Information Technology
Industry Council

Benefits of Information Communications Technology to Energy Infrastructure

I. About the Information Technology Industry Council

The Information Technology Industry Council (ITI) represents high-tech and electronics manufacturers in the information and communications technology (ICT) sector. Our members are global leaders in all facets of ICT innovation, from hardware, to services and software, and have long been leaders in sustainability. Our members commonly exceed environmental design and energy efficiency requirements, and lead the way in product stewardship efforts. As a result, the Dow Jones Sustainability Index, the Financial Times Sustainability Index, and the Global 100 have consistently recognized ITI member companies for their significant environmental and sustainability achievements.

II. The Quadrennial Energy Review

President Obama issued a Presidential Memorandum on January 9, 2014 directing the administration to conduct a Quadrennial Energy Review (QER). The President's Climate Action Plan directed that this first QER "will focus on energy infrastructure and will identify the threats, risks, and opportunities for U.S. energy and climate security, enabling the federal government to translate policy goals into a set of integrated actions."[1] As the Department of Energy (Department) prepares the first installment of the Quadrennial Energy Review (QER), we at ITI would like to highlight the importance of and benefits derived from the implementation of Information Communications Technology (ICT) to the energy grid's transmission, storage and distribution infrastructure (TS&D).

III. Background on Information Communications Technology and the Energy Grid

ICT, as used here, refers to the communications networks that connect all parts of the grid including operations, service providers, customers, distribution, and transmission[2] by facilitating communications between machines, between humans, and between humans and machines.[3] ICT applications can include "sensors for remote measuring, chips and controllers for monitoring, smart meters… grid management systems… load analysis and automated dispatch software… demand response software that allows automated load maintenance,"[4] etc.

In an increasingly complex energy grid, ICT can be used to improve the reliability, resiliency and efficiency of the grid's transmission, storage and distribution infrastructure, and to help reduce pollutant emissions through better real-time monitoring and control of grid systems.[5] One study showed that effective use of ICT has the potential to reduce America's total energy consumption by 12-22% by 2020,[6] and another showed that "for every kilowatt-hour consumed by ICT systems, a savings of 10 kilowatt-hours were enabled elsewhere in the economy."[7] Simply put, grid-related investment in ICT provides enormous benefits for energy efficiency, economic growth and maximum use of non-polluting energy sources.

IV. Recommendations: ICT in Energy Transmission, Storage and Distribution

Because of the many ways in which ICT applications improve critical grid TS&D functions, ITI recommends that the Department address the importance of ICT to the grid in the QER.

Option 1: ITI recommends that the Department consider a new requirement for all new energy infrastructure proposals that require federal approvals. Before licenses or approvals are granted, the applicant should assess and analyze potential enhanced ICT options that would improve the reliability, resiliency and efficiency of the proposed additions to the grid. Just as agencies preparing Environmental Impact Studies (EIS) must analyze alternatives with potentially less environmental impact before issuing an EIS, agencies that license generation, transmission or storage infrastructure should assess whether improvements/upgrades to the grid through the utilization of currently available ICT technologies could lower the size and cost of needed expansions of capacity or improve performance that results in increased reliability or resiliency.

Option 2: Alternatively, the Department should require all applicants for new energy infrastructure to include a description of the use of ICT in their project and to analyze whether enhanced ICT could be a greater part of the proposal, to determine whether it could increase energy efficiency or reduce energy demand.

Option 3: The Department should develop a strategy for the use of energy efficient and energy saving ICT and practices to improve the grid's TS&D infrastructure. Examples include advanced metering infrastructure, efficient data center strategies, improving IT asset utilization levels and energy management plans. This recommendation is similar to proposals included in pending legislation before Congress such as The Energy Savings and Industrial Competitiveness Act (S. 2262) co-sponsored by Senators Jeanne Shaheen (D-NH) and Rob Portman (R-OH), and The Energy Efficiency Government Technology Act (S. 126) co-sponsored by Senators Mark Udall (D-CO) and James Risch (R-ID). ITI urges the Department to seek Administration support for these bills, but believes the strategy can be developed independent of enactment of any new legislation.

