# JOINT RUSSIAN/AMERICAN STUDY ON LEGAL/REGULATORY, MARKET, CONSUMER AND TECHNICAL IMPEDIMENTS TO SMART GRID TECHNOLOGY DEPLOYMENT

Russian/American Smart Grid Partnership Initiative
Cooperative Agreement: EEE-A-00-02-00054-00

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# U.S./RUSSIA BILATERAL PRESIDENTIAL COMMISSION ENERGY EFFICIENCY WORKING GROUP

## Russian/American Smart Grid Partnership Initiative

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## Prepared for:

**United States Agency for International Development
and United States Energy Association**

**Cooperative Agreement: EEE-A-00-02-00054-00**

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# JOINT RUSSIAN/AMERICAN STUDY ON LEGAL / REGULATORY, MARKET, CONSUMER AND TECHNICAL IMPEDIMENTS TO SMART GRID TECHNOLOGY DEPLOYMENT

This Study was prepared by the United States Agency for International Development (USAID), the Russian Energy Agency (REA), and the United States Energy Association (USEA) under the framework of the U.S./Russia Bilateral Presidential Commission Energy Efficiency Working Group's Russian/American Smart Grid Partnership Initiative.

This study was designed to provide the Russian and American stakeholders with on overarching 360 degree perspective on the major impediments to Smart Grid deployment in the U.S. and Russia

The U.S./Russian study team consisted of Steven Pullins, President, Horizon Energy Group, U.S., Irina Volkova, Professor, Deputy Director, Institute of Pricing and Regulation of Natural Monopolies of National Research University Higher School of Economics, and Ivan Danilin, Chief Expert of Energy Forecasting Agency and Head of Department, Institute of World Economy and International Relations. Special gratitude is due to Alexey Konev, Director for Innovation at the Russian Energy Agency, and Igor Kozhukhovski, Managing Director of the Energy Forecasting Agency, for guidance provided to the team.

The study doesn't include recommendation; it only assesses the current barriers that prevent smart grid technology deployment in the United States and Russia. It is organized into two parallel sections, one focusing on the impediments to smart grid technology deployment in the United States and the other on the impediments to its deployment in Russia. A common analytical framework for the study was jointly developed by the U.S. and Russian counterparts to ensure that the studies were parallel in their analyses and the impediments are divided into the following high level main Smart Grid related themes:

- Smart Grid Concept
- Markets
- Efficiency
- Cross-Subsidy
- Generation
- Consumer Participation
- Behavioral Norms
- Data & Analytics
- Smart Grid Investment Environment
- Education
- Grid Modernization

A parallel series of in-person interviews were conducted in the U.S. and Russia with relevant smart grid stakeholders including government agencies, regulatory officials, infrastructure companies, electric utilities, industry associations, market operators, and research institutions. The interviews ranged 2-3 hours in length. The subjects were informed in advance that their opinions were not for attribution, leading to a candid exchange of opinion. A customized questionnaire jointly developed by the Russian and American expert consulting teams was utilized during each stakeholder interview.

**Interviews were conducted with the following organizations in Russia:**

- Ministry of Energy, Department of Electricity
- Ministry of Energy, Department of Energy Efficiency
- Russian Duma Federation Council of the Russian Federation
- Federal Grid Company
- Inter-Regional Distribution Holding Company (IDGC)
- MOESK – Moscow Distribution Company
- System Operator Unified Power System of Russia
- JSC Optima
- Transmachenergo
- Russian Academy of Sciences
- Moscow Energy Institute
- Association of Guaranteed Energy Suppliers
- Federal Tariff Service
- ENEL
- Fortum

Authors want to express gratitude to experts of Energy Forecasting Agency, JSC “Science and Technology Center of FGC UES”, InterRAO UES energy company, State Atomic Energy Corporation ROSATOM corporation and Limited Liability Company "Lithium-ion technology" (LLC "Liotech"), who provided this study with some useful insights and ideas on problems and state of Russian energy system, energy technologies in Russia and associated issues.

Special thanks should be given to Mr. Igor Sorokin, Director for Information and Analytical Products and Methodology of Energy Forecasting Agency, who`s expertise and important remarks were very useful in preparation of this study and editing the text.

**Interviews were conducted with the following organizations in the United States:**

- Power Systems Engineering Research Center (PSERC)
- Direct Energy
- Electric Power Research Institute
- Ohio Consumer’s Counsel
- ICF International
- AEP Corporate
- US Department of Energy – Office of Electricity
- Public Utilities Commission of Ohio
- Federal Energy Regulatory Commission
- IPL
- PJM
- Midwest Independent System Operator (MISO)
- DTE Energy

# IMPEDIMENTS TO DEPLOYMENT OF SMART GRID TECHNOLOGY IN RUSSIA

The following major impediments to the deployment of smart grid technology in Russia were identified. These are discussed in detail in the body of the Russian section of the report.

