industry Will Benefit Stakeholders Financially

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This document was prepared under the sponsorship of the GridWise Architecture Council for the purpose of estimating financial benefits that might accrue as a result of implementing interoperability in a smart electric grid. The focus of this paper was not on original research, but rather with the goal of identifying similar benefits experienced in other industries through a review of the existing literature. By publishing this document, the GridWise Architecture Council hopes to expand the understanding of potential benefits of interoperability in the electric power industry.

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Executive Summary

Volatile energy prices, painful strain on infrastructure, rapidly growing concern for the environment, and lower power quality are creating the need for a transformed power system. There exists the technology to improve power production, distribution, and usage through the implementation of an interoperable power grid.

Interoperability is the capability of systems or units to provide and receive services and information between each other, and to use the services and information exchanged to operate effectively together in predictable ways without significant user intervention. Anecdotal evidence suggests that standards for equipment and information systems integration will drive significant financial benefits for the energy and power sector. The goal of this white paper and the underlying research is to analyze the economic impacts and financial benefits that have grown from the adoption of interoperability in peer industries such as healthcare, emergency services, and building construction.

Examining the financial and related benefits from peer industries presents a possible model for the electricity network of the future where information becomes interactive across heterogeneous systems and decision-making becomes distributed. This type of integrated network would enable the integration of new distributed generation technology, alternative power systems, and new efficient power storage technology. It will also reduce unnecessary transaction costs and drive the advancement of new services such as load management. Such a model would lead to new business and trade opportunities based on new power sources and new consumption habits that, in turn, drive more efficient power and communications transactions among all players.

Peer industry experience shows that interoperable systems lead to the following financial benefits:

- Lower Costs Per Transaction
- Increased Operating Efficiency
- Improved Reliability and Security
- Lower Design & Installation Costs
- Lower Operations and Maintenance Costs
- Lower Support, Systems Restoration and Upgrade Costs
- Higher Quality of Service with Fewer Mistakes
- New Services Through Competitive Innovation.

While it is difficult to assess the precise financial benefits for the electric power industry, our investigation indicates that based on peer experience, the potential savings in the electric power industry due to interoperability falls in the range of 1% to 3%. In the U.S. power system alone, this could amount to as much as $10 billion in savings.

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Introduction

Electricity is everywhere and is among the most pervasive forces in modern society. However, the current electricity infrastructure is insufficient to meet our needs. Not only is our century old grid “aging, inefficient, and congested,” but it also lacks the network connectivity that has defined business in the 21st century.[1] Information networks have had a profound ability to create and transform a myriad of new economies. Current marketplace forces are bringing together information networks and the electric grid as players realize that the possibility of this combination will create a more efficient marketplace with unambiguous positive benefits.

Technology innovation is enabling demand for connectivity and integration of an increasingly wide array of devices such as networked computers, cellular telephones, personal digital assistants (PDAs), global positioning system (GPS) receivers, Radio Frequency Identification (RFID) tags, and sensors. The “Internet of Things” is now upon us.[2] The demand to aggregate and integrate these disparate data sources extends to power systems as well. For stakeholders to fully understand the value that will grow from integrating power and information systems a deeper understanding of the corresponding financial benefits is required.

Interoperability – EICTA Definition

According to the European Information & Communications Technology Industry Association (EICTA), interoperability is defined as follows: “the capability of two or more networks, systems, devices, applications, or components to exchange information between them and to use the information so exchanged.”

Defining Interoperability

Interoperability—commonly associated with “open systems”—usually refers to the ability of diverse systems and organizations to work together. In the context of the evolving global power system, interoperability is “the capability of two or more networks, systems, devices, applications, or components to exchange information between them and to use the information so exchanged.”[3,4] The exchange of meaningful, actionable information between two or more systems across organizational boundaries includes:

- A shared understanding of the exchanged information
- An agreed expectation for the response to the information exchange
- A requisite quality of service: reliability, fidelity, and security.[5]

Why Interoperability is Required to Achieve a Smart Power System

Today's energy and power systems are roughly similar to a society without a financial trading system. Financial economies that lack an abstracted, liquid currency are nothing more than barter systems. You can accomplish rudimentary trade in such a system, but not sophisticated, ever-evolving exchange that transcends the inherent meaning of traded objects such as silk or grain or livestock. The idea of a liquid currency was a paradigm-shifting innovation in running an economic system. Similarly, the common ―currencies" of the bit, the byte, and the packet have enabled massive and rapid evolution in computing and networking. Until the world agreed upon these basic concepts, it was not possible to move forward.

