



GRIDONOMICS

An Introduction to the Factors Shaping
Electric Industry Transformation

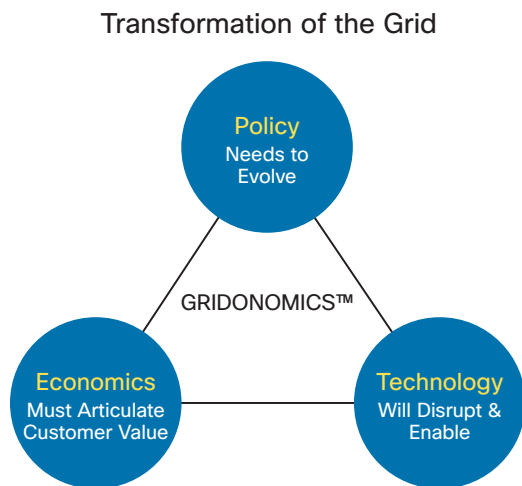
White Paper

Connected Energy Networks



The electricity industry is at a tipping point where the pace of change and opportunity for disruption is accelerating. Thirty years of energy policy and industry structural changes are combining with accelerating social and technological evolution. This is creating significant pressure for fundamental changes in the design, operation, structure, and regulation of the electric industry. It has become clear that effective business and public policy strategies to enable the transformation of the global electric industry require alignment of policy, economics, and technology (Figure 1). This interrelationship of policy, economics and technology is what Cisco calls Gridonomics™.

Figure 1. Three Building Blocks to Enable Cloud Computing



Cisco has built its business success by recognizing market transitions. As our Chairman and CEO, John Chambers, says: “Market transitions wait for no one.” Given the global re-examination of the direction and pace of transformation, Cisco offers Gridonomics as a framework for discussion and for enabling critical alignment between policy, economics, and technology.

Global economic changes, aging infrastructure, and energy innovations are further compressing the timeframe to act. Increasingly, questions are being raised as to how the transformation should proceed and who should participate in the new opportunities without losing sight of customers not able to fully participate and legacy utility grid and generation investments. Cisco believes that collaboration across all of the global energy stakeholders via public-private dialogues is the best path forward to achieve active customer participation and grid modernization goals, and a clean and sustainable energy future.

Cisco first addressed these grid modernization questions through a quantitative analysis of the value of smart grid investments in the United States and European Union, in a webcast we hosted on Gridonomics in January, 2011.¹ We continued our assessment through a series of strategic discussions and analyses with customers, partners, industry associations, research institutes, universities, and policymakers globally. This paper summarizes our analysis and key considerations for the electricity industry.

Smart Grid Investment Analysis

Significant Societal Value Potential

The Cisco® Gridonomics quantitative analysis indicates that smart grid investments may yield a 15-year net present value (NPV) in the United States of about \$210 billion² This value analysis is in line with McKinsey’s total value estimate of \$130 billion³ annually by 2019 and other recent U.S. value analysis on a comparative basis.

Our analysis was performed through a combination of economic dispatch models for Europe and the United States and a detailed cost-benefit model developed by Cisco. The dispatch model was used to simulate the evolution of generation portfolios and the impact of changes resulting from smart grid technologies. The cost-benefit model utilized cost and benefits data sets drawn from regulatory filings, the Electric Power Research Institute’s (EPRI) smart grid cost model, and Cisco’s information and communications technology (ICT) estimates to evaluate the cost across

¹ Cisco Gridonomics webcast, https://tools.cisco.com/gdrp/coiga/showsurvey.do?surveyCode=5596&ad_id=US-GEN-GEN-A-GRIDONOMICSWEBCAST-GEN&keyCode=204788_1

² \$210 billion is the mid-point in the range estimate of \$145 to 275 billion identified in Cisco’s analysis of 15 year NPV over 2010–2024 using a 10% nominal discount rate