Option 4: ITI recommends that the Department encourage the States to provide regulatory incentives such as accelerated cost recovery for utilities that seek to deploy enhanced ICT technologies that bring increased efficiency, reliability and resilience to their systems. It should also encourage FERC to provide similar incentives to interstate systems within its jurisdiction. Incentives could also include federal grants and tax incentives, including accelerated depreciation, for deployment of innovative technologies.

Option 5: As a centerpiece of the Department's TS&D section in the QER, we encourage the Department to take into account how TS&D technologies will be implemented in real world scenarios such as the numerous and innovative smart cities initiatives taking place across the country and around the world. The Department should develop and publish a cross-cutting program guide to assist state and local governments in developing and implementing enhanced ICT technologies to support the energy TS&D infrastructure. Such a guide could include information about existing federal programs that promote ICT usage to support TS&D, including:

- DOE energy efficiency programs
- DOE GHG reduction initiatives
- DOE renewable energy programs
- DOE alternative transportation programs
- DOE smart grid programs
- Available DOE technical assistance resources
- Available sustainability grant-matching programs
- Available or new peer-to-peer partnership programs
- Available or new "information clearinghouse" initiatives
- Available or new sustainability best practices studies

Option 6: The Department should develop and host workshops, either peer-to-peer or led by the Department, focused on the importance of ICT to the grid's TS&D infrastructure. These workshops, for utilities, PUCs, state and local policymakers, energy and ICT industries, end-users, and other stakeholders, could focus on best practices in the U.S. or abroad and highlight innovative demonstrations globally.

Option 7: The Department should assist utilities in making appropriate investment decisions by commissioning a study that quantifies the savings and impact of the strategic implementation of ICT across the TS&D infrastructure.

Option 8: The Department should develop a grant-matching program for cities and / or states that would focus on driving ICT investments in TS&D infrastructure.

Option 9: The Department should maintain a robust research and development program that identifies technology gaps and outlines a visionary technology roadmap to support the grid's TS&D and ICT infrastructure needs of the future.

V. Energy Grid: Historic vs. Current Needs

Transmission, storage and delivery in the energy grid historically was a relatively straightforward, linear system of generation to transmission to distribution. Dispatching was generally local and based on marginal cost considerations. Margins of safety were large because of limited real-time information and limited options for replacement of power generation sources in an emergency.

As the Department points out, today's grid "must adapt to emerging challenges and opportunities: fluctuating energy prices, an increasingly transactive role for customers, integration of distributed energy resources, the need for improved resilience, and the need… to reduce greenhouse gas emissions."[8] In order to meet these challenges, a vastly increased role for

ICT is essential. Without continually enhanced ICT in the TS&D infrastructure, the grid cannot achieve these 21st century goals. ICT will allow real-time monitoring of actual conditions throughout the system, and provide the ability to control TS&D system functions so as to maximize efficiencies and ensure reliability with less additional costly excess capacity.

VI. Illustrations: Benefits of ICT in Energy Transmission, Storage and Distribution

ICT infrastructure can connect the many parts of the TS&D grid, from near real-time forecasting of intermittent renewable energy outputs to smart appliances and smart meters to electric vehicles. This comment illustrates a few of the key ways in which ICT can improve the efficiency, resiliency and reliability of the grid.

A. REAL-TIME INFORMATION SOLUTION TO CHALLENGE OF INTERMITTENT GENERATION

Use of renewable power generation continues to increase, both as required by state Renewable Portfolio Standards (RPS) and to achieve state and federal policy goals to reduce greenhouse gas emissions. Renewables, principally wind and solar, are inherently intermittent, and not just seasonally as traditional hydropower, but on an hourly or even more frequent basis. This requires precise real-time measurement and prediction to adjust dispatching of power generation because supply must match the demand perfectly. ICT is essential to achieve this TS&D function.[9]

ICT can help forecast demand and supply for grids that rely in part on intermittent energy sources. Current demand and supply forecasts that include intermittent energy sources like wind and solar are based largely on estimations because of a lack of real information.[10] These forecasts, and the resulting energy outputs, are often dependent on current weather conditions and cannot be timetabled.[11] However, ICT can assist in these forecasts by providing real-time monitoring of intermittent energy sources. ICT in the grid can be used to "balance[] an optimum share of renewable sources with a high reliability of supply and an adequate stability of the system."[12] The knowledge that ICT provides in the case of intermittent generation will allow power plant operators to more efficiently determine the necessary energy output at any given time and allow them to provide this energy more reliably with lower costs of dispatch as well as reduced redundancies.