## SMART GRID CONCEPT

- Less than Optimal Legislation and Regulation
- Unpreparedness of the Grid for Disruptive Smart Grid Innovations
- Weak Smart Grid Research and Development and Federal R&D Policies
- Weak Interactions between Science and Business
- Lack of Federal Leadership in Smart Grid Development

## MARKETS

- Weak Market Policy of the Government and Administrative “Manual Control”
- Unpolished and Inefficient Capacity Market Rules, Favoring Big Generators
- Market Oligopoly Structure and Government Policy Supports Large Generation and Depresses Competition
- Non-Transparent and Distorted Pricing Mechanism
- Regulators are not Ready for Significant Changes in Current Market Rules and Regulatory Framework
- Retail Market Rules Impede Distributed Generation Deployment
- Lack of Ancillary Service Market Regulations
- Fragmentation of the Power Market Regulatory Framework

## EFFICIENCY

- Policy Makers Concerns about Distributed Generation Harms Generation Efficiency
- Inability of Prosumers to Sell Excess Energy to the Grid
- Grid`s Equipment is Physically and Technologically Outdated, Networks are Poorly Maintained
- Insufficient Investment Resources for Monitoring and Accounting Systems and Inadequate Cost-Benefit Analysis
- Absence of Proper Data and Data Management Methodology
- Insufficiently Developed Regulations and Rules for Implementation of Existing Laws and Norms
- Smart Metering Regulation Gaps
- Illiteracy, Proper Information and Expert Support for Decision-making on Energy Conservation Solutions
- Undeveloped Market of Energy Efficiency Services

- Lack of Qualified Personnel, Methodology and Training of Decision Makers on the End-Use Side
- Problems in Getting Access to Credit Capital for Energy Efficiency Projects
- Current Regulations do not Incentivize Consumers to Increase their Load Density
- Lack of Policy Coordination

## CROSS-SUBSIDY

- Subsidizing Residential Consumers at the Expense of C&I Consumers
- Pot-Mixture Tariffs De-stimulate Investments and Use of New Technologies
- Cross-Subsidizing of Electric and Heat Energy at CHP
- Maintaining Reserves of Unused Generation and Network Capacities
- Populism and Short-Term Approaches of Regulators
- Absence of  Powerful Sponsor for Changes
- Absence of Clear Implementation Plan for Eliminating Cross-Subsidies

## GENERATION

- Regulators, Policymakers and FGC UES Concerns that Distributed Generation Development would Cause Atrophy the UES and its Social Functions
- Absence of Direct Governmental Support for Distributed Generation
- Federal Long-term Planning Process is Biased toward Big Centralized Generation
- Inadequate Attention to Economics of Power Generation and Substituting Solutions
- Restrictions for Fuel Supply for Distributed Generation
- Grid Architecture does not Allow for a Two Way Flow of Electricity
- Inability of Prosumers to Sell Excess Energy to the Grid
- Grids are Prohibited to have Own Generation Capacities
- Absence of Proper Data and Methodology Defers Replacement of Inefficient Generation
- Lack of Proper Energy Efficiency Methodology on the Generator Side

## CONSUMER PARTICIPATION

- Mechanisms of Pricing on Power and Capacity Markets
- “The imposition” of Tariffs to the End User
- The Limitations Imposed by the State on Market Price Volatility
- Problems of Residential Participation through Energy Efficiency and Demand Response
- Absence of Scientific and Methodological Approaches and Financial Support for Consumer Participation in Load Management
- Law Restricts Cooperation Between Retail and Energy Companies
- Lack of a Universal Methodology of Demand Management for Grid Companies

## BEHAVIORAL NORMS

- Residential Consumers Lacks Understanding of Energy Markets, Efficiency and Smart Grid Benefits
- Regulators Lacks Understanding of Energy Systems and Smart Grid

- Absence of Energy Efficiency Values and Practices of C&I Customers
- Absence of Common Terminology in Smart Grid
- High-level of Non-payments

## DATA AND ANALYTICS

- Customers are not Incentivized to Deploy AMI and Smart Meters
- Regulation and Administrative Provisions Gaps in Smart Meters Installation
- Customers are Suspicious on Smart Meter Installations
- Regulation Gaps in Smart Metering and Smart Meter Information Ownership
- Smart Metering Methodology Gaps
- Abuses in Accounting Devices Installations
- Lack of Standards and other Technical Regulations for Smart Meters
- Lack of Coordination in Data Reporting and Acquisition
- Unpreparedness to Analyze and Store Future Smart Grid-enabled Data Arrays