Interoperable System Example

For power industry stakeholders who may still question the value of interoperability or are uncertain about what benefits it will drive, illustrative examples help communicate the importance of standards. From an electric utility perspective, this would mean that any system could read any meter; any meter could be read by any system without special effort on the part of the installer or any modification from the equipment manufacturer. This would allow any new advanced metering infrastructure device to register itself upon installation with a device directory allowing the device to begin communicating with other devices in the system it has permissions to communicate with true "plug-and play" device and information systems integration.

Like the use of money as a means of exchange, interoperability in the electric power network has value because it enables value-creating transactions to occur that would not be able to happen otherwise. The next big step in energy and power systems—completely fluid information and fully interoperable systems—requires an equally simple, flexible, and universal abstraction that will make information itself truly portable in both physical and virtual space, and among any conceivable system or application. New products, services, and capabilities such as time-of-use reporting and demand-response enabled devices and equipment (such as thermostats, switches, appliances, and motors) will not progress in foreseeable future without interoperability.

Interoperable electric power systems integrate electricity infrastructure and information technology to enable us to confront pressing challenges as consumers and producers of electricity including: additional power shortages; increasing electricity costs; demand for greater reliability; concern over energy security; and the desire to reduce carbon emissions associated with adding additional generation capacity. These looming challenges, coupled with increasing difficulty and expense of building traditional physical infrastructure, point towards the creation of interoperable smart grid systems.

Future Benefits of Interoperability

The motivation for developing a smart grid lies in added efficiency of distribution and increased reliability of energy services, both from the point of view of the utility firm and the customer. Power customers are increasingly demanding higher quality, cleaner power with no disruption or downtime, and lower prices. Utility firms are looking for ways to reduce expenditures, maintain system stability, and offer customized services. Achieving these quality, reliability, service, and price demands will become increasingly difficult without interoperability, including the following:

- Physical Network Connectivity
- Network-to-Network Integration
- Common Data Structures and Models
- Business Process Standards.

While there are a broad range of benefits to the electricity business tied to interoperability, the following are examples of impacts interoperability can bring to the smart grid:

- Financial efficiencies and savings for utility operations
- Lower energy investment and fuel costs per delivered unit of electricity
- More options that will provide control and savings for electricity users
- Greater energy security and independence for the nation
- Reduced carbon emissions
- New product and service innovation opportunities for utilities
- New product innovation opportunities for electricity-using devices.

As attention grows around power quality, availability and uptime, interoperability enables a means to help significantly reduce the need to deploy new, expensive power systems, thereby saving costs to both the utilities and customers. It will further help provide customers with detailed usage information and will enable end users to take control of their energy use. By setting energy parameters customers will be able to safely forget about their energy consumption while systems look after their interests—actively connecting and disconnecting unused and unnecessary loads automatically as they go about their daily lives. Organizing load management without disrupting consumers' life styles will be key to attaining important –green" goals in society.

Section 2: Financial Benefits of Interoperability

While the benefits of implementing a smart grid are many, it is important that we isolate the direct financial benefits from residual and societal benefits. The following examples illustrate the benefits of interoperability that will drive the creation on value:

Automatic Meter Reading Reduces Transaction Costs: Network connectivity across multiple brands of meters allows for automatic meter readings on behalf of the utility provider, thereby reducing transaction costs and increasing service quality.

Demand Response Leads to Efficient Systems: Dynamic end use pricing based on integration of information from systems and users means that end users can adjust consumption, thereby reducing peak loads and decreasing variance of daily demand patterns. This increases capacity and utilization from the utility side, leading to more efficient asset utilization.

Standardization Makes Design and Installation Simple and Less Costly: Standardized equipment interfaces based on standards for connectivity and information integration make design and installation simple and less costly. Standardized systems allow for a reduction in switching costs for supplier equipment. Additional supplier competition leads to a reduction in capital costs and easier upgrades.

Load Management and Distributed Resources (DR) Increase System Predictability: The integration of information from multiple parallel devices and application sources will enable DR to be a source for system reserves, eliminating pressure from power plants. Embedded sensing can be integrated into appliances to monitor system status and control usage, thus reducing stress on the grid.

Predictive Maintenance Increases System Stability: Network connectivity/integration, common data models, and common business processes standards allow for predictive maintenance. Power distribution operators can predict and identify problems before they lead to failure, increasing system stability.