B. MORE EFFICIENT INTEGRATION OF DISTRIBUTED ENERGY RESOURCES

The increased use of distributed energy resources (DER) such as solar photovoltaics (PV) on rooftops, wind turbines, small natural gas-fueled generators and combined heat and power plants by individual companies or individuals creates even greater challenges to power dispatch operators. This challenge will become even more complex as states adopt net metering—allowing consumers to sell back power to the grid, thereby increasing the portion of intermittent generation that is beyond the control of system operators.

Because consumers can now also be energy producers, bi-directional communication between consumer/producers and power plant operators is necessary—ICT can fulfill this role.[13]

According to one study, "[m]anaging a bidirectional grid and making optimal use of various small (and intermittent) energy sources (while guaranteeing high reliability) is a non-trivial issue that requires an adequate information and communication infrastructure."[14] ICT can provide better integration of these sources into the regional TS&D grid, allowing more efficient and economic dispatching of central system generation. Another study notes that ICT "allow[s] distributed generators to be integrated, achieving a balance of generation and usage."[15]

Some have responded to the increase in local distributed energy resources, like rooftop solar, by creating virtual power plants (VPP).[16] VPPs combine distributed energy sources at a local geographic level and run them collectively to "allow[] for the integration of renewables and provide[] higher efficiency and more flexibility with peak load and fluctuations."[17] According to a recent study, "ICT is essential"[18] to VPPs. VPPs are highly complex systems and "ICT helps manage complex optimization, control, and communication."[19]

C. GROWTH OF REGIONAL INTEGRATED POWER POOLS

As distances between sources of generation and centers of demand have lengthened, the options and therefore the complexity for dispatching power have increased. The growth of Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) has allowed more renewables and lower cost power to be dispatched on a local basis, but has also made these TS&D decisions more complicated. As grids become more integrated, these challenges will grow. Interactive ICT at all sources of generation can help to ensure that the lowest cost power (or the most renewable power) is always being used to the maximum in the TS&D grid.

The RTOs and ISOs run hourly energy auction markets to determine, through price signals, which generators will run, and the demand that is willing to be cut, to keep the grid in balance. The operators also ensure that sufficient resources are committed over some future periods; some accomplish this through capacity auction markets. There have been concerns recently that the capacity markets are attracting mostly low-cost gas generators and not taking into account the need for fuel diversity and for generators that can serve as workhorse "base load" resources. During the Polar Vortex, energy market pricing rules and operational practices may have interfered with the markets' response to the extreme conditions. In response, FERC conducted a conference on market performance to explore improvements to market designs and operational practices of RTOs/ISOs.[20] This initiative to improve the market performance of the TS&D grid will require accurate and real-time coordination of many resources that can only be accomplished with sophisticated ICT.

D. GREENHOUSE GASES

Greenhouse gases are a byproduct of many energy producing parts of the TS&D grid, "The emissions from this sector make up 42 percent of all U.S. emissions."[21] ICT can help reduce greenhouse gases by facilitating the integration of renewable energy sources, increasing efficiency in the amount of energy produced, and supporting greater reliability while utilizing non-polluting generation.[22] One study found that if ICT "[is] used systematically, ICT can make a substantial contribution to the reduction of energy demand and therefore to a low-carbon economy."[23] Furthermore, some studies estimate that "the total abatement potential of ICT in the [U.S.] power sector is 350 MtCO2 e or 1.7 times the total emissions from the ICT industry in 2020."[24]

Since 2010, the reduction of greenhouse gases has been one of the most important environmental goals of this Administration. Specifically, the Administration aims to reduce federal greenhouse gas emissions by 24% by 2020.[25] ICT can help to reach that goal. One report found that half of the administration's goal of reducing federal greenhouse gas emissions by 24% can be accomplished through the adoption of ICT and could also result in $5 billion in energy savings.[26]