## SMART GRID INVESTMENT ENVIRONMENT

- Lack of Economic and Administrative Stimuli for Innovative Development
- Market and Regulatory Restrictions on Distributed Generation, Energy Efficiency and AMI Systems
- Absence of Coordinated Vision
- Absence of Coordinated Investment Efforts
- Rising Regulator`s Requirement for Reliability
- Weak Ecology Policy

## EDUCATION

- Uncoordinated Approach to Energy Industry Educational Policies
- Universities Lack Skills, Knowledge, Competences and Infrastructure for Perfecting their Educational Practices
- Weak Links between Education and Technology Innovation Activities
- Outdated Educational Standards, Inefficient Efforts and Lack of Coordination to Prepare new ones
- Absence of Educational Standards and Courses for Specialties, needed for Smart Grid

## GRID MODERNIZATION

- High Ratio of Grid Equipment Depreciation  and Contradiction between Modernization and Innovations
- Rising Regulator`s Requirement for Reliability
- Lack of High-level Industry Coordination
- Lack of a Unified Approaches, Development and Deployment Policies among Key Network Companies
- Geographical Differences as Requirements for Standard Projects
- Regulatory Gaps

- Technology Gaps on the Side of Russian Vendors
- Underdevelopment of Financing Mechanisms for Network Upgrades
- Lack of Skilled Workers Ready to Work with Smart Grid Technologies and a Lack of system of Education and Training.
- Integration of Energy and ICT Technologies, Competences and Practices.

# IMPEDIMENTS TO DEPLOYMENT OF SMART GRID TECHNOLOGY IN THE UNITED STATES

The following major impediments to the deployment of smart grid technology in the U.S. were identified. These are discussed in detail in the body of the report.

## SMART GRID CONCEPT

- The Objective of the Smart Grid is not Clear to All Stakeholders.
- Smart Grid Performance Goals and Metrics are not Available at the Federal, State and Local Levels.
- The Lack of Standard and Simplified Road-Mapping Methods Diminishes the Potential for Actionable Smart Grid Policies and Projects.
- Ineffective Change Management Prevents Alignment of Smart Grid Stakeholder Visions.
- Residential Consumers are not Seeing the Benefit of Smart Grid in States without Retail Choice.
- Current Research Initiatives Are Insufficient to Drive Next Generation Smart Grid Technologies.

## MARKETS

- Dichotomous Wholesale and Retail Electricity Markets Discourage the Benefits of Smart Grid Technology Deployment.
- Inefficient Coordination Between Wholesale and Retail Markets Impedes the Development of the Smart Grid.
- Smart Meters are of Little Value to the Consumer without Time of Use (TOU) Retail Electricity Market Rates that Reflect True Prices.
- Current Retail Rate Structures are a Substantial Mask on the True Costs of Delivered Electricity and Skew the Smart Grid Business Case.
- Only States that have Undertaken Deregulation are able to Accrue the Smart Grid Benefits Afforded by Retail Energy Providers (REP).
- Uncertainties Related to Energy Efficiency, Demand Response, Consumer-Owned Generation, and other Smart Grid Enabled Behaviors Challenge Planning Processes and Clouds the Long Term Benefits of Smart Grid Investment.
- Inconsistent Coordination among Federal, State And Local Regulators Impedes Development of Smart Grid Technology.

## EFFICIENCY

- The Most Efficient Smart Grid Technologies are Often Cost Prohibitive
- The Limited Use of Smart Rates Deters End-Use Energy Efficiency
- Regulatory Incentives do not Support Network Efficiency and Reliability Improvements Supported by Smart Grid Technology
- Combined Heat and Power (CHP) is a Technology that Can Benefit from Smart Grid Technology, but Lacks Strong Federal, State and Local Support

## CROSS-SUBSIDY

- Cross Subsidies are a Disincentive to the Smart Grid Business Case.
- The Patchwork Development of Subsidies at the Federal, State and Local Level Obscure Price Distortion Preventing Policymakers from Effectively Addressing them.
- Fixing Cross-Subsidies is not A Priority in the Regulatory Process and Will Remain a Deterrent to the Smart Grid.

## GENERATION

- The Emphasis on Traditional Large Central-Station Power Plants Undervalues the Benefits of the Smart Grid.
- Large Capital Expenditures by Utilities to Comply with Federal Environmental Mandates Reduces the Funding Available for the Smart Grid.
- Many Utilities are Unaware that Smart Grid Technologies can Enable Large Amounts of Distributed Energy Resources to Connect to the Grid.

## CONSUMER PARTICIPATION

- Consumers are Largely Unaware of Compelling Consumer Oriented Benefits of Smart Grid Technology.
- The Emphasis on the Network Benefits of the Smart Grid Obscures the Potential Consumer Oriented Benefits.
  Policies, Incentives and Programs do not Sufficiently Encourage Consumers to Adopt Smart Grid Technologies.

