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IEA IMPLEMENTING AGREEMENT FOR A CO-OPERATIVE PROGRAMME ON SMART GRIDS (ISGAN)

Managing Consumer Benefits and Costs

ISGAN white paper
Annex 4, Subtask 3.5

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Approval: _____X______ ISGAN Executive Committee Chair or Vice Chair

From the ISGAN Annex 4 Programme of Work, adopted October 2011:
"*This white paper will survey the critical issues in managing the benefits and costs of smart grid for consumers, identify proven consumer engagement programs, and recognise regional differences in consumer expectations and the challenges that such differences might imply for international cooperation in this area."*

Abstract:
The range of smart grid system configurations has grown rapidly in recent years, challenging efforts to track and evaluate the various potential benefits and costs of grid modernization efforts. This report outlines the range of benefits that may be achieved by smart grids, the role of consumer engagement in achieving system benefits, the sources of costs, and the varying allocation methodologies that may be achieved under different energy market structures. Where applicable, recommendations are made for potential ISGAN collaboration.

Disclaimer

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1. Introduction and Context

In an increasingly electrified world where demand for electricity is growing rapidly along with population and economic activity, Smart Grid technologies have the potential to provide significant benefits for private consumers, businesses, and society at large. Achieving these benefits will, however, require significant investment, and deciding how to allocate these investment costs is a key public policy challenge. This ISGAN white paper examines the benefits of a range of possible smart grid technologies across the variety of energy delivery frameworks, discusses the range of costs necessary to achieve these benefits, and examines frameworks for allocating these costs, all with the aim of assisting decision makers to deliver a sustainable and fair model for promoting smart grid development**.**

Globally, more than US$18 billion was spent on smart grid projects in 2010.[1] Across the ISGAN membership, these costs have been borne in varying degrees by governments, utilities, and consumers. Significant evolution is underway in the proposed mechanisms to recover investment costs: in the U.S., the number of utility appeals to rate-setting commissions is as high as it has been in 20 years, as utilities request new methods to recover smart grid project costs. Similarly, Australian governments, regulators and industry are grappling with market reforms required to fairly apportion funding for demand management investment programs. The European Commission has noted that:

> "At present, there is a considerable gap between current and optimal investment in Europe, which can only partly be explained by the current economic downturn. Grid operators and suppliers are expected to carry the main investment burden. However, unless a fair cost sharing model is developed and the right balance is struck between short-term investment costs and long term profits, the willingness of grid operators to undertake any substantial investment might be limited."[2]

In some jurisdictions, the roll out of smart grid technologies has achieved less consumer engagement than would be desirable, and in particular some projects have failed to clearly communicate the benefits and costs of smart grid technologies, resulting in mixed reactions from consumers. This is a key risk area that must be addressed for successful implementation.

In this context, it is worth briefly reviewing conventional methods of cost-benefit analysis and mechanisms for cost recovery with a greater focus on the consumer side of the equation, as the underlying values and processes will inform new cost allocation methods for smart grid investments.

ISGAN brings the experience and perspective of the global Smart Grids community together in this paper in order to increase understanding of the costs and benefits of smart grids from a consumer perspective, so that they may be communicated more widely and more effectively.

2. Definition

ISGAN uses the European Technology Platform Smart Grid (ETPSG) definition for a Smart Grid:

> *"A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies."[3]*

This definition allows for a very wide range of technology configurations and market structures. As an enabling technology, the costs and benefits to consumers depend upon the particular configuration of smart grid technologies that are implemented by utilities and taken up by consumers. In this context, it is useful to explore the relationship between smart grid *impacts* and *benefits*. The *impact* of a Smart Grid technology or system is a change in the technical performance of the electric system. The term *benefit* connotes a monetary or tangible service-related result. A transformation function is required link the impact to the benefit."[4]

This relationship is important, as it clarifies that the *impacts* of smart grid investments do not automatically or directly translate to *benefits* of these investments. The 'transformation function' that links the two is heavily influenced by the starting conditions of the grid, the role of the consumer in electricity management, and the framework for electricity delivery that is in place. Furthermore, identifying where the benefits (monetary or other tangible results) accrue is a key objective of public policy. Understanding these factors is key to thinking about fair and appropriate cost and benefit management.

This paper attempts to address these issues across a range of likely possible smart grid configurations and market structures, while acknowledging that many other technology configurations are possible. In light of the continuing evolution of the smart grid, cost allocation will be an ongoing subject of ISGAN research and analysis, and this white paper aims to provide a framework for this ongoing analysis.