³ McKinsey & Co report, “U.S. Smart Grid Value at Stake”, 2010

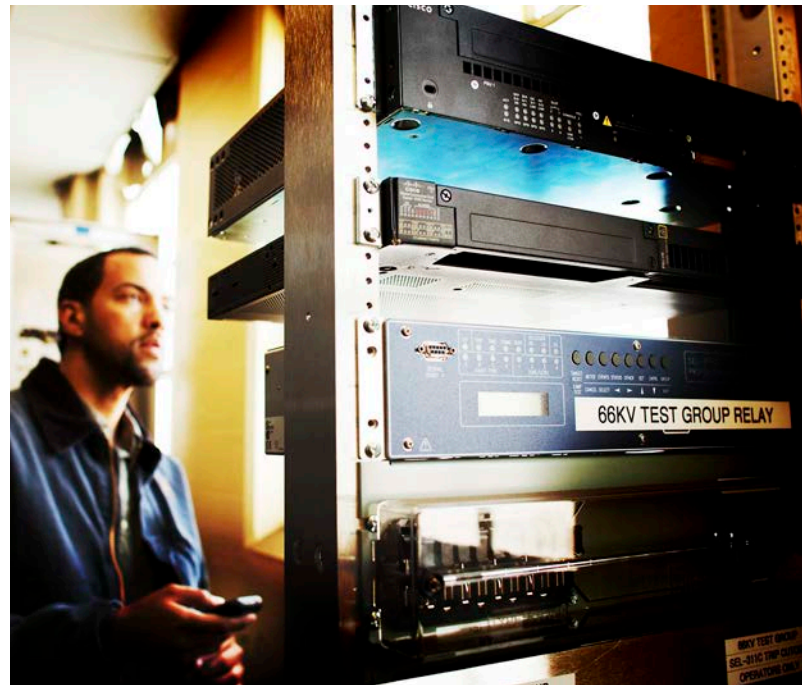
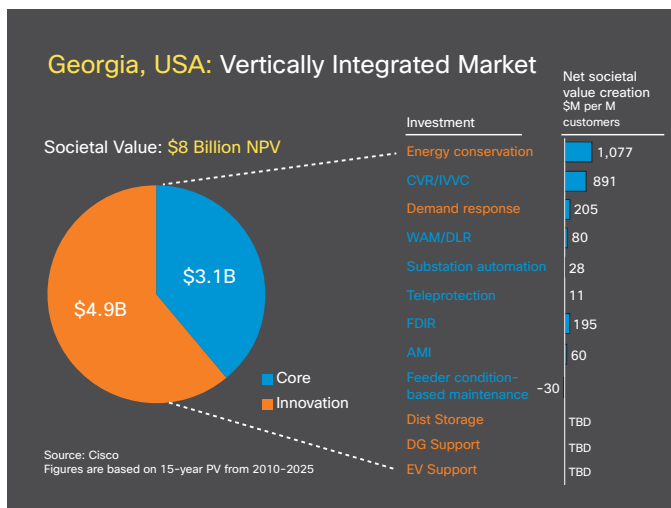
different solutions and underlying cross-asset platforms, as well as to construct a framework for an analysis of benefits and their effect on the value chain.

For our analysis of the United States, we selected Georgia, California and Texas to assess the economic opportunity, as these states frame the three US electricity market types: Georgia’s market that is traditional vertically integrated and fully regulated; California is semi-disaggregated and deregulated; and the Texas market is fully disaggregated and competitive. For each state, we analyzed 12 investment areas that generally define the scope of smart grid deployments. These were evaluated using a 15-year discounted cash flow based on operational savings, energy value chain benefits, reliability improvements, and carbon emissions reduction. The twelve areas evaluated were:

- Energy conservation (via real-time energy use information)
- Conservation voltage reduction (CVR)
- Demand response (DR)
- Dynamic line rating (DLR)
- Substation automation
- Advanced teleprotection
- Failure detection, isolation, and recovery (FDIR)
- Advanced metering infrastructure (AMI)
- Distribution-feeder condition-based maintenance
- Distributed storage infrastructure
- Distributed-generation integration infrastructure (DG support)
- Electric-vehicle integration intelligence (EV support)

Figure 2 shows the results of our analysis of these 12 investment areas for Georgia’s vertically integrated market.