## BEHAVIORAL NORMS

- The State-Driven Regulatory Compact Sometimes Discourages the Adoption of Smart Grid Technologies.
- A Consistent Emphasis on the Network Side of the System Diminishes the Customer Driven Capabilities of the Smart Grid.
- Current Approaches to Consumer Education have Insufficiently Informed Customers of Smart Grid Technologies and its Benefits.
- Utility Behavior Regarding Vendor Selection is Based more on Trusted Relationships than on Functionality Required or Offered.

## DATA AND ANALYTICS

- The Electric Utility Industry's Current Approach to Data and Analytics does not Fully Realize the Data Rich Environment Afforded by the Smart Grid.
- A Lack Of Industry Data And Analytic Standards Is an Impediment To The Smart Grid.

## SMART GRID INVESTMENT ENVIRONMENT

- Inconsistent Federal and State Regulatory Incentives Impede Investment in Smart Grid Technologies.
- The Smart Grid is Viewed as an Additional Capital Expense Over and Above Utility Capital Budgets.

- Technology and Process Cost Uncertainties Impede Smart Grid Deployment.

## EDUCATION

- The U.S. Workforce does not have Enough Skilled Workers to Fully Implement the Smart Grid.
- The Necessary Skills to Successfully Support the Smart Grid Still Need to be Fully Identified.
- Universities do not have the Academic Curricula Developed to Provide the New Skills Required by the Smart Grid.

## GRID MODERNIZATION

- Ineffective Change Management Principles Prevent Implementation of the Smart Grid Vision.
- The Lack of a National Policy for Grid Modernization Results in Inconsistent Approaches to Smart Grid Deployment.
- There Are Numerous Fundamental Barriers to the Smart Grid that still need to Identified, Acknowledged, and Addressed.
- Smart Grid Deployment Best Practices and Lessons Learned are not Effectively Shared Among all Stakeholders.
- The Development Of The Smart Grid Is Not Necessarily Seen As Complementary To Other Grid Modernization Strategies.

# ANALYSIS OF OVERCOMING SMART GRID IMPEDIMENTS IN RUSSIA

Last decades in Russia are characterized by rapid development of technology, economy and society. These radical changes impact also on activities of the Russian electric power system presenting new and ever-more-demanding standards which are connected to constantly increasing power energy cost; limitations of traditional sources of electric power energy; constantly growing demands on reliability and quality of power from consumers and society; aging equipment; increasingly growing shortages of skilled personnel in power utilities; increasing demands of all stockholders to the results of operation of the power companies; the growing role of environmental factors and constrain; requirements of the system-wide cost reduction, new threats emerge in the form of terrorism, cyber-attacks, etc.

Electric power industry in Russia is the main backbone sector of the national economy, ensuring its economic security due to significant consumer benefits of its products (first of all electric power) over other types of energy. However, the industry condition has significantly deteriorated compared with 1992 as the year that marked the transition from the centralized to a market-based industry. There are the following present day key status indicators of the Russian Power Industry as compared with 1991 in the Russian Power Industry Modernization up to 2020 Program:

- Relative electric power transmission losses of power networks increased more than 1.5 times;
- Specific numbers of personnel in the industry increased more than 1.5 times;
- efficiency of capital investments decreased more than 2.5 times;
- Commissioning of generating capacity decreased more than 5 times compared with the 60-80ies of the last century;
- Tariffs for electricity have grown significantly; they approached the U.S. and other countries tariffs, though the price of natural gas for power plants in Russia is significantly lower.
- Further increases of electric power prices is planned

In general it can be stated that the economic efficiency and rates of the power industry development significantly declined in Russia after the Soviet Union collapse. The main reasons of slowdown of economic efficiency of the power industry are:

- Lagging technologies used at gas and coal-fired power plants and electric power networks
- Worn out and outdated equipment use at power plants and networks (Table 1);
- The lack of optimal control system for the industry when numerous owners of power installations emerge;
- Drastic reduction of science and technology industry capacity;
- High dependence of the energy enterprises on imported modern technologies and equipment and, as a consequence, reduction of domestic power plant and electric machine industries potential.

- Decline of professional competencies of engineering staff due to inefficient human resource policy of power companies in the 90-ies of the last century;
- About two third of the Russian territory is out of the centralized power supply zone, which is the territory where the preferential (preferred) development of the mineral resources of the country through the use of new technologies is planned in accordance with the concept of sustainable development of Russia until 2020;
- Significant weakening of State mechanisms of legal and technological regulation and control of the current industrial and technological activities of energy companies, and the advanced comprehensive innovation and technological development.