3. Descriptions of Consumer Benefits

Depending upon system configuration and market structure, a wide range of consumer benefits are possible through smart grids. In order to structure the analysis of costs and benefits, ISGAN has identified the following high level benefits that smart grids can deliver to consumers:

1) **Supporting a growing economy** over the long term that can promote international competitiveness while minimizing increases in energy costs.

As energy is a critical input into virtually any economic activity, the lower the delivered cost of energy, the less costly and more competitive are the goods and services produced in that economy. While smart grid technologies and their applications may not be able to reverse the current upwards trend of energy prices, they can impart downward pressure, minimising reductions in consumer wealth and spending. Smart grid systems can also serve to attract new businesses as seen in various communities like Chattanooga, USA. All else being equal, smart grid systems bring the potential to positively impact an economy's global competitiveness.

These types of benefits accrue predominantly to society as a whole, of which residential and commercial consumers are a sub set. As with many energy efficiency activities, delivering electricity more efficiently can both increase economic wealth and reduce greenhouse gas emissions. With line losses in many economies typically approaching between 8 and 15 percent in many jurisdictions, [5] the potential benefits are considerable.

2) **Providing consumers with greater choice and increased transparency,** by enabling consumers to:

   a) *better understand and manage their energy use through better education and more transparent and cost reflective information within their energy bills;*
   b) *choose to manage energy costs through adoption of flexible tariffs or direct load control programs that will incentivize load shedding during peak demand times;*

For consumers, the most direct and easily described benefit of a smart grid is that they are able to see details of their electricity consumption in real time and change their usage behaviour accordingly. A related benefit of these real time portals is that they can be a medium for electricity Distribution System Operators (DSOs) to communicate tariff data, load control signals, and other information. This two-way, customer-centric, near real-time communication lies at the heart of seeing most smart grid consumer benefits realised to their full potential and provides one of the greatest challenges for utilities into the future.

EPRI has analysed a range of U.S. trials on direct, real-time feedback and found that energy savings of 5 to 10 percent should be expected.[6] In Australia, one study has estimated that the gross annual benefits to society of customer applications enabling reduced consumer energy usage is AUS$0.38 – 2.45 billion, or $38 – 245 per customer.[7] A study of all smart meter-enabled consumers in Europe suggests that they have reduced their energy consumption by up to 10 percent.[8] A North American study found peak load reductions from 2 to 50 percent under different mixes of in-home technology visualisation systems and pricing programs.[9] In some system configurations, users have the capability to control appliances remotely, increasing levels of comfort and utility for consumers in addition to giving them increased opportunities to save energy.

While better consumer energy usage information can reduce overall energy usage, smart grid systems and applications can also improve the delivery of peak demand management techniques. These include flexible tariffs that better reflect the cost of energy as it is delivered (i.e. more costly in peak times) and direct load control programs where a DSO can remotely reduce non-critical energy usage.

The potential for smart grid-enabled demand management applications is considerable. For comparison with benefits from overall demand reduction benefits, the same Australian study quoted above estimated gross annual benefits to society of demand management (DM) applications of AUS$0.88 - 3.9 billion or $88 – 390 per customer.[7]

The value of this benefit to consumers is particularly high in areas of rising electricity prices. Some types of consumers do, however, benefit more directly than others from personally taking up demand management programs. This mainly depends on their ability to easily change their consumption patterns. All consumers will require clear and credible communication of system operation and new pricing products. Lower income consumers often rent their homes, cannot readily afford newer, more efficient appliances and may not maintain their existing appliances. Senior citizens who are at home during peak hours are less able to shift consumption patterns. Social welfare groups may also be wary that any market mechanism may see an erosion of the electricity tariff “safety net” that is in place in most jurisdictions.

Consumer advocate and social welfare groups, while generally supporting technologies that put downwards pressure on prices, can be wary of DSOs or government placing too high an up-front cost on their members when DSOs and wider society also receive benefits from their roll out. As in clean generation and advanced transmission investments, fairly allocating costs associated with technology systems that produce public benefits is important. Technologies that fail to live up to expectations, or misuse of the granular energy usage data generated can increase wariness amongst consumers, requiring careful implementation, data protection, and community education strategies.

c) *choose new, environmentally friendly supply alternatives such as renewables.*

Smart grid technologies have the potential to allow consumers to choose from a greater variation of electricity supply models, with renewable based supplies more able to exploit their competitiveness in niche markets.*

Consumers can benefit from an increased ability to control the cost of their energy use and its impact on the environment. Valuation of these types of benefit is very customer specific. Environmentally conscious consumers who wish to reduce their own carbon footprint but cannot generate electricity themselves will value these technologies, as will communities who wish to disconnect from the existing grid for environmental or supply reliability reasons. It should also be noted that increased choice and the potential for complexity that it brings to energy decisions may not be valued by all consumers. Some under-engaged consumers may become overwhelmed and withdraw altogether from making energy decisions that may benefit them, or alternatively it is conceivable that over engagement may provoke obsessive tracking of energy consumption and real time prices.[10]

3) **Increased reliability and resilience** to weather events through multiple generation sources and self-healing capabilities in the network.