Figure 2 Georgia Smart Grid Value Analysis



More importantly, we closely examined the interdependencies of the 12 smart grid investment areas regarding the technology and economic relationships. To do this, Cisco developed reference business architecture to link with our information technology architecture for modern electric grids.⁴ Our business architecture is a logical framework that links public policy and business strategy to business models. These potential business models and corresponding investment options are mapped to the respective underlying use cases and people, process, and technology options. We further mapped the corresponding technology options to Cisco’s electric industry technology architecture. Cisco’s technology architecture has been used by several customers. It was also a foundational component in the “Southern California Edison-Cisco-IBM” smart grid reference architecture released earlier this year.⁵

Specifically, through a combination of economic analysis and business model-to-technology architecture mapping, we are able to identify key interdependencies that can yield improved smart grid investment returns and reduce technology adoption risks. The business and technology architecture assessment are being leveraged by several customers and governments globally for investment roadmaps as well as the development of business cases and policy.

4 Taft, IEEE 2010 keynote: <http://host.comsoc.org/livebroadcast/smartgrid10/KeynoteTaft/KeynoteTaft.html>

5 SCE-Cisco-IBM Smart Grid Reference Architecture, <http://osgug.ucauiug.org/EIM/Contributions/20110715%20-%20SGRA%20Overview.pdf>

The Value of Network Convergence

Prosumerization Drives Horizontal Market Transition

We have also been deeply engaged in evaluating the significant impact of customer adoption of distributed energy resources (DER), including onsite generation, dynamic load management, and energy storage. As electric customers adopt DER, they will have opportunities to sell energy and related power services to markets and grid operations.

This means a growing number of customers will become producers of energy services, not just consumers. We believe these “prosumers” will play an increasingly important role in the operation and structure of electric networks and wholesale markets. The participation of prosumers will transform the electric industry from a centralized and vertical market to a hybrid, horizontal market. This future grid state will combine large-scale power generation and storage with significant distributed, customer-owned generation, storage, and dynamically controllable load—perhaps 30 percent of system peak by 2025 in several locations globally. We have discussed this view as “A Future History of the Grid.”⁶

Triple-Play Convergence: Social/ICT/Physical Networks

Smart grid investments combine ICT with energy technology (ET) to achieve a level of convergence that can yield the value chain benefits identified by many and quantified in our Gridonomics analysis. Three major areas are having a dramatic impact on the physical state of the grid:

- The acceleration of renewable integration
- Prosumerization
- The explosion of intelligent energy devices on the grid

Three major areas are having a dramatic impact on the physical state of the grid: 1) Electrification of energy through the growth of clean and renewable electricity as a primary fuel for economic growth⁷, 2) Prosumerization and 3) the creation of the Enernet⁸ resulting from the explosion of supply, demand and storage resources as well as intelligent energy devices on the grid. ICT networks continue to evolve through the proliferation of the Internet of Things (machine-to-machine IP communication), convergence of voice, video, and data (VVD), and the migration to borderless networks and computing. Social networks are having a significant impact on society and culture worldwide as well. The result of these forces converging is that we are very likely to see a radically different future role of customers and their engagement and participation in electric markets and operations (Figure 3). That is when Web 3.0 meets Grid 3.0,⁹ expect a significant change in the operation and function of the grid.



Figure 3 Triple Play Convergence



⁷ IEA, 2010 World Energy Outlook, World electricity demand is expected to continue to grow more strongly than any other final form of energy. In the New Policies Scenario, it is projected to grow by 2.2% per year between 2008 and 2035, with more than 80% of the increase occurring in non-OECD countries.