All of the problems, as has already been pointed out, are the same in a number of positions as the main factors defining problem statement of fundamental changes in the energy industries of industrially developed countries. The obvious conclusion from the above is the need for urgent measures to change the current state of the industry and its development.

**Table 1 – Comparison of Technical Level of the Electric Power Industry of Russia and the World**[i]

| Data | Russia | | World level | |
|---|---|---|---|---|
| | Average | Advance | Average | Advance |
| EC TPP (gas), % | 38,5 | 51 – 52 | 44 – 45 | 58 – 60 |
| EC TPP (coal), % | 34,2 | 38 – 44 | 37 – 40 | 45 – 47 |
| Transmission Loses | 12,7 | - | 5,5 – 6,5 | - |

In Russia there has been a recent political stimulation of innovative activity, including in the power industry. In the policy exercise manner introduction of newest technologies begins, energy efficiency, renewable energy, and also the Smart Grid technology attract increasing attention, whose prospects of introduction in Russia have different assessments of the Russian and foreign experts.[ii]

In November 2009, the law "On Energy Saving and Energy Efficiency" came into force, to which was hoped to create incentives for the energy conservation and efficiency marked in the ES 2030. But experts have raised doubts about it; given its bureaucratic character and insufficiently elaborated mechanism of encouraging consumers to save energy (almost all its actions are coercive and cause unnecessary red tape).[iii]

In the area of technological development of the UES of Russia the Energy Strategy of Russia up to 2030 to the purpose of increasing reliability of electric power system provided the widespread introduction of flexible power transmission systems (FACTS devices), as well as improved systems of emergency protection and automatic supervisory control.

In the area of generation as one of the principles of perspective development the Energy Strategy 2030 stated maximum use of capacities of small-scale energy supply through:

- Construction of GTUs of low capacity (up to 30 MW) for the combined heat and power supply of own load districts, as well as transfer of a maximum possible number of gas boilers and RTS to the mode of operation as PSU-CHP and GTU-CHPP;
- Facilitating private investment into construction of small cogeneration power plants on local fuels, primarily in isolated systems;
- Construction of small hydropower stations using water resources in the Southern regions of Russia, especially the hydro potential of the rivers of the North Caucasus.[iv]

Recently a course was set for a decentralization of generation. Cogeneration capacity assessments were made arising from the replacement of boilers for the GTU-CHPP, and according to the generated data the potential capacity is about 175 GW, which is comparable to the total current installed capacity of power stations in Russia (219 GW). According to expert estimates, in the perspective the distributed generation could reach 20% of total electricity production.[v]

At the same time, the development of small-scale power generation faces a number of problems, including the problem of limited capacity of distribution networks.

There are all necessary prerequisites in Russia for the Smart Grid technologies implementation in to the national power industry, considering its condition and technological peculiarities: the analysis revealed presence of a wide range of scientific, technical and technological developments and developed areas, which constitute a basis for the Smart Grid technology concept. This primarily refers to the transmission network, anti-damage automatics, power companies' operation management, relay protection and WAMS.

At the same time, maintain records of status and functioning of the industry, as well as the goals and targets, which were set out in the framework of the Energy Strategy of Russia up to the year 2030, give reason to conclude that conceptual outlooks, principles and approaches to the implementation of this concept, adopted and developed in other developed countries, require adaptation, specification and development, taking into account national socio-economic priorities of structural and technological features of the status and development of energy industry and economy of Russia. Significant influence on the formation of the Smart Grid concept in Russia will provide evidence of a significant technological gap between domestic and foreign energy industry.

The Russian energy industry transition to a new path of development, that is associated with the implementation of the Smart Grid technology, requires serious analysis of technological aspects, as well as institutional, economic and legal issues of the development in this direction.

# 1. SMART GRID CONCEPT

***SGC #1: Less than Optimal Legislation and Regulation***

***SGC #2: Unpreparedness of the Grid for Disruptive Smart Grid Innovations***

***SGC #3: Weak Smart Grid Research and Development and Federal R&D policies***

***SGC #4: Weak Interactions between Science and Business***

***SGC #5: Lack of Federal Leadership in Smart Grid Development***

The factors determining the need for major changes in the Russian power industry and the factors influencing innovative breakthroughs based on the Smart Grid concept in industrialized countries are similar. The starting point for this conclusion is set out in the energy strategy for Russia for the period up to 2030, «The Main Goals and Objectives of Industry Development ».

The key attributes of the Smart Grid and its functional properties match the developmental needs of the Russian energy sector. However, there was a unified consensus among all Russian interviewees for this study that the country lacks a unified concept for energy development based on intellectual technologies for the entire industry.