System disturbances that result in interruptions to electricity supply can cost up to US$119 billion a year in the USA alone.[11] Strategic portfolios of control, monitoring, and supply-side smart grid technologies can limit the extent that these disturbances will impact industrial, commercial, and residential consumers at the time of the disturbance.

Customers with a history of unreliable supply such as those in rural and remote areas, or those who have experienced cascading blackouts, such as those on the East Coast of North America in 2003, will value these increased reliability and resilience benefits more highly. Consumer advocacy groups in regions of more stable electricity supply however may view sceptically any attempts by DSOs to pass what they may see as operational grid management costs onto consumers or the public purse.

4) **Automated fault detection, isolation and restoration activities** enabling faster maintenance and removing the need for customers to directly notify the supplier about power outages;

In a typical grid without smart grid technologies, localised outages often go unnoticed until consumers notify their DSO. Closely linked to benefit number 3, smart, on-grid systems such as sectionalisers, mid-circuit reclosers, smart relays and ties and fault sensors can reduce the duration and scale of outages.

Potential benefits to consumers are not only the reduced outage time, but also elimination of the inconvenience and time spent by large number of consumers simultaneously telephoning the electricity DSO to inform it of an outage.

* The unique contributions of smart grid technologies to greater renewable energy integration are discussed in greater detail in ISGAN white paper completed under Annex 4, Subtask 3.1: “Smart Grid Contributions to Variable Renewable Resource Integration.”

The gross benefits of improved reliability from automated responses to some types of outages and faster scouting and repair for others has been estimated at between AUS$0.9 – 2.3 billion dollars annually in Australia (or $90 – 230 per consumer) and a 44 to108 minute improvement in the System Average Interruption Duration Index (SAIDI).[7]

5) **Facilitating long term savings in electricity supplier operations** that can be passed onto the consumer:

   a) *Automatic meter reading and Remote connection and disconnection.*

The costs of manual metering reading and on-site connection and disconnection of services are considerable. In addition to efficiencies in reducing physical site visits, there are also benefits in faster response times to consumer queries, reduced billing errors and reduced retailer hedging costs from better forecasting enabled by improved granularity of data. Australian estimates are for gross benefits to retailers and DSOs (which may or may not be passed on to consumers), totalling AUS$0.5 – 0.7 billion per year or $50 – 70 per consumer per year.[7]

Consumer attitudes to these potential benefits vary according to the regulatory system in place, the level of trust consumers have in their electricity supplier and the level of engagement and understanding they have of electricity supply issues. Technology early adopters will likely support the investment; those more sceptical of change may lament the demise of the meter reader. Additionally, some observers have raised concerns about the cyber security implications of remote disconnect functionality.[12]†

   b) *Load management – especially during peak usage times to relieve grid stresses, enable deferment of capital for new assets, and align supply and demand loads; and*
   c) *Direct load control opportunities for consumers and other market participants.*

Smart grids enable load management as distinct from demand management detailed at 2c through technologies and applications that better control grid voltage and power factors, avoiding line losses, reducing consumption and prolonging equipment life. In addition to reducing network operating costs and putting downward pressure on prices, the increased efficiency could lead to a reduction in greenhouse gases. The IEA predicts that smart grid deployment will reduce annual global carbon dioxide emissions by 0.7 to 2.1 gigatonnes by 2050.[13] In the future, Smart Grid technologies may also provide opportunities for consumers and other market participants to be able to sell the load they curtail to DSO's or third party market operators, enabling new business models and markets to emerge.

6) **Providing functionality to enable consumers to sell their generation on the grid.**

Currently, energy supply companies are responsible for managing the impacts of increased distributed generation on the grid. In the future, smart grids may enable consumers who generate their own electricity (prosumers) to partner with the electricity supply companies in managing the integration of their generation onto the grid by delivering electricity at a time and at a price that is beneficial to both parties. An added benefit enabled by smart grid technologies could be the ability for prosumers to disconnect from the grid and use their own generation during periods of outages, or whenever it is financially viable to do so.