Even though the primary and residual financial benefits of interoperability in the electricity business are difficult to quantify directly, peer industry experience shows that interoperable systems leads to similar sources of financial benefit. For example, the telecom, building construction, geospacial, software, healthcare, and emergency services industries all are using interoperability in various ways and segments to lower transactions costs, improve efficiency, and drive innovation. One of the most impacting ways these other industries implement interoperability is through information integration—entering information or data into the system once, and then making it available to appropriate stakeholders when they need it through integrated information delivery networks.

Table 1. Interoperability Creates Financial Benefits

Interoperable Elements	Power Industry Examples	Financial Benefit
Physical Network Connectivity	Automatic Meter Reading Reduces Costs	Lower Costs Per Transactions
Network-to-Network Integration	Demand Response Leads to Efficient Systems	Increased Operating Efficiency
Shared Data Models	Standardization Make Design & Installation Simple	Lower O&M needs
Business Process Standards	Load Management and Distributed Resources (DR) Increase System Predictability	Lower Design & Installation Costs
	Predictive Maintenance Increase System Stability	Lower Support & Upgrades Costs
		High Quality of Service with Fewer Mistakes
		New Products & Services Through Competitive Innovation

While the telecommunications, software, and information technology (IT) industries provide a general context for understanding the economic benefits of interoperability, the healthcare, building/construction arenas and emergency services share similar distinct attributes with the power systems sector.

These include:

- **Lower transaction costs**: Lower transaction costs are achieved through sharing information when interfaces are standardized and facilitate application integration and data exchange. Investigative research shows that information system integration substantially reduces transaction costs due to data errors, mistakes from misinformation, and the manual re-entry of data.[6] The healthcare, building construction, and geospatial industries each identify severe inefficiencies and transaction costs that can be significantly reduced with the implementation of interoperability.
- **Lower operations and maintenance (O&M) services costs**: Antiquated O&M systems in capital intensive industries, such as in building construction, lead to unnecessarily high costs. Implemented standards can reduce O&M needs and allow for more suppliers of support services to provide flexible lower-cost O&M services.

- **More efficient systems and equipment upgrades and modifications**: The ability to change or upgrade systems is very difficult and costly due to high ―switching costs" that result from each individual supplier having different equipment communications and integration protocols. Standards-based systems often reduce the number of devices purchased for both new systems and upgrades—one sensor or monitoring device can be shared among many different systems, thus fewer devices are needed and the overall cost of the system drops. For example, in building automation systems, an interoperable motion sensor can share its status with the zone heating system for occupancy sensing, the access control system for request-to-exit purposes, the security system for intrusion detection, and the fire alarm system for occupancy sensing. The motion sensor still performs the same task of detecting motion, but it can share the information with many subsystems that can make use of its status.[7]

- **Higher quality service levels and more predictable response**: Interoperability facilitates the ability for multiple parties to share information on the status of constituents and systems. Advances in wireless networking, monitoring sensors and interoperability software create the possibility to improve upon the quality of service and leads to more predictable response. The need for effective emergency response information systems has become increasingly evident in recent disasters such as the attacks on 9/11 and Hurricane Katrina. The emergency response network, plagued by disparate and incompatible hardware is currently developing interoperable systems that will enable fluid information exchange in times of need.

- **Data creation and information integration, which drives innovation**: Interoperability enables the creation of new data or it integrates previously disparate pieces of information together in order to create a homogeneous data set. Geospacial interoperability will allow for the creation of whole new industries based on the integration of heterogeneous data. Businesses are increasingly embedding geospacial data into their business functions; interoperability of these functions will foster innovation in everything from supply chain logistics to customer relationship management. In the public realm, geospacial interoperability will drive new conclusions on such worldly topics as climate change and the spread of communicable diseases.

- **Increased competition for customers, which drives innovation**: Interoperable equipment helps constituents get the most out of technology, and it also encourages innovation. When different products can be combined without complicated and expensive interfaces, small companies can enter a field and make specialized products. Without interoperability, institutions are typically forced to turn to large vendors that provide suites of compatible devices but that do not specialize in any one area. Interoperability promotes competition, and competition encourages innovation and quality. Interoperability opens the path to many new application and service values. Another example is currently unfolding in the telecom sector. Apple entered what many consider a very saturated and mature cellular market with its iPhone [smartphone] offering. As Apple has opened its architecture many third parties have signed on to develop new applications. This is causing significant disruption in the market as a broad range of new participants start gravitating towards delivering new functions and services to cell phones, all of which will deliver enhanced value to users of the devices. Taken to the extreme, this all has the potential to reshape the definition of a cell phone.