E. DEMAND RESPONSE: SMART METERS

The expansion of smart interactive electric meters has great potential for both monitoring and voluntarily controlling demand by consumers. Smart meters provide consumers and power plant operators with information about energy consumption, often in real-time. Specifically, they enable "customers to make smart decisions using real-time information with the aim to shift their consumption to low-load and low-rate times, or even to turn off applications."[27] The consumer's ability to adjust demand based on real-time pricing information will reduce the need for increased generation and increased grid infrastructure.

Incorporating smart meters across the US market with real-time pricing can "achieve load reductions equal to 12-33% of participants' peak demand; incorporating demand response into the US market with dynamic pricing would lead to $10 billion to $15 billion savings per year."[28] These benefits are realized by both the utility and the consumer. Utilities save on the costs of meter reading and can respond more quickly to emergencies such as overloaded transformers or other outages. Smart meters "enable utilities to quickly and automatically pinpoint where an outage has occurred and respond more rapidly… reducing the average outage time experienced by customers."[29] Customers can save by "shift[ing] their consumption to low-load and low-rate times, or even to turn off applications."[30]

Smart meter ICT can allow customers to shift demand automatically to non-peak, lower cost times for consumption. For example, the California PSC has developed protocols for assessing the cost effectiveness of various demand shifting programs, many of which use ICT.

> The deployment of advanced metering technology and development of new energy markets is enabling greater use and flexibility of demand response by all types of customers. Increasingly, customers are able to manage their loads to provide different levels of load reduction in response to price signals or other incentives. These load reductions provide value to the grid not only during emergencies, but also during times of high energy prices or in the ancillary services market. As a result, the methods we use to measure the costs and benefits of demand response (DR) must be flexible enough to capture these emerging benefits.[31]

These protocols are to be used for evaluations associated with approval of all DR programs that provide measurable load reductions.

F. ELECTRIC VEHICLES

As plug in electric vehicles (EV) proliferate, unusual demands will be placed on local distribution systems. Specifically, the increase in 240V charging stations for EV will pose a challenge to "aging and undersized" power distributors.[32] Advanced interactive metering using ICT can help utilities monitor current usage of charging stations to improve efficient dispatching of power.[33] Additionally, smart meters that can distinguish EV usage patterns can be used to inform consumers and power distributors about EV charging patterns. Power distributors can use this knowledge to develop incentives for off-peak charging, such as discounts, to balance the demand on the grid.[34]

In a report completed for RTOs/ISOs looking to manage the complexities of private electric vehicle (PEV) charging, two of the key objectives were to determine key technologies, communications, cybersecurity, and protocols required to enable PEV products and services; and to determine the types of investments in ICT infrastructure needed to integrate PEVs, and estimate their costs.[35] The report found that in order to integrate PEVs into the RTO/ISO markets and manage TS&D functions, the RTOs/ISOs needed to adopt specific ICT technology.[36]

With the proliferation of EV, the possibility of using EV as an energy resource has begun to be developed and is referred to a vehicle-to-grid or V2G.[37] In a vehicle-to-grid system, EV would be used as energy storage that the grid could draw upon during low supply or high demand. These vehicle-to-grid systems are currently being developed and will require extensive communication between the storage source and the power distributor to determine supply and demand levels. For example, ICT will be necessary to monitor and control new technologies like the battery on the Nissan Leaf that is being developed to "discharge stored energy to power a home, presenting an attractive remedy for capacity-driven brown-outs."[38] Because a vehicle-to-grid system would require extensive bi-directional communication between EV, smart meters and power distributors, an ICT network is critical to the development of a vehicle-to-grid system.[39]

G. ENERGY STORAGE

The increasing development of energy storage technology provides alternatives to construction of additional generation and grid capacity. Storage will permit far greater and more efficient use of existing generation. But storage can meet its promise only if system operators have real-time knowledge of capacity and recharge parameters. This will be particularly complex if storage proliferates in relatively small, local systems, all of which must be monitored and "dispatched"/transmitted to their local demand centers. The integration of increased storage will require increased and sophisticated use of a bi-directional ICT network.[40]