† Cyber security issues of smart grids are discussed in more detail in the 2012 ISGAN white paper completed under Annex 4, Subtask 3.4: "Smart Grid Cyber Security."

As grid supplied electricity prices rise and on-site generation costs fall, often as a result of government intervention, the penetration of distributed generation on the grid will increase. The societal benefits of distributed generation, or putting supply close to the load, are considerable. EPRI estimates that "[w]hen correctly valued, distributed resources are often two to three times less expensive than large-scale centralized resources".[14]

In Australia, analysts estimate that distributed generation has the potential to realise AUS$130 billion in present value worth of benefits in the period 2006-2050.[15] The annual GDP in Australia in 2009 was approximately AUS$1.1 trillion.

The benefits to specific consumers (or prosumers) are difficult to quantify as they are prosumer specific and a result of distributed energy generation applications that are currently largely untested in real market situations.

The benefits of distributed generation are most likely to be highly valued by consumers with the disposable income available to install their own generating infrastructure and knowledge of how to negotiate an effective selling position with supply companies, (though there are likely to be intermediaries that arise to assist with this process.) Policies to ensure fair market operation between supply companies and consumers will be important. Many off grid rural and regional consumers may already have been generating their own electricity and may find it financially viable to re-connect to the grid in order to sell their excess generation.

7) **Enhanced customer service experience** as a result of improved business processes, customer usage data and an enhanced, two way consumer / supplier relationship.

The proliferation of smart grid technologies will lead to a rising number of prosumers, personalised tariff structures, new energy generation options and energy usage information that is freely available in real time. As a result, consumers will increasingly expect energy DSOs and retailers to do more than keep the lights on, meter energy usage and bill for that usage accurately.

Importantly, the information that allows this enhanced customer service experience must be readily available to the consumer and kept secure by network operators in order to deliver this benefit. A large portion of smart grid development focus is on delivering this functionality.

An enhanced customer service experience is essentially a qualitative rather than quantifiable benefit for consumers. Virtually all consumers and consumer groups would value an improved customer service experience, especially if it is to be supplied at minimal extra cost. The exceptions are some social welfare groups that may see their constituents as paying for services that they are unlikely to use.

8) **Reduced and more stable transportation costs in the long term** facilitated through movement to electric vehicles (EV) and vehicle-to-grid storage enabled by smart grid technologies.

Transportation costs are currently highly dependent upon the price of oil, the supply of which is an energy security risk. Smart grid technologies enable the use of EV's for energy storage, (vehicle-to-grid and vehicle-to-house technologies), thus providing a key driver for their increased uptake. Smart grid technologies will be a crucial enabler for the Clean Energy Ministerial goal of 20 million EV's by 2020 but the less developed nature of the current electric vehicle industry means this benefit will not be delivered for a greater length of time and accordingly is not as highly valued as the other consumer benefits listed here.

4. Consumer Cost Allocation

While there are clearly significant potential benefits to consumers from smart grids, there are also significant costs required to implement the technologies and market structures required to provide these benefits. Furthermore, many benefits flow to society at large, and still other benefits may flow to electricity utilities and their shareholders. It can therefore be expected that smart grid implementation costs should be borne fairly by utilities, governments, and consumers. Designing the appropriate mix of cost sharing and cost recovery is the primary public policy challenge of smart grid finance.

It is a commonly stated that all energy supply costs, including smart grid implementation costs, are ultimately born by the consumer. This is not typically the case. Energy utilities only pass on net costs to consumers through pricing, and only according to the relevant supply and demand curves and market and regulatory environment. In perfect free market conditions, these costs will be allocated to all parties in the supply chain, including wider society, according to the benefits they receive. As the electricity market is not perfectly free in any jurisdiction, costs are often apportioned according to principles applied by regulators and governments which in turn are heavily influenced by the types of electricity markets they oversee.

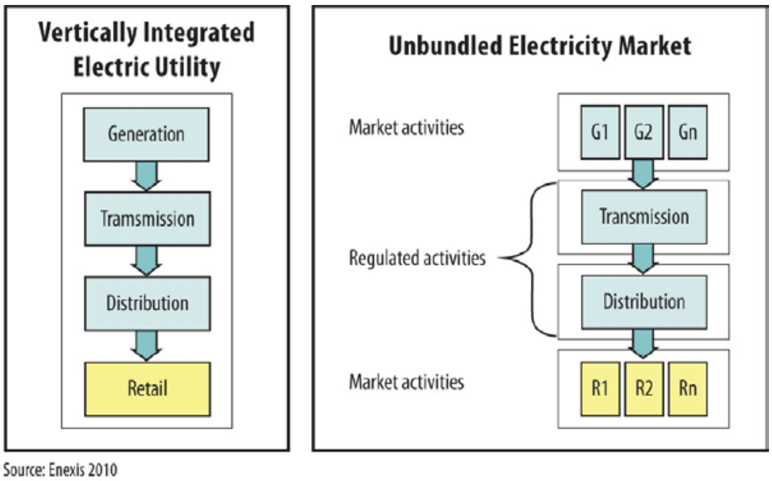

Figure 1: Figurative illustration of vertical and unbundled electricity market structures Source: Enexis, 2010