Table 2. Financial Benefits are Common across Industries

	Peer Industry Benefits	Smart Grid Benefits
Lower Transaction Costs, & Increased Operating Efficiency	Healthcare Information Exchange and Interoperability will reduce transaction costs, errors, and redundancies associated with paper based systems Geospatial interoperability will enable heterogeneous computer systems to share data and services that are otherwise costly to integrate	Network connectivity across multiple brands of meters allows for automatic meter readings on behalf of the utility provider, thereby reducing transaction costs. Real time data will lead to better capacity management and demand response that will increase production efficiency and reduce costs.
Lower O&M Costs	Interoperability in building construction and capital facility management will save as much as $16 billion a year. Two thirds of these savings is attributed to the updating antiquated O&M support systems.	Interoperability will allow providers to easily monitor systems, having greater ability to know when maintenance and repairs are needed, thereby reducing O&M costs
Lower Design, Installation & Upgrade Costs	Interoperable motion sensors in building automation systems can share its status with various subsystems, thereby reducing the number of devices purchased for new systems and upgrades.	Standardized systems allows for a reduction of switching costs for supplier equipment. Additional supplier competition leads to a reduction in capital costs and easier upgrades.
Higher Quality Service & Fewer Mistakes	Wireless networking, monitoring sensors and interoperable software can increase the quality of emergency services by making real-time patient information accessible to multiple users in a time of crisis.	Customers will have more control over their power quality; improved ability to manage their load; more accurate charges; reduced losses for power outages; and improved diagnostics & control.
New Markets & Services Through Competitive Innovation	Geospatial interoperability will enable the creation of new location-based services and will increase the quality of current location-based services. By opening their IPhone architecture, Apple has enabled third party players to develop new applications, thereby driving innovation and delivering enhanced value to the user.	Customers will have more opportunity for demand-side management (DSM) products and services. It will allow for improved diagnostics, monitoring, and control. Interoperability will allow for more opportunity for distributed generation (DG) and related distribution energy resources (DER)

Comparing peer industry experience suggests that interoperability could save the electricity business a factor something close to 3% of industry output value (measured as revenue) compared to environments that rely upon proprietary standards (see sidebar on methodology). The electric utility industry has many similar cost-saving opportunities related to the codification and transmission of information in operations (e.g., administrative actions and time associated with meter reading, systems monitoring and reporting, and customer interactions such as billing) as well as similar savings in maintenance and upgrades.

Parallels to the Electricity Business

Since the late 1970s, the growth in information technologies, including computing, telephony, networks, and enterprise systems has accelerated the recognition of the value of interoperability and the need for standards. These examples can serve as a guide in demonstrating the impact of interoperability on the electricity generation and distribution arena:

Healthcare

The use of IT in healthcare is intensifying rapidly, with many stakeholders driving the development of electronic medical records (EMRs), computerized physician order entry (CPOE) systems, decision support, and related tools. Currently, the health system is reliant on paper-based data recording of health information that is difficult to exchange between stakeholders and prone to errors. Interoperability would thereby enable the sharing of electronic patient information between stakeholders in order to reduce errors, eliminate redundancies, and better communicate health information. In addition to digitizing the information that providers use to care for their patients within organizations, clinicians, patients, and policy makers are looking ahead to sharing appropriate information electronically among organizations.

To analyze the qualitative and economic implications of healthcare information exchange and interoperability, researchers studied the financial value of electronic data flow between providers (hospitals and medical group practices) and other providers, and between providers and other groups of stakeholders with which they exchange information most commonly: independent laboratories, radiology centers, pharmacies, payers, and public health departments.

Methodology

We used a wide range of sources, including literature reviews, published studies, and focused discussions with industry thought leaders to guide our search. We examined studies focused on the economic benefits of interoperability addressing nine industry sectors, ultimately focusing on four industry study efforts. Examination of the four industry studies was supported by secondary analysis focused on the evolution of standards and the related stakeholder benefits. We then created a framework for comparison to interpret values and benefits created in peer industries with potential values and benefits in the energy and power systems sector. Our comparison was limited primarily to tangible benefits that could be measured – those where we could assign a dollar value in savings or cost avoidance and align that value with a reasonable equivalent function or value in the power systems business. We then used percent of industry revenues as the comparative measure. Ultimately, based on comparison, expected savings ranged from a low of approximately 1% to a high of approximately of 3%. Hence, the estimated savings will range from about $3.5 billion to about $10 billion, based on an estimate of the value of electricity produced in the United States of $340–$360 billion.