⁸ Robert Metcalfe introduced the concept of the Enernet in 2008: <http://mitworld.mit.edu/video/559>

⁹ EPRI, “Needed: A Grid Operating System to Facilitate Grid Transformation,” July 2011

⁶ De Martini, UCSB Energy Summit 2011 <http://iee.ucsb.edu/content/summit-2011-video-paul-de-martini>

Additional Value

This additional dimension of network convergence creates incremental new benefits from three principal areas:

1. Recognition that electric networks will yield similar opportunities seen in other industry sector transitions from vertical to horizontal market structures
2. Derivative benefits to the underlying value identified in the original Gridonomics analysis stemming from adapting Web 2.0 business models
3. New value potential arising from the intersection of these three networks and dynamic interaction among social, ICT, and electric networks

These three network values above include both known and potentially quantifiable benefits as well as conceptual and nonquantifiable benefits. Valuation methods like Beckstrom's Law¹⁰ could be applied to the known derivative transaction values identified in numbers 1 and 2 above. Real options analysis could be applied to the conceptual but nonquantifiable values described in number 3 above. These valuation considerations are missing from current regulatory and business investment analyses.

New Valuation and Business Paradigms Required

Paradigm shifts often happen slowly, particularly in a 125-year old industry. Also, looking ahead and trying to make sense of the massive global social, economic, and technological change to envision the future of the electric industry is daunting. However, this is exactly what is needed as the planned \$6.9 trillion capital investment in global electric networks¹¹ (IEA, 2010) span the 15 to 25 year industry transformation period. The current economic climate has many industry sectors, including utilities refocusing on operational excellence strategies to squeeze financial gains from existing core operations. However, as Geoffrey Moore points out in *Escape Velocity*¹², this strategy works reasonably well "until you expose the enterprise to secular market change." Secular change is what the electric industry is undergoing in the transformation we describe in this paper.

That is why new business paradigms for assessing the opportunities and potential threats are required. These

new models should consider the industry sector transitions that have already occurred in financial services, media, telecommunications, and retailing, for example. By understanding these changes better and the evolving Web 2.0 business models, it is possible to create new frames of reference to identify the opportunities in a future electric industry. This future is already occurring on a limited basis in a variety of locations around the world. As William Gibson has often noted, "The future is already here, it just isn't evenly distributed."¹³

Aspects of these future values or business opportunities have been discussed over the past decade, yet we still use only discounted cash flow analysis on operational and energy market values to assess smart grid investments. Often, the conceptual discussion of new value is in the context of trying to identify new "killer apps" for electric markets. However, much of the discussion tends to concentrate on the underlying physical value. For example, demand response or electric vehicles most often relate to business models deriving underlying physical value in the energy value chain including carbon. We believe that the industry should also explore these additional network convergence benefits toward defining acceptable valuation methods for regulatory and business decision making.



10 Beckstrom's Law, http://www.beckstrom.com/The_Economics_of_Networks

11 IEA New Policies scenario (\$3.1 Trillion to 2020)

12 Geoffrey Moore, *Escape Velocity: Free Your Company's Future from the Pull of the Past*, Harper Business, 2011

13 William Gibson's first mention reported to be in an interview on Fresh Air, NPR (31 August 1993)

Doing Both: Opportunities to Invest in Core Operations and Innovation

The challenge for utilities and services firms now becomes how to invest in both their existing core business as well as in new areas of innovation. Inder Sidhu, Cisco senior executive and author of *Doing Both*¹⁴ explains: “Doing both means refusing to accept that tradeoffs are the only way. In simple terms, it means consciously choosing to pursue two seemingly opposing activities at the same time, each for the benefit of the other.” We believe that many of the smart grid investments today will show that seemingly discrete investments actually have synergistic relationships. This insight stems from Cisco’s electric industry business and technology architecture development. In fact, the additional network effects and convergence benefits may very well provide the “flywheel effect” also described in *Doing Both*.

One example of this type of investment is field area networks (FAN) that can be used for a) smart meter aggregation and backhaul; b) distributed automation; c) distributed protection; and d) workforce connectivity and productivity. Each of these applications can be considered within a unified communications network that provides significant cost and benefit synergies related to the underlying value. This same network can be used to interface with intelligent DER and customer interfaces that enable derivative benefits, as described earlier.

Another example is utilizing a multiservices, IP-enabled wide area network (WAN) network to support both enterprise and operational applications over a single infrastructure. This includes enterprise applications like voice, video, and data, as well as operational applications like security, supervisory control and data acquisition (SCADA), phasor measurement, and even advanced teleprotection. The models to justify a “common network platform” are new to the electric industry, but are mature and validated in many other industries.