A jurisdiction with a vertically integrated electricity utility such as Korea (see figure 1) is likely to heavily apply the tax-payer pays principle. A jurisdiction with relatively contestable electricity market such as the United States is likely to more heavily apply a user-pays principle, in order to avoid distorting the market. Jurisdictions like most of Europe, Australia and New Zealand which experience regulation of transmission and distribution sectors but contestable generation and retail sectors try to apply a beneficiary-pays model. This model sees DSO regulated to pay according to the benefit they receive from a Smart Grid investment, with tax payers funding broader benefits to society, and consumers paying for benefits they receive through tariffs.

If a regulator (or a market) allocates a disproportionately low share of investment burden to the sector that directly benefits, the market actor receiving the benefit will be incentivized to over-invest, distorting the market and raising costs for other market actors. If the excess beneficiary is a DSO, this is often termed “gold plating” the network. This has been a risk in many jurisdictions if security of supply issues dominate and alternatives to grid augmentation such as the demand management programs enabled by smart grid technologies are not promoted. If the regulator or market allocates a disproportionately high share of benefits to consumers or society as a whole, the market actor will be incentivized to under-invest, and the business model may collapse due to lack of revenues unless governments step in with funding.

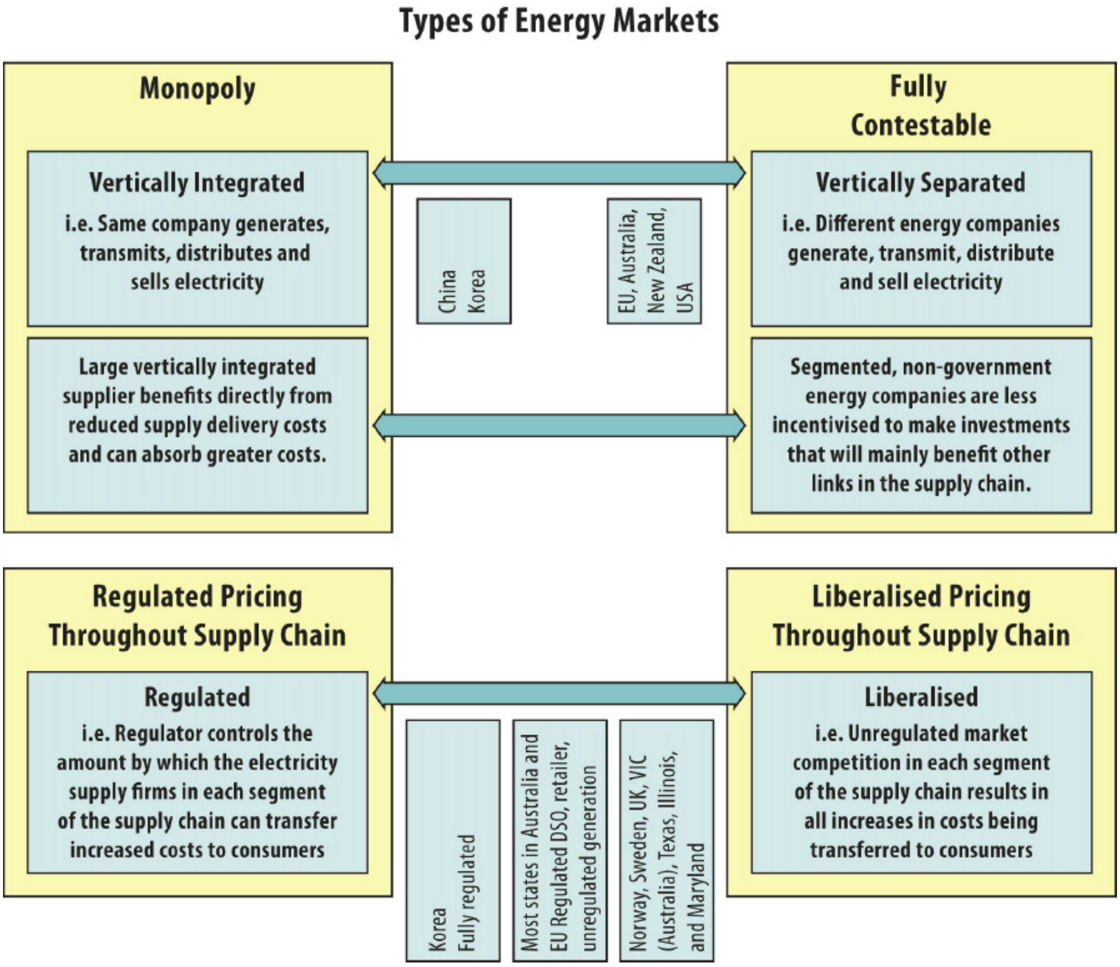

Figure 2: Some characteristics of monopoly and contestable energy markets
Source: Author analysis

5. Calculating Costs and Benefits

Many national and international organizations are developing protocols for rigorous cost-benefit analysis. One analysis methodology developed by EPRI in 2010 projected a 20 year benefit-to-cost ratio of a smart grid investment in the United States to be in the range of 2.8-6.0 to 1 and that residential prices would increase by 8.4 to 11.8 percent. As EPRI comments:

> *"These costs are modest compared to the benefits a smart grid will yield. However the challenge for all of those in the electricity sector will be communicating that the Smart Grid is indeed a good investment."*[16]

This methodology is being field tested on a range of U.S. smart grid demonstration projects,[17] and a modified version is also being developed for European projects. Additionally, a range of pan-European agencies, including the European Commission and ENTSO-E are advancing the development of rigorous cost-benefit methodologies for various grid modernization efforts that cross national boundaries.[18]