While healthcare providers will bear costs of implementation of interoperable data exchange, they stand to gain the most from a reduction of transaction costs, increased operating efficiency, and the elimination of redundancies.[8] A second source of interoperability within the healthcare sector exists in location-based monitoring sensors that create more efficient systems and upgrades. The benefits realized when equipment and system upgrades include adding these location-based monitoring sensors (aligning doctors, patients, equipment, technicians, etc.) is potentially worth as much as $18 billion annually to the U.S. healthcare provider sector.[9]

Altogether, healthcare interoperability will result in benefits primarily in the following areas:

- **Lower Transaction Costs and Efficiency Gains**: This includes computer-assisted reduction of redundant tests; eliminate errors with orally reported results; optimize ordering patterns; reduce delays and errors with paper based recording systems, save time associated with communication of charts, reduce duplicate therapy and adverse drug effects, and optimize ordering patterns.
- **Easier and Less Costly System Upgrades**: Integration of multi-vendor equipment systems, i.e., ―plug-and-play" capabilities, will allow for easier and cheaper system upgrades.
- **Higher Quality of Service with Fewer Mistakes**: Clinical benefits include improved safety, quality of care, fewer medical errors, better continuity of care, better access to test results.

National implementation of fully standardized interoperability between providers and other types of organizations could yield $78 billion annually, or approximately 5% of the projected value spent on U.S. healthcare.[10]

The parallels between healthcare interoperability with power systems include a wide diversity of device populations that would benefit from machine-to-machine integration, significant reduction in ―paper processing" functions, the ability to share records across heterogeneous organizations, and more predictable reductions in operations and maintenance costs. The analysis of healthcare interoperability allows us to see the value that comes to multiple stakeholders with the reduction of transaction costs through the ease of data exchange. Whereas the communication of patient information enables doctors to best prescribe an efficient diagnosis to a patient, interoperability within the smart grid allows a consumer to best monitor and allocate their energy usage.

Building Construction and Capital Facilities

Interoperability problems in the capital facilities industry stem from the highly fragmented nature of the industry, the industry‘s continued paper-based business practices, a lack of standardization, and inconsistent technology adoption among stakeholders. Examples of unnecessary transaction costs resulting from inadequate interoperability include manual re-entry of data, duplication of business functions, and the continued reliance on paper-based information management systems.

	Healthcare	Building Construction & Capital Facilities	Geospatial	Emergency Services	Smart Grid Interoperability
Lower Transaction Costs	Primary Benefit	Primary Benefit	Primary Benefit	Secondary Benefit	Primary Benefit
Increased Operating Efficiency	Primary Benefit	Primary Benefit	Secondary Benefit	Secondary Benefit	Primary Benefit
Cheaper Design & Installation	Primary Benefit	Primary Benefit	Secondary Benefit	Secondary Benefit	Primary Benefit
Lower O&M Costs	Secondary Benefit	Primary Benefit	Primary Benefit	No Direct Benefit	Primary Benefit
Higher Quality of Service	Primary Benefit	Secondary Benefit	No Direct Benefit	Primary Benefit	Primary Benefit
Cheaper Support & Upgrades	Primary Benefit	Primary Benefit	No Direct Benefit	Primary Benefit	Primary Benefit
Competitive Innovation	Primary Benefit	Primary Benefit	Primary Benefit	No Direct Benefit	Primary Benefit

Primary Benefit   Secondary Benefit   No Direct Benefit

Figure 1. Financial Benefits of Interoperability are Comparable across Industries

Researchers conducted surveys with 105 individuals representing all the stakeholders in the industry: architects and engineers, general contractors, specialty fabricators and suppliers, and owners and operators. T he analysis focuses on making electronic data exchange, access, and management interoperable between appropriate stakeholders. Researchers identified and quantified costs associated with sources of efficiency and operating losses due to interoperability. These include:

- **Lower Transaction Costs and Efficiency Gains** including the elimination of manually re-entering data; elimination of excess training; reduced delays in building construction; and elimination of redundant systems.
- **Reduced O&M Costs** through the elimination of communication and information failures from construction to maintenance; increased O&M continuity over life cycle of building; and update antiquated O&M support systems.