In response to this challenge, the Federal Grid Company of United Energy System (FGC UES, which owns and operates the Russian transmission grids) initiated development of a comprehensive Concept for Intelligent Energy System (IES) with Active and Adaptive Network (AAN, Russian for "smart grid") in 2009. This Smart Grid Concept was seen as a *basis* for a unified vision, shared by stakeholders, directing innovation and development of the electric energy sector. Leading Russian scientific and innovation centers, engineering companies and universities participated in the development of the FGC concept paper. The first version of the Concept was approved in the fall of 2011 by the Joint Council for Science and Technology of the FGC UES and the Russian Academy of Sciences.

The Concept elaborated core values for further development of the power sector based on consumer needs, including a social focus with high public visibility. These values are included:

- Opportunity to make the most rational use of energy resources, including baseload and back-up capacity, electric connections, control systems and data channels needed to maintain balanced production and consumption of "everyone";
- Organizational and technological "survivability" (ability to stay functional) of electricity consumers supply in the event of local reliability accidents, and the prevention of cascading incidents through the use of self-healing network technology;

- "Orientation on Customer" – a customer-centered approach of the energy market and system functioning, coupled with social and environmental responsibility.

The IES AAN must ensure:

- Standardized high-tech flexible interfaces between the generator and the network, and between the network and the consumer;
- Efficient use of electric power at the expense of situational regulation of maximum load (including economic) consumers;
- Regulation of power exchanges between grids using AAN active control elements to balance generation, based on a new network topology;
- Adaptive and responsive real-time operations of the grid through a combination of centralized and local emergency controls in normal and emergency modes of operation;
- New information technologies and resources for real-time monitoring and control, ensuring rapid and lasting solutions;
- Improved market opportunities - by providing the infrastructure for a wide range of stakeholders in the electricity market.[vi]

**Smart Grid investments and Programs of Russian Stakeholders (general information)**

**FGC UES** actively invests in Smart Grid technology for transmission networks (FACTS, direct current transmission systems, superconducting transmission systems, etc.). Recently FGC UES also started work on a Smart Grid Pilot in the United Energy System of the East (UESE – one of the geographically largest subsystems of the UES), that would embrace all network elements: transmission, distribution, consumer (demand response, demand management). NIST-like reference standards architecture and models for current and future UESE energy system have been created in order to support this project, to find optimal solutions for grid and market organization, and to apply the best available technologies.

A second stakeholder that is actively engaged in the development and deployment of Smart Grid technology is **Holding IDGC**. Despite the fact that Holding IDGC lags in developing a *conceptual* framework for its activities, it focuses on Smart Metering projects, as well as on some automated and integrated solutions (city lighting, etc.). However, these activities currently only weakly correspond with FGC UES` developments and priorities. In 2012 the Russian Government made a decision to unite FGC UES and Holding IDGC under FGC control (the exact form is to be defined during late 2012), which promises to overcome this impediment.

**Generating companies** appear to have little interest in the development of Smart Grid technologies. The reasons for this are numerous, among them lack of resources, imperfectness of market instruments, lack of coordinated efforts and common vision, perceived risks of distributed generation development and others (see a more detailed overview in "Generation" Section).
Utilities and retail companies also do not invest in Smart Grid programs. The reasons are the same as for generators (see below in "Market", "Consumer" and other Sections)

The Concept itself and its Main Provisions (key principles without economic and financial parameters and calculations of IES AAN) were set up for revision and endorsement to all key industry actors. The Main Provisions has been agreed in 2012 by the System Operator of the Unified Power System (SO UPS) and was sent for revision and comments to other stakeholders.

The long endorsement process (only one important stakeholder endorsed the document as for December of 2012), passive role of Ministry of Energy in this process, and stakeholder`s willingness to support only key principles, rather then integrated vision, in turn, once again stressed the need for harmonization of stakeholders` and actors` positions.

To overcome these highly anticipated developments, some of the most import communications were made through the public-private partnership called the Technology Platform for Intellectual Energy System of Russia (a communication instrument, made after analogous European Technology Platforms). The most important stakeholders and organizations, that identified Smart Grid as a key innovation priority, were scheduled to participate in this dialogue. Among them were JSC "Inter-Regional Distribution Holding Company" (Holding IDGC, owns and operates distribution networks), JSC "RAO Energy System of East", JSC "INTER RAO UES" (generators), "Gazprom" and others.

During the interview process the following barriers to implementation of the Russian Smart Grid Concept were identified:

## SGC #1: Less than Optimal Legislation and Regulation

Although the existing legislation does not *preclude* directly deployment of Smart Grid technologies, the legal basis for changing the key principles that will guide development of the industry on the basis of the new Concept are missing. This is true for:

- basic industry documents, like Federal Law #35 "On electric power industry" and corrections to it;
- market laws and regulations (See also below in "Markets" Section);
- technical regulations – for example Norms and Rules for Building, so-called SNIPs (codes of construction and object placement rules, one of basic documents for power industry),
- Other special normative documentation (Federal Law #261 on Energy Efficiency, etc.).