In many cases, it is a helpful practice to clearly delineate the range of benefits and costs, and to articulate the parties likely to benefit and to bear cost allocations. An example table is included below.

Summary Table: Consumer Cost Items, Impacts, Benefits, and Cost Allocations

Elements of a Smart Grid implementation that are likely to be more heavily borne by consumers in most jurisdictions are:

<table>
<tr><th>Application and Cost Items</th><th>Impact</th><th>Benefits</th><th>Benefit Received By</th><th>Costs (Initial bearer)</th></tr>
<tr><td rowspan="7">Real Time Customer Energy Usage Measurement and Feedback (Enabling improved demand management)
Energy Usage Feedback devices including, In House Displays, Home Area Networks (Energy Management Systems), web and smart phone applications (smaller costs)
Advanced Metering Infrastructure (Including meters, communications and IT infrastructure)
Grid ready appliances
Communications Infrastructure
Web Platforms
Information Management
Financial and Technical Risk for pilots
Climate change incentives</td><td rowspan="2">Reduced average consumption</td><td>Reduced rate of energy cost increase</td><td>All consumers</td><td rowspan="7">Energy usage feedback devices themselves (Participant Consumers)
AMI, (DSO)
Grid ready appliances (Participant consumers)
Communications, (DSO)
Web platforms, (DSO and Retailer)
Information Management (DSO and Retailer)
Financial, technical risk for pilots (Early adopters, Govts)
Climate change incentives (Govts)</td></tr>
<tr><td>Greenhouse gas emission reductions</td><td>Society</td></tr>
<tr><td rowspan="2">Reduced peak consumption</td><td>Reduced energy delivery costs through infrastructure investment cost deferral</td><td>All consumers
DSOs
Society (Economic Growth)</td></tr>
<tr><td>Increased consumer choice / ability to manage and save on energy through time of use applications.</td><td>Participant consumers</td></tr>
<tr><td>Ability to remotely control energy usage</td><td>Increased consumer comfort / utility</td><td>Participant consumers</td></tr>
<tr><td>Ability for near real time and two way information flows</td><td>Increased consumer engagement</td><td>Participant consumers
DSOs</td></tr>
<tr><td>Remote, automated meter reading</td><td>Reduced energy delivery costs</td><td>All consumers
DSOs
Retailers
Society (Economic Growth)</td></tr>
</table>