Leading utilities are considering the “core” investment opportunities within the context of “operational excellence” strategies as well as considering “innovation” opportunities and potential synergies. These activities include developing integrated business strategies, technology architectures, and deployment roadmaps to guide these critical investments.

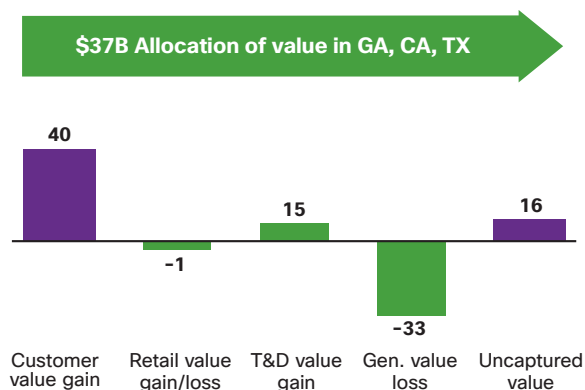
Of course, these investments should be deployed reliably and securely and in a way that is consistent with present and future customer needs. The investments must also ensure flexibility to accommodate changes in market structures and customer use of the networks.

Value Allocation and Incentives Matter

One of the most important considerations today is market and regulatory alignment of financial incentives with policy goals. In many jurisdictions worldwide, the current structures do not fully consider the short-, medium-, and long-term value of smart grid investments and do not adequately address the economic returns and incentives needed to sustain a viable marketplace for all stakeholders, including technology products and services firms. Specifically, these barriers to market transformation include a) inherent conflicts in value allocation from existing structures for incumbents and emergent market participants; b) structural challenges to monetize the potential societal value into tangible customer and business value; and c) regulatory investment returns and incentives for smart grid investments.

Value Allocation

Figure 4 Value Chain Stakeholder Analysis for Georgia, California and Texas



Cisco conducted a second-level analysis of the aggregate \$37 billion NPV of the 12 smart grid investment areas that would potentially flow to the stakeholders across the existing value chain, given existing regulatory and market structures in Georgia, California, and Texas (Figure 4). As background, much of the value identified is derived from a) reduction of energy purchases through energy conservation and reduction

14 “Doing Both: Capturing Today’s Profit and Driving Tomorrow’s Growth”, Inder Sidhu, FT Press, 2010 <http://www.doingboth.com/>

of system losses; b) reduction in incremental generation and network capacity; c) operational benefits; d) reliability improvements; and e) reduction of carbon in descending order. Value from “a” and “b” is why incremental generation has the largest negative impact. Transmission and distribution (T&D) is slightly positive owing to operational savings offsetting value loss from transporting less energy. Customer value is derived principally from lower energy bills as a result of consuming less energy and reduced peak demand. However, to realize the potential \$40 billion in customer value requires new products and services, so part of the identified value would be shared with other market participants.

Several observations can be made from this value chain analysis. First, existing market stakeholders do not benefit from the efficiency, distributed energy resource, or active customer participation policies. Additionally, to realize the \$40 billion in potential net benefits for customers, you must have business models that involve capital investment in connected grids and customer-side equipment and/or volume operations. Existing market rules often preclude those capable of providing those services from participating and/or monetizing the value. Finally, the \$16 billion in uncaptured value is derived from carbon emissions reductions, reliability, and other benefits that are not monetized in those U.S. markets. While this analysis focuses on the U.S., the results are analogous to other markets including the EU, Australia, and New Zealand. The current industry structures in much of the world are clearly impeding adoption of smart grid and customer energy savings enabling technologies by creating significant potential winners and losers among industry stakeholders.