This situation makes almost impossible or extremely difficult some Smart Grid initiatives, leaving them in normative vacuum (like in case of Demand Response) or impeding desirable trends of development (as in case of development of Renewables and Small Distributed generation in general), while changes in the system are hardened by inertia, lack of understanding and vision by authorities, unpredictable socio-economic effects and other reasons.

The situation is partly explained, partly aggravated by absence of proper economic and technical methodologies and assessments for specific technological solutions. This situation reduces the level of motivation of stakeholders to adopt Smart Grid technologies and hinder development of new federal regulations. As for 2012 neither industry, nor research and educational community was able to invest resources in development of such methodology, while authorities do not initiate the needed work.

### SGC #2: Unpreparedness of the Grid for Disruptive Smart Grid Innovations

Distribution networks in Russia are not developed and modernized enough to make implementation of the Smart Grid Concept feasible in the near future (See also “Grid Modernization” Section). Only a series of pilot projects, restricted in scope and depth, are realistic. This situation is explained technical degradation of the infrastructure – as a result of underinvestment in 1990-2000s - and need for urgent modernization, rather than in Smart Grid long-term projects, as well as by more problematic financial situation of distribution companies.

### SGC #3: Weak Smart Grid Research and Development and Federal R&D Policies

This problem is general for the entire Russian innovation system (See also “Grid Modernization” and “Education” Sections) problem. The level of academic and industry **scientific and technological expertise for now is insufficient** to support full-scale implementation of the Concept. This is explained by nearly 1 ½ decades of underfinancing of R&D in the networking complex, as well as in universities and academic R&D institutions. The following numbers are indicative: in 2008, before President D. Medvedev’s push for innovations policy, the amount of R&D spending for *all* publicly-owned energy companies was just RUR424 million (about USD13.7 million). Private companies have even smaller R&D budgets or, like FORTUM, do not invest in R&D in Russia at all.

What makes things worse, the domestic market of scientific and technological services is not competitive:

- There are not many Smart Grid R&D groups;
- Expertise and competences of current research groups are not always up-to-date;
- Market demand is insufficient to provide enough stimulus for evolvement of new R&D organizations or research groups;
- Federal innovation policies (also in part of *recommendations* for public companies R&D) do not support competition or a quality-based approach for R&D entities and are biased in favor of universities (despite the fact that universities are generally not the top R&D performers in Russia);
- There is no special Smart Grid granting or programmatic R&D funding on both federal and regional levels;
- Industry-wide *applied research* institutions, that originally played a role of interfaces between basic research and technology development sectors, are weakened in terms of R&D personnel and competences, knowledge on recent trends and connections with global science; etc.

In practical terms this results in situation, when R&D organization provide companies with low-level or outdated research, rater then technologies, while companies themselves lack ability to transform these research results in technological solutions.

## SGC #4: Weak Interactions between Science and Business

Interactions between the science sector and network and other energy companies is another troubling factor. For now due to insufficient market stimulus, excessive governmental influence and not always rational federal science and technology policies (e.g. its pro-public, not pro-business orientation), weakening or disappearance of Soviet-era interface organizations (special industry-wide applied research and technology institutions, etc.), lack of modern competences and knowledge on Smart Grid technologies and other factors the level of *effective* cooperation and interactions between science and business – both public and private – is unacceptably low.

From the statistical point of view R&D investments of state-controlled energy companies in universities and research organizations have raised dramatically - due to the President`s Dm. Medvedev targeted policy. But the effect of that processes is still minor, while the cooperation itself sometimes is much more formal, than business- or technology-led.

From an *institutional* point of view, there is also lack of technology incubators, technology transfer and training centers, as well as venture capital entities in energy complex.[vii]

New financial and institutional mechanisms are discussed with so-called Development Institutions (Russian Venture Company, Russian Fund for Technology Development, Rosnano, Skolkovo Foundation and other federal or federally-sponsored entities, financing innovations in Russia). But still there is a very limited ability and instruments for *practical and systemic* support of practice-oriented R&D and business-academia-university dialogue. In part this is also due to the pro-modernization, instead of pro-innovation focus of energy companies R&Ds.

## SGC # 5: Lack of Federal Leadership in Smart Grid Development

According to the majority of interviewees, the low-key role of the Government is one of the main obstacles to the formation and realization of Smart Grid concepts. The Federal role has been limited to *passive approval* of decisions agreed upon by the main stakeholders. What is lacking is the leadership role that combines the functions of a motivator, facilitator, and powerful sponsor similar to the role played by the governments in other countries.

