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"The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"

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Summary

The smart grid will be one of the largest and most complex machines ever conceived. It will likely prove one of the most significant scientific achievements of the 21st century. Each component of the power value chain, from generation, transmission, distribution, metering, to customer consumption, is supported by multiple, independent, information technology systems that are not designed to work with each other and therefore prevent data sharing, data analysis, and interoperability.

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable. The most common example is the smart meter that allows the grid operator to remotely sense the electric of gas meter's state in near real time. As the grid becomes increasingly sensored, it becomes a fully connected sensor network (think of it as the Internet of Energy) and unprecedented amounts of data are produced. These data volumes can be integrated, processed, and analyzed using state-of-the-art information technology in a manner to optimize the power generation and distribution value chain.

C3 Energy is a private sector response to this challenge and opportunity, harnessing the power of big data, social networking, cloud computing, human-computer interaction models, and machine learning to realize advances in safety, reliability, cost efficiency, and security of power generation and delivery – unlocking a benefit of up to $300 per meter, per year, in recurring annual economic benefit for U.S. utilities, retailers, and their energy customers.

Progress has been dramatic in the current decade. That being said, outdated state rate regulations have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models. Utility regulatory agencies should be encouraged allow rate recovery for

cloud-based SaaS license arrangements. This change will accelerate the adoption curve and accessibility of today's innovative computing models and reduce the current, unnecessary barriers to technology advancement in the utility industry. This is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system.

The Power of the Smart Grid

Thomas M. Siebel

A sociologist from Harvard by the name of Daniel Bell published a book entitled *The Coming of Post-Industrial Society* in 1976 in which he predicted what we know of today as the Information Age. Years before the conception of the Internet, the minicomputer, the personal computer, and the cell phone, Bell predicted that information and communications technology would effect a fundamental change in the structure of the global economy, a change on the order of magnitude of the Industrial Revolution.

This information revolution would portend the preeminence of the "knowledge worker" and result in the emergence and growth of the information technology industry, driving fundamental and ubiquitous changes in the ways we work, communicate, and operate business processes.

With the advent of the utility smart grid, Bell's predictions meet the business value chain associated with power generation, transmission, distribution, consumption, and energy efficiency.

In the United States, more than 3,270 utilities[1] are responsible for operating the grid and delivering over 1,100 GW[2] of power capacity to nearly 150 million electricity customers,

[1] "Electric Power Industry Overview 2007." U.S. Energy Information Administration, n.d. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/archive/primer/>.
[2] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Electricity Generation Capacity*. U.S. Energy Information Administration, 2011. Web. 26 Feb. 2015.

generating revenues of $376 billion per year[3]. Globally, the electric power industry delivers over 5,500 GW of capacity[4].

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable[5]. Almost $1 trillion of this investment will occur in the United States[6]. These devices include meters, thermostats, home appliances and HVAC equipment, factory equipment and machinery, and transformers, substations, distribution feeders, and power generation and control componentry.

The smart grid is advancing at a rapid rate. A nascent market at the beginning of the 21st century, as of the end of 2013 over 310 million smart meters have been installed globally. That number will more than triple by 2022, reaching nearly 1.1 billion[7]. While representing only a fraction of the sensors on the grid infrastructure, the smart meter installation numbers provide a good indication of the penetration and rate of growth of the smart grid. These developments are occurring worldwide.

The truth is that the smart meters and other smart devices themselves provide little utility. They simply provide the capability to remotely sense a device's state. For example, is the device

[3] *Form EIA-861 Detailed Data Files* (n.d.): n. pag. *Annual Electric Power Industry Report*. U.S. Energy Information Administration, 19 Feb. 2015. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/data/eia861/>.
[4] "International Energy Statistics - EIA." *International Energy Statistics - EIA*. U.S. Energy Information Administration, 2012. Web. 26 Feb. 2015.
[5] Electric Power Research Institute (EPRI), "*Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid*" (2011).
[6] "EEI to Wall Street: The Future Is Here." *EEI Newsroom*. Edison Electric Institute, 11 Feb. 2015. Web. 27 Feb. 2015. <http://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20to%20Wall%20Street%20The%20Future%20is%20Here.aspx>.
[7] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.

operative or inoperative? If operative, at what velocity, voltage, or amperage? It might allow us to know the amount of energy that the device has consumed or recorded over some period of time or is consuming in real time.