Monetization of Value Potential

The electric industry needs to consider the regulatory rules and market structures to realize the full value potential of the smart grid. The Australian Energy Market Commission (AEMC) noted as much in its issues paper, the *Power of Choice*: “Market and regulatory arrangements across the entire electricity supply chain need to be considered to support the market conditions necessary for a more flexible demand side. This would ensure that the demand side is able to compete with the supply side to achieve an economically efficient supply/demand balance.”¹⁵ Cisco’s analysis suggests that we collectively need to a) recognize and monetize the underlying and derivative value, and b) consider the roles of all stakeholders related to market participation at this early stage of development.

The inability to consider and/or monetize societal and network effects value in investment business cases and regulatory cases is undervaluing today’s smart grid investment opportunities. This is leading to investment deferrals, and in some cases, short-term focus resulting in less “future-proof” investments. Much of the nonoperational value in many regulatory jurisdictions cannot be specifically considered in rate cases; in addition, there may not be adequate market structures to monetize the full traditional value chain potential.

Also, other industry sectors are creating additional substantial derivative value results from the convergence of physical, ICT and social networks. For example, the value derived from data and information has transformed the retailing industry over the past two decades. Incremental value from a variety of derivative business models could be used to offset the upward pressure on customer rates and bills, just as other industries are incorporating these offsets into their business models.¹⁶ Cisco fully understands that in today’s economic climate, difficult capital investment decisions are being made by governments and utilities worldwide. This is why we believe it is essential to consider the full value in investment prioritization. Failure to formally recognize and monetize this full value potential will lead to suboptimal infrastructure investments that will not fully enable current global policy objectives for renewable energy, distributed resources, and active customer participation in markets over the next two decades.



¹⁵ AEMC, “Power of choice—giving consumers options in the way they use electricity”, July 2011 <http://www.aemc.gov.au/Media/docs/Issues%20Paper-891c93cd-2bad-4e32-bf1b-6370eb63a3b0-0.PDF>

¹⁶ New economy business models discussed in “Free” by Chris Anderson and “Not for Free” by Saul Berman.

Additionally, current or emerging rules in some locations preclude certain stakeholders from participating in the new opportunities. Often these rules diminish the role that utilities and electric network owners may play. For example, California recently issued a ruling precluding utility participation in the deployment of electric charging stations. This approach contrasts with Japan, which views the utilities ability to fund, deploy, and operate charging stations as a critical aspect of their electric vehicle policy to ensure broad deployment of a large-scale electric transportation infrastructure. As in the California example, policymakers have often looked to new competitive entrants to make the large-scale investments that unlock much of the transformation value potential. Yet new entrants increasingly look to traditional participants to fund the investment or to purchase products/services because of their existing customer franchises and/or capabilities for managing large capital investments. Underlying these trends are a variety of business model and market development reasons, including:

- The time and expense of scaling global mass market businesses due to the cost of customer acquisition and retention
- Energy services firms typically do not invest large amounts of capital in customer equipment
- Technology product development typically needs a ready market to quickly scale to millions of unit sales to achieve profitability

A recent electric industry presentation by Geoffrey Moore highlighted several of these market development issues.¹⁷ Policymakers need to reconsider the industry rules and market participants' roles and capabilities to achieve the policy goals that are aimed at unlocking the societal and customer potential value. AEMC also recognized these issues in their *Power of Choice* paper and have begun an industry discussion to resolve these issues in potentially new regulatory/market frameworks. Failure to consider these issues may result in several 2020 policy goals worldwide not being realized.

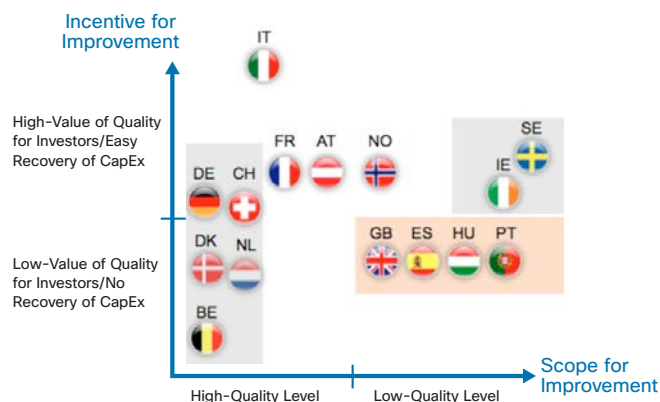
Regulatory Incentives

As highlighted in a recent report by the European Electric Industry Association (Eurelectric, 2011), many current regulatory frameworks do not sufficiently incentivize utilities to allocate their resources in order to embrace these paradigm changes. Eurelectric details some of the most important gaps that are blocking the transition to a “smart” regulation and enabling grid companies to attain the 2020 goals. The main gaps listed are:

- Suboptimal rates of return and regulatory instability
- Lack of clarity regarding the roles and responsibilities of the individual market players
- Narrow view on evaluating cost efficiency, penalizing innovation

Cisco analyzed some of these gaps in a report that provided a European benchmark for treatment of CapEx and Quality of Supply (reliability) regulation, concluding that setting clearly defined, long-term targets based on overall industry performance and using a simple, targeted, and balanced treatment of CapEx would be a better conduit to spur investment from the grid companies.¹⁸ Figure 5 compares 15 European countries on two dimensions; relative electric service quality (quality of supply) and the relative favorability of regulatory rules for financial returns on capital investment in electric infrastructure (quality for investors).

Figure 5



18 Cisco European Quality of Supply Regulation paper, June of 2011 http://www.cisco.com/web/about/ac79/docs/eurmkt/Regulation-of-Energy_QoS_IBSG_0606FINAL.pdf

17 Geoffrey Moore's 2011 Connectivity Week keynote, <http://www.youtube.com/watch?v=gFIOZz0AEmw>

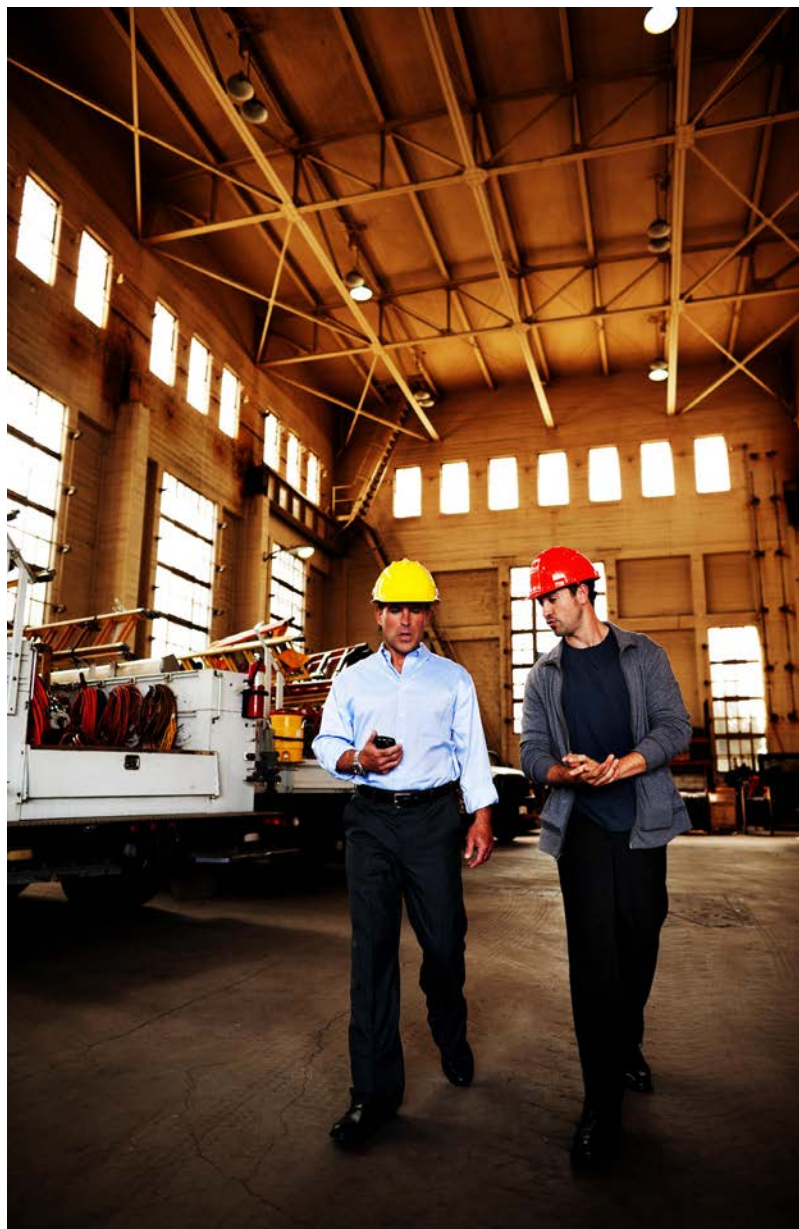
Traditionally, network regulation has focused on one main aspect: the price to deliver energy. The next step in the evolution of regulatory models has been the consideration of quality in the delivery. Given the ambitious new goals of sustainability set by policymakers worldwide, it is becoming clear that the focus for incentives should go beyond a pure question of reliability and total cost. It should move toward a portfolio of incentives and social obligations that need to be balanced in the planning and operational process.