<table>
<tr><th>Application and Cost Items</th><th>Impact</th><th>Benefits</th><th>Benefit Received By</th><th>Costs (Initial bearer)</th></tr>
<tr><td rowspan="8">Improved Grid Performance
• Grid Monitoring technologies such as;
o Phasor measurement technology for wide area monitoring
o Transmission line sensors including dynamic thermal circuit rating
o Communications infrastructure to support transmission lines and substations
o Enterprise back-office system, including GIS, outage management and distribution management
• Improved grid management, performance & load control technologies such as
o Storage for bulk transmission wholesale services
o FACTS devices and HVDC terminals
o Short circuit current limiters
o Core substation infrastructure for IT
o Cyber-security
o Intelligent electronic devices (IEDs)
• Financial and Technical Risk for pilots
• Climate change incentives</td><td rowspan="2">Better fault detection and restoration</td><td>Outage avoidance and reduction of outage duration</td><td>All Consumers
DSOs
TSOs
Retailers (customer satisfaction)
Society (economic growth from reliable supply)</td><td rowspan="8">• Grid Monitoring Technologies (DSO & TSO)
• Grid Management, performance and load control technologies (DSO & TSO)
• Financial and Technical Risk for pilots (Early adopters, Govt)
• Climate change incentives (Govt)</td></tr>
<tr><td>Less consumer time reporting outages</td><td>Fault reporting consumers</td></tr>
<tr><td>Increased grid asset life and performance</td><td>Reduced energy delivery costs through decreased operational costs</td><td>All consumers
DSOs
TSOs
Society (Economic Growth)</td></tr>
<tr><td rowspan="2">Reduced line and other system losses</td><td>Reduced energy delivery costs</td><td>All consumers
DSOs
TSOs
Society (Economic Growth)</td></tr>
<tr><td>Reduced greenhouse gas emissions</td><td>Society</td></tr>
<tr><td>Improved load management and prediction capabilities</td><td>Reduced energy delivery costs through infrastructure investment cost deferral</td><td>All consumers
DSOs
TSOs
Society (Economic Growth)</td></tr>
<tr><td rowspan="2">A more robust energy supply grid</td><td>Increased energy supply security</td><td>All consumers
Society (Economic Growth)</td></tr>
<tr><td>Increased grid safety (ie fires)</td><td>Society</td></tr>
</table>

<table>
<tr><th>Application and Cost Items</th><th>Impact</th><th>Benefits</th><th>Benefit Received By</th><th>Costs (Initial bearer)</th></tr>
<tr><td rowspan="7">Renewables, Distributed Energy and Distributed Storage (including EV) Integration

• Advanced Metering Infrastructure (Including meters, communications and IT infrastructure)
• Local controllers in buildings, on microgrids, or on distribution systems for local area networks
o Intelligent reclosers and relays at the head end and along feeders
o Power electronics, including distribution short circuit current limiters
o Voltage & VAR control on feeders
• Integrated PV Inverters
• Renewable / Distributed Storage System
• Electric Vehicle, (including charging infrastructure)
• Payment / Billing Support
• Financial and Technical Risk for pilots
• Climate change incentives</td><td rowspan="7">Increased penetration of renewable energy, distributed generation and energy storage supplied into the grid</td><td>Increased prosumer choice, flexibility and commercial opportunities</td><td>Participant consumer (prosumer)</td><td rowspan="7">• AMI (DSO)
• Integrated PV Inverters (Con / pro sumer)
• Renewable / Distributed Storage System (Con / prosumer)
• Electric Vehicle (Consumer)
• Payment / Billing Support (Retailer)
• Financial and Technical Risk for pilots (Early adopters, govt)
• Climate change incentives (Govt)</td></tr>
<tr><td>Spreading of DSO costs in managing renewable and distributed integration</td><td>DSO</td></tr>
<tr><td>Reduced greenhouse gas emissions through increased renewables</td><td>Society</td></tr>
<tr><td>Reduced greenhouse gas emissions through electricity generated and stored closer to the load</td><td>Society</td></tr>
<tr><td>Reduced energy delivery costs through electricity generated and stored closer to the load</td><td>All consumers
DSOs
TSOs
Society (Economic Growth)</td></tr>
<tr><td>Reduced energy delivery costs through infrastructure investment cost deferral through EV storage to grid demand management</td><td>All consumers
DSOs
TSOs
Society (Economic Growth)</td></tr>
<tr><td>Increased energy supply security</td><td>All consumers
Society (Economic Growth)</td></tr>
</table>

Cost Allocation Case Study: Maryland Public Service Commission

In June 2010, regulators in Maryland (USA) rejected a smart grid cost recovery proposal from a local utility, Baltimore Gas & Electric (BGE). The proposal was later revised and approved, but the rationale for initial rejection of the proposal is instructive to utilities and regulators around the world, and is detailed in an analysis from the U.S.-based National Regulatory Research Institute. The NRRI analysis identifies seven planning errors on the part of the utility:

"Bridge Halfway: Eager to get going, BGE failed to plan—or reveal—the full route. So the Commission filled out the picture, detailing the need "to deploy an advanced automated distribution control system that utilizes embedded sensors, intelligent electric devices, automated substations, 'smart' transformers, analytical computer modelling tools, high-speed integrated communications, and reconfigured distribution circuits"—all omitted from the Company's cost proposal...