A report to the DOE From Sandia National Laboratories on the myriad potential benefits of increased storage detailed the many ways in which integrated storage technology can contribute to a more resilient and efficient grid.[41] It placed "robust integration of distributed/modular storage and Smart Grid"[42] as one of the primary R&D needs.[43] The report specifically addressed the importance of communications and control technology to successful applications of storage devices:

> Storage used for most applications must receive and respond to appropriate control signals. In some cases, storage may have to respond to a dispatch control signal. In other cases, the signal may be driven by a price or prices. Storage response to a control signal may be a simple ramp up or ramp down of power output in proportion to the control signal. A more sophisticated response, requiring one or more control algorithms, may be needed. An example of that is storage used to respond to price signals or to accommodate more than one application.[44]

All of these signals and controls must use ICT to be effective. The Sandia report also notes that currently "many, or even most, renewable energy systems do not have what is needed to facilitate use of storage. Consequently, … renewables … must have additional hardware and software to accomplish and to manage charging and discharging of the storage."[45]

VII. CONCLUSION

ITI commends the Department for conducting the first QER. It is a timely review and a critical step toward moving our national energy policy fully into the 21st century. Change requires leadership and vision. We hope the Department will recognize the importance of ICT to the emerging energy grid. It is as important to the coming century's energy delivery systems as transformers and transmission lines were for the last. It is only by properly combining physical infrastructure with ICT that the nation can achieve its energy policy goals.

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[1] The Quadrennial Energy Review (QER), U.S. DEPARTMENT OF ENERGY, *available at* http://energy.gov/epsa/quadrennial-energy-review-qer.

[2] *See* Ban Al-Omar et al., *Role of Information and Communication Technologies in the Smart Grid*, 3 JOURNAL OF EMERGING TRENDS IN COMPUTING AND INFORMATION SCIENCES 707, 709 (May 2012); *Smart Grid: A Beginner's Guide*, NIST, *available at* http://www.nist.gov/smartgrid/beginnersguide.cfm; *GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future*, GLOBAL E-SUSTAINABILITY INITIATIVE (GESI)*,* 33 (2012) ("ICT can be instrumental in integrating electricity into the grid, managing intermittent electricity production, monitoring and optimizing the performance of the generation, and helping to predict the impact of the weather on generation, as well as in many other applications.") *available at* http://gesi.org/SMARTer2020.

[3] *See* Teja Kuruganti & Michael Brambley, *Buildings-To-Grid Technical Opportunities: From the Information and Communications Technology Perspective*, U.S. DEPARTMENT OF ENERGY, 1 (March 2014), ("ICT depends on computer and networking technology to deliver automation and communication for interactions among physical components and humans (i.e., between machines, between humans and machines, and between different humans.") *available at* http://energy.gov/sites/prod/files/2014/03/f14/B2G_Tech_Opps--Info_Comm_Tech_Perspective.pdf.

[4] Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, EMPA TECHNOLOGY AND SOCIETY LAB, 38-39 *available at* http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[5] *See* Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, EMPA TECHNOLOGY AND SOCIETY LAB, 9 *available at* http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[6] Stephen Seidel & Jason Ye, *Leading By Example 2.0: How Information And Communication Technologies Help Achieve Federal Sustainability Goals*, CENTER FOR CLIMATE AND ENERGY SOLUTIONS, iv (June 2013), *available at* http://www.c2es.org/publications/leading-by-example-2-how-ict-help-achieve-federal-sustainability.

[7] Neal Elliot, Maggie Molina & Dan Trombley, *A Defining Framework for Intelligent Efficiency*, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY, 25 (June 2012), *available at* http://www.qualityattributes.com/wp-content/uploads/2012/12/Inteligent-Efficiency-ACEEE-Report.pdf.

[8] Press Release, Stakeholder Meeting on Electricity Transmission, Storage, and Distribution, U.S. DEPARTMENT OF ENERGY, 1 (July 7, 2014), *available at* http://energy.gov/sites/prod/files/2014/07/f17/portland_backgroundmemo_qer.pdf.