When considering sustainability targets policymakers should also consider that subsidizing clean, decentralized energy sources cannot be decoupled from a lock-stepped grid integration through smart grid technologies: supply and integration are two sides of the same coin. High funding and subsidies for the supply side need to be paired with corresponding attention to the integration side. Otherwise, imbalances are likely to arise and cause strains that eventually hamper the reliability and the quality of national and transnational electric networks. This opinion has recently also been voiced by the EU Commissioner for Energy, who has detailed the need for grid development in Europe to support the sustainability goals (FAZ, 2011).

In order for investments to be made, adequate financial incentives and rates of return have to be in place. Also, the electric industry has globalized over the past 20 years, and electric infrastructure investment capital has increasingly sought the highest return worldwide. As cited at the beginning of this paper, in many countries the rates of return are considered too low to be attractive for grid development. Regulators across the globe should consider the competing capital investment opportunities provided by more attractive environments abroad.

Already, some regulators have taken notice of these misalignment issues and have begun to consider new regulatory frameworks that go beyond their traditional regulatory structures. The U.K. regulator Ofgem, for instance, expanded the RPI-X framework (price cap regulation) toward what they labeled RIIO (Revenue = Incentives + Innovation + Output), a framework that bases revenue recognition on multiple, different aspects of the utility operation. The overall objective of this new regulatory structure is to help the regulated entities to push beyond their current duties and explore new models that will enable them to achieve the new energy supply and demand paradigms that are going to sweep the U.K. in the coming years, while ensuring reliable supply and customer service (Ofgem, 2010).

The main parameters that grid companies are measured against are: customer satisfaction, reliability and availability, conditions for connection, environmental impact, social obligations, and safety. These parameters are an example of the way the regulatory structure is starting to enable the utility to capture and monetize many of the elements that would otherwise flow into what we defined as uncaptured value in the value chain stakeholder analysis.



Conclusion

This primer has introduced Cisco's Gridonomics framework and its application through quantitative analysis to identify great value that can be unlocked through the implementation of smarter grids. The NPV of such investments is estimated to be \$210 billion in the United States alone.

As an analytical framework, Gridonomics is a tool to look at the intersection between technological, economic, and policy aspects that will exert influence on the future of the power industry. Cisco's vision for the future of energy is based on deep experience with transitions in other market sectors that disrupted traditional business models, including entertainment, financial services, telecommunications, government institutions, and today, healthcare and education.

The changing use of electric networks toward more distributed energy resources and the corresponding rise of prosumerization will create a more horizontal market. Convergence with a sophisticated ICT network linked to energy-aware social networks will create significant value beyond the traditional value chain. Now is the time to engage in public-private dialogues on electric industry transitions regarding value creation and shifting value capture opportunities, as several global megatrends are redefining industry structure and business models. Cisco's intent is to support these industry dialogues regarding the shape of electric industry transformations currently underway in a number of venues around the world. We believe these public-private collaborations will lead to better decisions regarding policy, customer value creation, and industry investments.



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