Researchers estimate that the building construction industry incurs $15.8 billion in annual costs from its lack of interoperability, or 3–4% of the entire industry's revenue. They identify owners and operators as holding up to $10.6 billion in costs, or close to two-thirds of the entire burden most of which is associated with inefficient O&M spending. Owners and operators reported that interoperability costs do not simply result from a failure to take advantage of emerging technologies, but stem from a series of disconnects, both within and among organizations, that contribute to redundant costs.[11]

The building construction and capital facilities management and maintenance sector shares common O&M efficiencies with the electricity business. O&M costs typically range from as low as 5% of the original installed equipment cost per year in a capital facility to as high as 15%. Over the life of the system, O&M costs typically exceed the installed cost of equipment many times over. The implementation of standards will allow for more suppliers of support services to provide flexible lower-cost O&M services.

Geospatial Interoperability

Geospatial interoperability is the ability for two different software systems to interact with geospatial information (mapping and cartographic data). Interoperability between heterogeneous computer systems is essential to providing geospatial data, maps, cartographic and decision support services, and related analytical functions. Geospatial interoperability is dependent on voluntary, consensus-based standards.

These geospatial standards are essential to advancing data access and collaborations in e-Government, natural hazards, weather and climate, energy and natural resource exploration, and global earth observation. Government sponsored research to measure, both qualitatively and quantitatively, the return on investment (ROI) to organizations implementing geospatial standards projects that adopted and implemented geospatial interoperability standards have a risk-adjusted ROI of 119%.[12]

This ROI is a ―Savings to Investment" ratio. This can be interpreted in the following manner: for every $1.00 spent on investment, $1.19 is saved on O&M costs. The projects that adopted and implemented geospatial interoperability saved 26% compared to projects that relied upon proprietary standards. One way to interpret this result is that for every $4.00 spent on projects based on proprietary platforms, the same value could be achieved with $3.00 if the project were based on open standards.

The example of geospacial interoperability allows us to see the impact that information integration will have on reducing transaction costs and fostering innovation. Industry will save costs attempting to unite disparate pieces of geospacial data together. The ability to bring together this data will foster the next generation of geospacial products and services, advancing such services as location-based tracking and supply-chain management. The electricity industry will achieve similar gains through information integration from disparate equipment, systems, and users. In addition to financial gains through transaction costs, new services will arise in demand side management and improved diagnostics and controls.

Table 3. Interoperability Creates Billions of Dollars in Value

Industry Sector	Interoperable Characterization	Direct Benefits	Financial Benefit
Healthcare	**Electronic Medical Records Information & Data Exchange :** Standardizing electronic medical records (EMRs), computerized physician order entry (CPOE) systems, decision support, and related tools. Make sharing information accessible between stakeholders. **Equipment Systems Interconnection & Integration :** Integration of multi-vendor equipment systems, i.e. "plug-and-play" capabilities.	**Lower Transaction Costs, Efficiency Gains, Reduction of Redundancies, Simpler System Upgrades, Higher Quality of Service:** Computer-assisted reduction of redundant tests; optimize ordering patterns; reduce delays & errors with paper based recording systems, reduce duplicate therapy & adverse drug effects, and optimize ordering patterns.	**$77.8 billion annually**, or approximately **5 percent** of the money spent on U.S. health care for interoperability of Electronic Records Information & Data Exchange.
Building Construction & Capital Facilities	**Electronic Data Exchange & Management:** Information is entered into electronic systems only once and is shared by all stakeholders **Equipment Systems Interconnection & Integration :** Integration of multi-vendor equipment systems, i.e. "plug-and-play" capabilities.	**Efficiency Gains & Reduction of Redundancies, O&M Efficiency Gains, Increased Competition:** Elimination of manually re-entering data; elimination of excess training; reduced delays in building construction; elimination of redundant systems; increased O&M continuity over life cycle of building; update antiquated O&M support systems.	**$15.8 Billion annually,** or approximately **3-4 percent** of the industry's revenue for interoperability of Electronic Data Exchange & Management
Geospatial Interoperability	**Integration & Interaction Between Heterogeneous Systems & Applications** : Interoperability between heterogeneous computer systems is essential to providing geospatial data, maps, cartographic and decision support services, and analytical functions.	**Efficiency Gains, Lower Transaction Costs, O&M Efficiency gains, Innovation, Industry Gains:** Ability to reuse code; lower data acquisition & sharing costs; governments & academics can combine previously disparate information for analysis, increased functionality of geospatial information for business use	**$1.3 Billion** in savings, or a Savings-to-Investment ratio of **119%**