[9] *See* GeSI, *supra* note 2, at 128 ("ICT can assist this integration by improving communication between grid operator and the renewable power plant, analyzing weather for predicting future generation, and performing complex data analysis and optimization.").
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, GLOBAL E-SUSTAINABILITY INITIATIVE (GESI)*,* 128 (2012) *available at* http://gesi.org/SMARTer2020.

[10] *See* Lorenz M. Hilty et al., *supra* note 4, at 38 ("Furthermore, forecasting is particularly important on the supply side for sources such as wind power and solar power, which are an increasing challenge for the power grid because of their intermittency, difficulty of forecast and wide distribution.").
Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, EMPA TECHNOLOGY AND SOCIETY LAB, 38 *available at* http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[11] *See* Hans-Jürgen Appelrath, Henning Kagermann & Christoph Mayer (Ed.), *Future Energy Grid: Migration to the Internet of Energy*, EIT ICT LABS, 47 (Oct. 2012), ("In contrast, the output of power plants that generate electricity from wind power or solar power is dependent on the current weather conditions (wind, sun, cloud) and is also subject to wide climatic and seasonal fluctuations… It may be possible to forecast this feed-in within certain limits, and also to adjust it by controlling output, but it cannot be timetabled.") *available at* http://www.acatech.de/de/publikationen/stellungnahmen/kooperationen/detail/artikel/acatech-study-future-energy-grid-migration-to-the-internet-of-energy-1/print.html?type=98&cHash=ed0b2509b6921d7c8bf1dcab6e6204a6.

[12] Lorenz M. Hilty et al., *supra* note 4, at 38; *see also* Hans-Jürgen Appelrath, *supra* note 12, at 22 ("Along with the technical adjustments, the forecasting tools for fluctuating energy sources will be improved in order to facilitate

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planning. The accuracy of the forecasts of the duration and intensity of wind and sunshine will make a major contribution to ensuring the integration of renewables into the energy system is as easy as possible.”).
Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, Empa Technology and Society Lab, 38 *available at*
http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.
Hans-Jürgen Appelrath, Henning Kagermann & Christoph Mayer (Ed.), *Future Energy Grid: Migration to the Internet of Energy*, EIT ICT Labs, 47 (Oct. 2012), *available at*
http://www.acatech.de/de/publikationen/stellungnahmen/kooperationen/detail/artikel/acatech-study-future-energy-grid-migration-to-the-internet-of-energy-1/print.html?type=98&cHash=ed0b2509b6921d7c8bf1dcab6e6204a6.

[13] *See* GeSI, *supra* note 2, at 128 (“ICT plays an important role in integrating these renewables into the grid.”);
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 128 (2012) *available at* http://gesi.org/SMARTer2020.

[14] Friedmann Matter, Thorsten Staake & Markus Weiss, *ICT for Green – How Computers Can Help Us to Conserve Energy*, 2, *available at* http://www.im.ethz.ch/publications/ICTforGreen.pdf.

[15] *See* Hans- Jürgen Appelrath, *supra* note 12, at 2.
Hans-Jürgen Appelrath, Henning Kagermann & Christoph Mayer (Ed.), *Future Energy Grid: Migration to the Internet of Energy*, EIT ICT Labs, 47 (Oct. 2012), *available at*
http://www.acatech.de/de/publikationen/stellungnahmen/kooperationen/detail/artikel/acatech-study-future-energy-grid-migration-to-the-internet-of-energy-1/print.html?type=98&cHash=ed0b2509b6921d7c8bf1dcab6e6204a6.

[16] GeSI, *supra* note 2, at 33
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 128 (2012) *available at* http://gesi.org/SMARTer2020.

[17] *Id.*
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 128 (2012) *available at* http://gesi.org/SMARTer2020.

[18] *Id.*
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 128 (2012) *available at* http://gesi.org/SMARTer2020.

[19] *Id.*
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 128 (2012) *available at* http://gesi.org/SMARTer2020.