Collectively, these devices generate massive amounts of information. With recent developments in information technology, including elastic cloud computing and the sciences of big data, machine learning, and emerging social human-computer interaction models, we are able to realize the economic, social, and environmental value of the smart grid by aggregating the sum of these data to correlate and scientifically analyze *all* of the information generated by the smart grid infrastructure in real time.

By holistically correlating and analyzing all of the dynamics and interactions associated with the end-to-end power infrastructure—including current and predicted demand, consumption, electrical vehicle load, distributed generation capacity, technical and non-technical losses, weather, and generation capacity—across the entire value chain, we can realize dramatic advances in safety, reliability, infrastructure security, and energy efficiency.

Smart grid analytics enables us to provide real-time pricing signals to energy consumers, manage sophisticated energy efficiency and demand response programs, conserve energy use, reduce the fuel necessary to power the grid, reconfigure the power network around points of failure, recover instantly from power interruptions, accurately predict load and distributed generation capacity, rapidly recover from damage inflicted by weather events and system failures, prevent cyber attacks, and reduce adverse environmental impact.

The advent of smart grid analytics represents a major advance in the development of energy efficiency technology. Many leading utilities including Enel, GDF Suez, and Exelon work are driving innovation by applying the science of bug data and smart grid analytics to the benefit of their communities, consumers, and stakeholders.

At C3 Energy, we are committed to advancing the state-of-the-art science of smart grid analytics in the hope of making a substantial contribution to the important dialogue on the future of energy.

The rapid growth of sensor investments in smart grid opens up a new opportunity for utilities to take advantage of next-generation information technology including elastic cloud computing, analytics, machine-learning, and social human-computer interaction models to fully unlock the insights and value that a modern grid has to offer. Outdated state rate regulations and accounting rules however, have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models that will substantially improve system performance, reduce capital and operating costs, and produce substantial economic value to utility customers and shareholders.

Under current guidelines, a utility may classify investments in legacy hardware and supporting on-premise software as a capital expense, which can be included as part of the rate case on which it can receive a rate of return. Counter-intuitively, if a utility invests in state-of-the-art cloud-based technologies that both enhance the performance of legacy and new hardware systems and that eliminate the need for continual procurement of more expensive new IT hardware, it

typically must treat the investment as an operating expense for which it does not receive a rate of return, resulting in decreased cash flow and profitability.

This difference in treatment creates a perverse incentive for U.S. utilities to pursue more costly, less effective, and riskier on-premise technology investments, depriving ratepayers of the immense performance and economic benefits of the more advanced technology innovations that many other sectors are now experiencing. The effect is to deprive ratepayers of the benefits of innovation. A revision of rate regulations a can fix this problem.

This decade, utilities are investing billions of dollars to make the devices in the power grid remotely IP-addressable, including for example the nearly 1.1 billion smart meters that will be installed by 2022[8]. While representing only a fraction of the sensored devices on the grid, the number of smart meters provides a good indication of the growth rate of the smart grid.

McKinsey & Company has estimated that widespread use of big data analytics solutions could cut more than $50 billion per year from electricity bills in the U.S. Globally, the opportunity is $300 billion[9]. For example, C3 Energy smart grid solutions across the value chain can deliver $1.5 billion in recurring annual economic benefit to a typical integrated 5 million meter U.S. utility and its customers[8]. That is a very real private sector stimulus for the economy.

[8] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.
[9] Client Study, McKinsey & Company: February 2013.

I would like to share a few examples of these "big data" smart grid analytic solutions and their benefit to U.S. consumers. The following estimated are based upon research conducted by McKinsey & Company.

Predictive Maintenance applications help utilities predict asset failure, and take proactive action, saving customers $18 to 20 per year[10].

Revenue Protection applications help identify energy theft and asset malfunctions, saving each customer $8 to 10 per year[11].

Grid Cybersecurity applications secure grid reliability and help utilities identify and reduce the grid cybersecurity vulnerabilities, saving customers $8 to 10 per year[12].

Voltage Optimization applications reduce unnecessary power generation and deliver higher-quality power, saving each consumer $25 to 36 per year[13].