Emergency and Security Services

Interoperability is an important issue for law enforcement, fire fighting, emergency medical services (EMS), and other public health and safety departments, because first responders need to be able to communicate during wide-scale emergencies. Traditionally, agencies have not been able to exchange information because they operate widely disparate hardware that is incompatible. Agencies' information systems such as computer-aided dispatch systems (CAD) and records management systems (RMS) function largely in isolation under so-called ―information islands." These approaches have been inadequate, and the nation's lack of interoperability in the public safety realm became starkly evident during the 9/11 attacks on the Pentagon and the World Trade Center. Further inefficiencies due to a lack of interoperability surfaced when agencies tackled the aftermath of the Hurricane Katrina disaster.

Steady advances in wireless networking, monitoring sensors, and interoperability software create exciting possibilities for improving emergency services. The Advanced Health and Disaster Aid Network, being developed at The Johns Hopkins University, explores and showcases how these advances in technology can be employed to assist victims and responders in times of emergency.[13] The system provides a web portal to connect with the patient record database and makes the real-time patient information accessible to multiple users from any Internet browser. This web portal can be used by different participants in the emergency response team, such as the emergency department personnel who need this information to prepare for the incoming patient. A web service-based approach for intersystem communication gives the software the flexibility to interoperate with incremental third-party software in the future such as emergency dispatch systems for ambulances.

Many local, state, and national agencies are trying to bridge this isolation and are beginning to implement interoperable systems. The U.S. government is making a concerted effort to over-come the nation‘s lack of public safety interoperability. The U.S. Department of Homeland Security‘s Office for Interoperability and Compatibility (OIC) is pursuing the SAFECOM and CADIP programs, which are designed to help agencies as they integrate their CAD and other IT systems. Analysis conducted by several contractors working for the U.S. Department of Homeland Security have made estimates about the impact of standards just for communication and monitoring values and have estimated savings on the order of 5% of budget values annually—this just addresses the communication integration function alone.

Both emergency services and the electric power network are examples of critical infrastructure in our society that require rapid response, reliability, and cyber security. The monetary and societal benefits associated with rapid response, reliability, and cyber security due to interoperability in emergency services provides striking parallels the projected benefits to the power systems sector.

The emergence of standards and open systems from peer industries strongly indicates the increasing presence of low cost, network enabled technologies will change the economics of designing, deploying, and maintaining open and integrated systems.

Continuing development of embedded computing technology, the integration and use of wired and wireless networks, and standards for application-to-application integration will drive new market opportunities. As competition increases, making improvements in customer service will become the de facto behavior. Proactive monitoring and control of generation, transmission and distribution assets will become a minimum requirement for success in the power industry.

Table 4. Interoperability will Benefit all Stakeholders

	Healthcare Interoperability	Smart Grid Interoperability
Provider / Utility Benefits	• Computer-assisted reduction of redundant tests • Reduce costs associated with paper-based ordering and reporting of results. • Better access to patients' longitudinal test results • Optimize ordering patterns • Reduce medical related phone calls • Chart handling reduced chart handling • Easier communication with insurance • Better facilitation of care between patients and providers through reduction of duplicate therapy and avoidance of adverse drug effects • Increased access to latest technology	• Greater system stability • Reduced peak loads • Reduced transaction costs • Lower costs of capital and easier system upgrades • Increased profits from better capacity management • Lower, more predictable O&M costs • Lower, more stable fuel costs • Reduced costs of emission controls • Lower cost of outages • More opportunity for distributed generation energy resources (DER) • More opportunity for demand side management products and services
Patient / End User Benefits	• Improved efficiency of transactions • Avoiding redundant or unnecessary lab & radiology • High quality, faster, and more convenient health care service • Fewer diagnosis errors	• Better matching power quality to end user • More accurate charges with easier transactions • Reduced loss for power outages • Lower expenditure for power through lower demand charges • Improved ability to actively manage load • Improved diagnostics, monitor & control
Society & Other Stakeholder Benefits	• Early recognition of disease outbreak and biosurveillance • Reduced transaction charges between providers and alternative stakeholders	• Better use of renewable and alternative energy • Reduced emissions • Stronger control over power infrastructure

Section 3: The Drivers of Interoperability in the Power Arena are in Place

The Electricity Industry has Reached a "Tipping Point"

Like the other business sectors discussed in this paper, the electricity business has reached a —tipping point." Only the most sophisticated energy users have access to anything that approaches real-time power information. Historically, utilities have inhibited customer access to real-time power usage and cost information for fear that this will reduce their business. Hence, utilities have mostly invested primarily in technologies that reduce their operating costs and increase their capacity to deliver power.