[20] *See* Winter 2013-2014 Operations and Market Performance in Regional Transmission Organizations and Independent System Operators, Federal Energy Regulatory Commission (FERC), (April 2014), *available at* http://www.ferc.gov/CalendarFiles/20140401083609-Final%20Agenda.pdf.

[21] *See* GeSI, *supra* note 2, at 126.
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 33 (2012) *available at* http://gesi.org/SMARTer2020.

[22] *See* Greenpeace, *Make IT Green: Cloud Computing and its Contribution to Climate Change*, 10, (“The ICT sector holds many of the keys to reaching our climate goals by innovating solutions to mitigate greenhouse gas emissions and increase energy efficiency.”) *available at*
http://www.greenpeace.org/usa/Global/usa/report/2010/3/make-it-green-cloud-computing.pdf. *See also* GeSI, *supra* note 2, at 126-27.
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 126-27 (2012) *available at* http://gesi.org/SMARTer2020.

[23] Lorenz M. Hilty et al., *supra* note 4, at 9.
Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, Empa Technology and Society Lab, 38 *available at*
http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[24] *See* GeSI, *supra* note 2, at 126.
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative (GeSI), 33 (2012) *available at* http://gesi.org/SMARTer2020.

[25] *See* Seidel, *supra* note 6, at iv.

Stephen Seidel & Jason Ye, *Leading By Example 2.0: How Information And Communication Technologies Help Achieve Federal Sustainability Goals*, Center for Climate and Energy Solutions, iv (June 2013), *available at* http://www.c2es.org/publications/leading-by-example-2-how-ict-help-achieve-federal-sustainability.

[26] *See id.*

Stephen Seidel & Jason Ye, *Leading By Example 2.0: How Information And Communication Technologies Help Achieve Federal Sustainability Goals*, Center for Climate and Energy Solutions, iv (June 2013), *available at* http://www.c2es.org/publications/leading-by-example-2-how-ict-help-achieve-federal-sustainability.

[27] *See* Lorenz M. Hilty et al., *supra* note 4, at 38.

Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, Empa Technology and Society Lab, 38 *available at* http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[28] *See* European Commission, *ICT For A Low Carbon Economy: Smart Electricity Distribution Networks*, 27 (July 2009) ("DR benefits are well documented i.e. cost reduction… electricity price reduction and reliability benefits."), *available at* http://ses.jrc.ec.europa.eu/sites/ses/files/documents/ict.pdf.

[29] MIT, *The Future of the Electric Grid: An Interdisciplinary MIT Study*, 136 (2011), *available at* https://mitei.mit.edu/system/files/Electric_Grid_Full_Report.pdf.

[30] Lorenz M. Hilty et al., *supra* note 4, at 38.

Lorenz M. Hilty et al., *The Role of ICT in Energy Consumption and Energy Efficiency*, Empa Technology and Society Lab, 38 *available at* http://www.academia.edu/2686550/The_Role_of_ICT_in_Energy_Consumption_and_Energy_Efficiency.

[31] 2010 Demand Response Cost-Effectiveness Protocols, California Public Utilities Commission, (Oct. 2010) *available at* http://www.cpuc.ca.gov/NR/rdonlyres/5FBEB44C-0936-41C6-9A3C-2CFAA2104972/0/DemandResponseCost...

[32] *See* Stephen Johnson, Itron, *Itron Embedded Sensing: Communication, Collaboration, Control—Extending Intelligence to Grid Assets*, 4, ("As more auto manufacturers bring electric vehicles (EV) to market, the installation of 240V charging stations will accelerate. This radically changes the load profile of the typical residential electricity customer and could pose challenges to aging and undersized distribution assets.") *available at* https://www.itron.com/PublishedContent/Itron_Embedded_Sensing.pdf.

[33] Johnson, *supra* note 25, at 8.

Stephen Johnson, Itron, *Itron Embedded Sensing: Communication, Collaboration, Control—Extending Intelligence to Grid Assets*, 8 *available at* https://www.itron.com/PublishedContent/Itron_Embedded_Sensing.pdf.