Some of the world's leading utilities, such as Baltimore Gas and Electric in the U.S. and Enel in Italy, are among the first to use these new technologies to deliver substantial savings from their grid modernization investments.

[10] "Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid." EPRI, Palo Alto, CA: 2011. 1022519.
[11] Ibid.
[12] Ibid.
[13] "Volt/VAR Control and Optimization Concepts and Issues", EPRI, 2011.

Baltimore Gas and Electric (Exelon Corporation) in the United States[14,15]

In 2014, Baltimore Gas and Electric Company (BGE), a subsidiary of Exelon Corporation, launched C3 Energy's smart grid applications across all two million meters in its service territory. BGE is leveraging C3 AMI Operations™ to optimize the deployment and ongoing health of its advanced metering infrastructure (AMI) network and C3 Revenue Protection to identify and reduce unbilled energy usage. BGE expects these applications to deliver an annual economic benefit of $20 million to BGE and its customers. Deploying these solutions across the three Exelon utilities will result in $383 million in recurring annual economic benefit to consumers.

The deployment of C3 AMI Operations and C3 Revenue Protection involved unprecedented levels of data integration at BGE, developing 42 integrations to 12 source systems. C3 Energy loaded two years of historical BGE data in a 10-terabyte, federated cloud image and configured more than 140 complex analytic and predictive algorithms to match BGE's requirements and available data.

C3 Revenue Protection identified over 8,000 non-technical loss cases (energy theft) with field investigation accuracy rates of 90 percent, spurring BGE to develop a new back-billing process to handle the large volume of identified cases. During the same timeframe, C3 AMI Operations identified 3,600 meter health problems with a 99 percent accuracy rate, avoiding many billing errors..

[14] "Baltimore Gas & Electric Wins Project of the Year for Deployment of C3 Energy Smart Grid Applications." *C3 Community*. C3 Energy, 3 Feb. 2015. Web. 26 Feb. 2015.
[15] *Case Study: Exelon | Driving Grid Efficiency and Revenue Protection Efforts*. Rep. Redwood City: C3 Energy, 2015. Print.

The primary economic benefit comes from identifying and resolving unbilled energy usage, which reduces the cost of non-technical energy losses—a cost typically passed on to customers. Additional benefit derives from detecting problems with meters or with the communication network. This reduces the amount of missing usage data and increases billing accuracy and the overall effectiveness of the AMI meter deployment. These benefits represent a significant improvement over the benefits of smart grid infrastructure alone.

Other benefits come from the streamlining of existing BGE business processes across smart grid operations, revenue management, and field operations, saving time and effort. The solutions also provide safety benefits. C3 AMI Operations and C3 Revenue Protection reduce risks to customers and utility employees in the field by alerting users to potentially hazardous meter conditions, such as unsafe meter temperature or potential meter tampering.

Enel in Italy[16]

Enel is one of the world's largest utilities, and the first utility to replace traditional meters with smart meters—more than 40 million, or 80% of all smart meters in Europe. Enel operates 67 million meters in 40 countries. At Enel Italy, we integrated and processed over 50 billion rows of data from 11 legacy systems, and identified 93% of likely cases of theft or other non-technical loss. This the largest smart grid analytics deployment in the world. The economic benefit of Revenue Protection and Predictive asset Maintenance analytics for Enel, in Italy alone, is estimated to exceed €350 million annually.

[16] "Enel: Improving Smart Grid Reliability and Operational Efficiency." *Innovations Across the Grid | Partnerships Transforming the Power Sector* II (2014): 153-55. The Edison Foundation - Institute for Electric Innovation, Dec. 2014. Web. 26 Feb. 2015. <http://www.edisonfoundation.net/iei/Documents/IEI_InnovationsGrid_volII_final_LowRes.pdf>.

Because smart grid analytics technology produces far more savings than costs, it does not need any financial assistance or incentives from the federal government to succeed. But success will occur much faster if regulatory obstacles are removed. For example, by updating rate regulations to recognize Software as a Service products as the equivalent of a capital expense, and by updating rules and guidance to encourage utilities to add analytics solutions to their plans budgets for grid modernization, progress will accelerate.