Cost understatement: The utility claimed a benefit-cost ratio of 3:2. But its cost category skipped over items essential to success: (1) "the approximately $100 million in undepreciated value of existing, fully operational meters that would be retired before the end of their useful lives"; (2) "the estimated $60 million [for] ... the new billing system necessary to implement" the new time-of-use rates; (3) "the cost of in-home display devices, which easily could exceed another $100 million"; and (4) the cost of new customer appliances that can communicate with the new meters. Why omit these costs?

Benefit overstatement: Smart grid investments can produce two types of benefits: operational savings (e.g., substituting remote for manual meter reading), and power supply savings (e.g., reducing future capacity and energy needs as customers change their behavior). Almost 80 percent of BGE's claimed savings came from the second category—a category pervaded by uncertainties about future market prices and customer responses.

Excess optimism: Excess optimism is optimism without risk: My upside exceeds my downside; you pick up the difference. BGE claimed confidence but avoided risk. ("Although BGE claims that the assumptions underlying its business case are sound, the Company would have its customers bear all of the risk in the event those assumptions prove incorrect." Consumers became the reverse image: guaranteeing cost-plus-profit but receiving no promise. This tactic is otherwise known as "betting with other people's money."...

New rates without new education: The success of time-of-use rates depends on behavioral change by millions who have known only average rates. "Yet the Proposal contains no concrete, detailed customer education plan, includes no orbs or other in-home displays, and provides for grossly inadequate messaging, in our view, to trigger the behavior changes contemplated under the Proposal."...

Payment before performance: The customers' cost responsibility was clear, but the utility's accountability was not. Absent were metrics: specific commitments to cut demand and usage, measurably. BGE forgot what every teenage lawn mower learns: cut the grass, cut it well, then get paid. At bottom was an optical error: seeing ratepayers rather than consumers, pocketbooks rather than people.

Viewing service as voluntary: The obligation to serve includes an obligation to deploy technology to its best use, cost-effectively. The obligation is unconditional. But BGE, viewing innovation as voluntary, told the Commission, in a nutshell, "No surcharge, no proposal." When the game is voluntary, the dissatisfied can take his marbles home. Utility service—excellent service—is not voluntary.

Source: Hempling, S. (2010) "Smart Grid" Spending: A Commission's Pitch-Perfect Response to a Utility's Seven Errors.

6. Consumer Engagement Best Practices

As effective consumer engagement can underpin how consumers change their behaviour, it is important to the success of smart grid deployment projects. If implemented successfully, effective engagement of consumers can both increase the real and perceived benefits to consumers and lower the cost of achieving a desired change in behaviour. Effective community engagement in the energy field requires that the influencing organisation:

- Garners trust from its community,
- Undertakes extensive pre-planning and review by stakeholders,
- Tailors the campaign to the target audience,
- Communicates a simple message effectively through good choice of themes and mediums,
- Engages the community and encourages two way communication as opposed to just raising awareness or selling imposed solutions,
- Reduces consumer information barriers, and
- Complements the campaign with appropriate and appropriately priced products and services.

Consumers and their uptake of, and behavioural change responses to new smart grid technologies and applications are crucial players in achieving these benefits. Decision makers who understand the smart grid benefits consumers most value and are likely to take up will create better products and a society more engaged and willing to manage their energy demand. While education can influence the valuation consumers put on these benefits, and especially the benefits that accrue into the future or to society as a whole, decision makers should be wary of imposing solutions that have not attained widespread consumer acceptance.

7. Conclusion

Global peak demand for energy and electricity are predicted to rise for the foreseeable future, with electricity prices likely to rise accordingly. The IEA Smart Grid Technology Roadmap estimates that overall peak demand increases predicted between 2010 and 2050 can be reduced by 13 to 24 percent by the deployment of smart grids. Smart grids can also reduce annual carbon dioxide emissions by approximately 0.7 to 2.1 gigatonnes by 2050.

Smart grid implementation experience to date is that the way smart grid investment costs are apportioned amongst governments, utilities and consumers can be a key determinant in the relevant parties accepting those costs and making the necessary investments. Not only do Government and utilities need to fully understand and rationally value the long term costs and benefits, the critical challenge in smart grid deployment lies in understanding how those net benefits are valued by consumers.

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