Volatile energy prices, painful strain on infrastructure, and power quality too poor for the digital economy are all creating the need for a transformed energy market. Technology exists today that can help improve power production, distribution, and usage. Years of engineering developments are resulting in affordable technology solutions that, connected by the Internet, will lower power costs and increase its efficient use. New services are emerging that can quickly change how electric service providers increase revenues, and how consumers of power can better manage costs. These new services will rely on networked power devices that can be automatically monitored, controlled and managed to adjust to power cost, availability, and usage requirements. All these ‗dreams' share one common feature: the integration of information and electricity networks.

A Confluence of Forces is Driving the Smart Grid

The electric power industry's aging infrastructure is just one of several factors motivating industry participants to explore interoperable smart grid systems. Other critical forces driving the industry include:

- **Infrastructure Strain – Potential for More Disruptions**: Major blackouts, rolling blackouts, and brownouts over the past few years underscore the inability of the current supply chain to meet the needs of an increasingly electron-thirsty global economy.
- **Environmental Concerns – Increasing Intensity for Stainability**: Initiatives are underway in all regions to reduce harmful emissions produced by traditional energy sources.
- **Security and Quality of Supply**: Users increasingly demand a level of power quality and reliability that simply cannot be met by existing electricity supply structure.
- **High and Volatile Energy Prices – Increasing Impact on Markets**: High and volatile energy costs will accelerate the adoption of energy information and distributed resource technology systems. Price conscious customers will take advantage of energy information to reduce their costs where necessary.

Combining the pervasiveness of networking with embedded intelligence will drive new ‗real-time' capabilities for demand-side management down to socket and appliance level. As concern grows around power quality, availability and uptime, these technologies provide a unique unobtrusive means to enable customers to take control of their energy use.

Concluding Points

Electric Service reliability is among most common and important system performance metrics for utilities. Interoperability increases the amount of data and quality of information that guide the utilities in maintaining reliability in running a grid system. Reliability-based improvements can be quantified in many ways including the Institute of Electrical and Electronics Engineers (IEEE)-defined performance metrics for utility reliability performance such as SAIDI, SAIFI, CAIDI. Many of these performance metrics can be used to derive cost benefits including the costs of avoided outages and failed equipment, among others.

The overall economic benefits from interoperability of information between grid systems include the following and are summarized here due to their high importance within utility operations:

- **Prediction of Equipment Failure**: The ability to anticipate problems on the system before they occur (early detection, maintenance, and emergency cost savings).
- **System Restoration after Failure**: The ability to improve restoration of the grid and service loss to customers in the event of equipment failure.
- **Power Quality Improvement**: The ability to detect low or high voltage, power factor, voltage sags and interruptions, surges, frequency deviation, and harmonic distortion.
- **Outage Detection, Location, and Accelerated Repair Time**: The ability to identify that an outage has occurred, identify the precise location and equipment that has failed, isolate the outage to as few customers as possible, and repair the system as fast as possible.
- **Energy Security**: The ability to detect attacks both malicious and natural ones on the electricity infrastructure, and quickly survive the attack through intelligent reconfiguration, restoration, as well as operate portions of the system as islands such as Microgrids.

While the financial benefits of interoperability are not easily quantifiable, they are real and clear. Just as important are the non-financial benefits that will accrue from interoperability – higher quality services and improved value. Ultimately, utilities and customers will obtain greater control over their energy management. The time is now to update our energy infrastructure and create a 21st century smart grid.

About Harbor Research, Inc.

Harbor Research, Inc. has more than 20 years of experience providing strategic consulting and research services to product manufacturers, services organizations and core technology clients. Harbor‘s strategy and business development work is organized around emergent and disruptive opportunities, with a unique focus on the impact of the Pervasive Internet—the use of the Internet to accomplish global device networking that will revolutionize business by unleashing entirely new modes of system optimization, customer relationships, and service delivery – what we call ―Smart Services.” Harbor Research has built extended relationships with larger multi-line companies including ABB, General Electric, Danaher, Eaton, Emerson, Hewlett Packard, Hitachi, Honeywell, Siemens, and IBM as well as with a broad array of emergent start-ups and pre-IPO technology ventures.

Section 4: Notes

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