All of these hardware advances, however, are of limited usefulness without the cloud-based software innovations that will actually make the smart grid "smart". As the grid increasingly becomes sensored, an unprecedented amount of data are produced, which can only be addressed using the most state-of-the-art information technology. IT offerings have rapidly evolved to today's innovative cloud computing models, including Software as a Service, Platform as a Service, and Infrastructure as a Service. With these come opportunities to leverage numerous capabilities essential to fulfilling the promise of the smart grid – continuous access to increased processing speeds and power, more flexibility and mobility, elasticity/on-demand surge capacity, and lower costs through scale.

The majority of IT innovation and development in the 21st century is focused upon next generation, cloud-based, software as a service (SaaS) computing models. The acceleration of this trend is breathtaking with daily examples in the news including Google, Facebook, Amazon Web Services, and the Apple Cloud. CISCO recently predicted that by 2018 more than three-quarters of all corporate information will be processed via the Internet cloud rather than

internal company computer servers[17]. Just last week, Ginni Rometty, CEO of IBM, announced a $4 billion new investment in cloud-based technology development, predicting that 40% of IBM's expected total revenues will accrue from cloud computing by 2018[18].

The U.S. regulatory treatment of cloud computing models has not kept pace to take advantage of this technology opportunity, and utilities are faced with adverse consequences when they select a modern cloud computing. The existing guidelines are based on decades-old business models that classify last-generation on-premise software licenses as capital expenses, and modern cloud computing arrangements as operating expenses. The classification as a capital versus operating expense influences a utility's ability to obtain rate-base coverage consistent with other capital expenditures and incentivizes investments in antiquated technology.

To enable the goal of a modern electric transmission and distribution system, advanced cloud-based IT offerings are necessary. Regulations should respond to remove barriers and provide incentives to deploy cost-saving, high-performing 21st century software systems like those that a utility receives for investing in other infrastructure, including 20th century IT systems.

On-Premise Software

The traditional software model provides a physical copy of the software product on-premise under a license agreement. These licenses are typically structured as "perpetual" or "term" arrangements. A perpetual license is a right to use software for an unlimited period of time—it is paid for once and does not have to be renewed. A term license is a right to use software for a

[17] http://research.investors.com/quotes/nasdaq-cisco-systems-inc-csco.htm
[18] Clark, Don. "IBM Pumps $4 Billion Into Cloud and Mobile Initiatives." Wall Street Journal, 26 Feb. 2015. Web. 02 Mar. 2015. <http://www.wsj.com/articles/ibm-pumps-4-billion-into-strategic-imperatives-1424959681>.

specified period of time and requires renewal of the license at the end of the term for continued use.

Cloud Computing

Over the last decade, a rapidly growing number of companies have shifted from buying these on-premise software components under perpetual or term licenses, to leveraging cloud-based, SaaS software built, managed and continually improved by the technology vendor. These companies are replacing traditional on-premise software applications and platforms – even underlying IT infrastructures – with these cloud-based computing solutions.

Cloud computing refers to the use of Internet-based computing to deliver a variety of product offerings. Under cloud computing arrangements, the customer has a right to use or benefit from the functionality of software but does not receive a copy of it.

The most common cloud computing models for utilities are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). With a SaaS model, utilities pay to use an Internet-based software product hosted by the SaaS solution provider. SaaS solutions used commonly by utilities today include applications such as C3 Energy for smart grid analytics, Esri ArcGIS for geographic information systems, and SmartGridCIS for billing and customer information systems. Typically, SaaS solutions are service-based, scalable and elastic, and metered by use. By 2016, IDC estimates that SaaS solutions will constitute about 14.2% of all software spending and 18% of all applications spending, with a compound annual growth rate of 21.3%[19].

[19] McGrath, Benjamin, and Robert P. Mahowald. *Worldwide SaaS and Cloud Software 2013–2017 Forecast and 2012 Vendor Shares*. Rep. no. Doc #245084. IDC, Dec. 2013.

PaaS models are more commonly used by developers. With these solutions, utilities pay to use a web-based platform hosted by a software vendor or a third party to design, develop, and test their own applications. The most common examples of PaaS solutions in use today include Salesforce.com and Microsoft Azure. Specific to big data and the energy market, C3 Energy's data analytics platform has also been designed as a PaaS solution.