[34] *See* Johnson, *supra* note 25, at 8; and MIT, *supra* note 23, at 120 ("If electric rates do not vary over time, most EV owners will plug in their vehicles and begin charging when they arrive home each day, in many cases at the same time as neighborhood load peaks. This would exacerbate local peak load conditions, forcing utilities to invest in expanded infrastructure.").

See Stephen Johnson, Itron, *Itron Embedded Sensing: Communication, Collaboration, Control—Extending Intelligence to Grid Assets*, 8 *available at* https://www.itron.com/PublishedContent/Itron_Embedded_Sensing.pdf.

MIT, *The Future of the Electric Grid: An Interdisciplinary MIT Study*, 120 (2011), *available at* https://mitei.mit.edu/system/files/Electric_Grid_Full_Report.pdf.

[35] *See* KEMA, *Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems*, (March 2010), *available at* http://www.rmi.org/Content/Files/RTO%20Systems.pdf.

[36] *See id.*

[37] *See* Christopher Guille, *A Conceptual Framework for the Vehicle-to-Grid (V2G) Implementation*, ii ("The quest for energy independence and rising environmental concerns are key drivers in the growing popularity of battery vehicles or BVs – electric and plug-in hybrid cars… vehicles are integrated into the grid. The entire concept of using the BVs as a distributed energy resource – load and resource – is known as the vehicle-to-grid or V2G concept."), *available at* http://energy.ece.illinois.edu/gross/papers/Dissertations/Guille.pdf.

[38] *See* Johnson, *supra* note 25, at 4.

See Stephen Johnson, Itron, *Itron Embedded Sensing: Communication, Collaboration, Control—Extending Intelligence to Grid Assets*, 8 *available at* https://www.itron.com/PublishedContent/Itron_Embedded_Sensing.pdf.

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[39] *See* Guille, *supra* note 28, at 47 ("A critically important prerequisite is the construction of the information layer: the establishment of the infrastructural computer/communication/control network for the integration of the aggregated BVs into the grid.").
See Christopher Guille, *A Conceptual Framework for the Vehicle-to-Grid (V2G) Implementation*, 47, *available at* http://energy.ece.illinois.edu/gross/papers/Dissertations/Guille.pdf.

[40] *See* GeSI, *supra* note 2, at 33 ("ICT is also vital for off-grid renewables and storage.").
GeSI SMARTer2020: The Role of ICT in Driving a Sustainable Future, GLOBAL E-SUSTAINABILITY INITIATIVE (GESI)*,* 33 (2012) *available at* http://gesi.org/SMARTer2020.

[41] *See* Jime Eyer and Garth Corey, *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide*, SANDIA NATIONAL LABORATORIES REPORT, (Feb. 2010), *available at* https://www.smartgrid.gov/sites/default/files/resources/energy_storage.pdf.

[42] *Id*. at 151.

[43] In the Department's "Grid Energy Storage" Report, (Dec. 2013), it cites the Electric Power Research Institute's (EPRI) catalog of needed demonstrations to further energy storage research, all of which require ICT for communications and control: "bulk energy storage systems (for renewable energy ramp control, resource adequacy, short-term balancing and reserves, etc.); distributed energy storage systems (for voltage regulation/reactive power support, peak load management, etc.); edge of grid energy storage systems (renewable integration, upgrade deferral, EV charging, back-up power); customer premise energy storage systems (electricity bill management, back-up reliability, renewable integration, upgrade deferral)." Grid Energy Storage, U.S. DEPARTMENT OF ENERGY, 47 (Dec. 2013), *available at*
http://energy.gov/sites/prod/files/2013/12/f5/Grid%20Energy%20Storage%20December%202013.pdf.

The Department also pointed out the importance of effective microgrids to infrastructure protection:

> A more reliable, resilient, and secure power system is essential for the protection of critical infrastructure across regions. Microgrid systems combined with grid scale energy storage are being developed as a robust solution for increasing the resiliency of critical infrastructure. Grid scale energy storage, when combined with distributed renewable generation, would allow microgrids to provide reliable power for essential services over an extended time period of emergency. During non-emergency time periods the system can reduce demand charges for the user and provide compensated services to the grid.

Id. at 48.

[44] Eyer, *supra* note 42, at 19.

[45] *Id*. at 46.