Finally, IaaS allows utilities to pay to use a virtualized service environment such as computers, systems, hardware, network bandwidth, etc. maintained by a vendor. Utilities can rent (rather than own their own) servers or operating systems to run their choice of software solutions. According to a KPMG analysis, implementation of IaaS can save 30 to 60% of IT infrastructure costs[20]. Amazon Web Services is the current leader in this area.

In each of these models, the solutions are essentially rented by a utility instead of purchased outright. This allows utilities access to the latest advances in technology, mobility, elasticity, and scalability to realize operational efficiencies, without having to invest in hardware and software to meet their maximum requirements upfront. However, regulation has not kept apace, and despite the efficiencies available, utilities are not incented to invest in these solutions and are effectively encourage to continue to procure obsolete technology investments.

Accounting for the Cost of Cloud Computing

[20] *Cloud Economics: Making the Business Case for Cloud*. Publication. N.p.: KPMG CIO Advisory, 2014. Print. An Economic Framework for Decision Making.

Currently, U.S. generally accepted accounting principles (GAAP) do not have specific guidance that addresses accounting for cloud computing arrangements; so utility regulators have no clear roadmap. This results in differing representations of on-premise and cloud computing arrangements in financial statements.

With no explicit guidance, utilities are following traditional business and technology models, to the following effect: Perpetual software licenses, generally developed in the last half of third 20th century are treated as a capital expense, for which the utility is guaranteed a return on their investment through their rate cases. SaaS license subscriptions, generally developed in the 21st century based upon state-of-the-art technology are treated as an operational expense, for which the utility receives no return on their investment through their rate cases.

Solutions

Utilities should not be penalized for or discouraged from investing in technology advancements. Instead, utilities should be encouraged to lead the way to a more modernized electric system. In order to do so, they need simple clarifications on rate recovery rules on a state-by-state basis to support a model rule to benefit from rate recovery from modern cloud computing solutions.

To move forward, utility regulatory agencies should be encouraged allow rate recovery for SaaS license arrangements. This change will accelerate the adoption curve and accessibility of today's innovative computing models and unlock the scalability, elasticity, performance power, integration speeds, and cost/benefits for utilities and their customers. The classification of SaaS

in a manner to allow rate recovery will remove the current regulatory barriers towards technology advancement in the utility industry, which is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system. State utility regulatory agencies need to consider allowing utilities rate recovery from 21st century information technology, providing ratepayers the many significant benefits of IT innovation.

Speaker Biography

Thomas M. Siebel is the Chairman and Chief Executive Officer of C3 Energy, where he leads an accomplished team of machine learning, computer science, power system, and engineering experts to tackle one of the toughest technology challenges—to apply the science of big data and machine learning to today's energy industry to unlock significant value across the power grid. As the founder, chairman, and CEO of Siebel Systems—one of the world's fastest-growing software companies, Mr. Siebel built the foundation of the CRM market. Founded in 1993, Siebel Systems rapidly became a leader in application software with more than 8,000 employees in 32 countries, over 4,500 corporate customers, and annual revenue in excess of $2 billion before it merged with Oracle Corporation in January 2006.

Mr. Siebel serves on the Board of Advisors for, the University of Illinois – Urbana College of Engineering, and the University of California at Berkeley College of Engineering. He is a Director of the Hoover Institution at Stanford University and is the Chairman of the Board of the American Agora Foundation. He was elected to the American Academy of Arts and Science in 2013.

Mr. Siebel is a graduate of the University of Illinois at Urbana-Champaign, where he received a B.A. in History, an M.B.A., and an M.S. in Computer Science.

About C3 Energy

C3 Energy was founded in 2009 by a highly experienced team of executives with deep experience in software, analytics, and cloud computing, and a long track record of serving enterprise customers. C3 Energy is a SaaS and PaaS enterprise application software company that harnesses the power of big data, smart grid analytics, social networking, machine learning, and cloud computing to improve the safety, reliability, and efficiency of power generation and delivery. C3 Energy's family of utility-tested and proven smart grid analytics products deliver end-to-end solutions across the entire smart grid, from energy grid capital asset allocation, transmission, distribution, and advanced metering, to the customer experience and energy efficiency programs. C3 Energy products enable utility operators to realize the full benefit of their smart grid and energy system investments.