## 2. MARKETS

*MT #1: Weak Market Policy of the Government and Administrative "Manual Control"*

*MT #2: Unpolished and Inefficient Capacity Market Rules, Favoring Big Generators*

*MT #3: Market Oligopoly Structure and Government Policy Supports Large generation and Depresses Competition*

*MT #4: Non-Transparent and Distorted Pricing Mechanism*

*MT #5: Regulators are not ready for Significant Changes in Current Market Rules and Regulatory Framework*

*Power Market Regulatory Framework MT #6: Retail Market Rules Impede Distributed Generation Deployment*

*Mt #7: Lack of Ancillary Service Market Regulations*

*MT #8: Fragmentation of the of the Power Market Regulatory Framework*

It would be no exaggeration to say that the Russian energy sector is experiencing one of the most important periods of its development. In 2010, the transition period of energy reform in Russia ended. Beginning on January 1, 2011 electricity is de-jure fully sold to consumers at unregulated prices[viii]. Currently, in the Russian Federation, a two-level market structure has been adopted (wholesale and retail) in the field of circulation of special commodities - electricity and capacity.

Despite the abovementioned reforms carried out in the period 1992-2008, the Russian energy market is still not perfect and lacks competition, transparency and other important features. This problem is of paramount importance since "smart" liberalization of the power industry, enforcing competition in electricity and capacity trade were stressed by interviewees as a strong driver for innovation in the Russian power sector in general, and specifically for new intelligent technologies.

### MT #1: Weak Market Policy of the Government and Administrative "Manual Control"

Inconsistent and ill-conceived Government policy for the development of the electric power market lead to the absence of real competition (see also below) which could substantially lower prices. As a result, the 2011 transition to a fully liberalized energy and capacity market, and the adoption of a RAB method, caused a jump in electricity prices in the first two months of the year by 17%, which far exceeded the forecasted parameters for 2011.

This situation triggered another fault government practices, aimed at politically-motivated controlling prices and inflation at a *socially acceptable* levels. In contradiction with a de-jure free-market principles, in 2011 the Government and Ministry of Energy interfered in the electricity pricing by administrative means (executing a so-called "manual control") to reduce both wholesale *market* electricity prices and regulated network tariffs. This caused a temporary drop in electricity prices by approximately 14% by July 2011. And this intervention was not a unique action – only in 2012 the Government and regulators twice *caped growth* of RAB-tariffs. And it would definitely repeat use of this "manual control" practices again in a situation of significant price growth or imbalances) – despite normatively it is stated that this practice would be finally ended in some near future.

This policy of artificially smoothing and lowering of marginal prices distorts normal operation of the market and negatively affects the making of informed investment decisions on Smart Grid implementation. It also reduces investor`s interest in Smart Grid solutions, since return of investments through tariff or market mechanisms is unclear, while negatively affecting Smart Grid-related investments of networking companies, which find themselves in a unpredictable financial situation.

## MT #2: Unpolished and Inefficient Capacity Market Rules, Favoring Big Generators

According to most of the interviewees, the Russian energy sector suffers from too much complexity and opacity of the existing rules and regulations of the wholesale market, and a lack of well-conceived market mechanisms. This "heaviness" is a serious obstacle to the modernization of the power sector and the introduction of new Smart Grid technologies, reducing the incentives for private investment and the use of modern technologies. The market models and market structures, and the underlying legal framework, require significant reform to support a functioning market. The wholesale market structure and rules were identified by several stakeholders as a significant impediment to distributed generation.

As interviewees mentioned, the wholesale market is characterized by a relatively high and fixed price for generation capacity, which is not economically viable and is not determined through fully competitive bidding. Some interviewees even mentioned that the large wholesale generators have their electricity bids partially “sponsored” through the capacity payments (despite this is not correct). Imperfect rules and regulations of capacity markets finalized in a very high price for capacity. This de-facto played in favor of large centralized generation, while not creating enough stimuli for smart (such as Demand Response) or small and distributed generation solutions. Only now government under pressure of pro-renewables community considers using capacity market mechanisms for *competitive* development of renewable (excluding large hydro) generation[ix].

During 2011 many attempts were made by market regulators to improve market rules but there is still no clear understanding of what direction should be chosen for the electricity market development. However, there are some informal signs of dismantling of current capacity market mechanisms for large power generation.

## MT #3: Market Oligopoly Structure and Government Policy Supports Large Generation and Depresses Competition

Today’s producer-oriented system of market relations has formed a situation, where large generators dominate the market. Specificity of the privatization process, asset consolidation through mergers and acquisitions (including geographical concentration of assets of generating companies) and monopolization of the fuel markets has caused degradation in the competitive markets to the point where wholesale generation is "neither market-based nor a regulated activity”. As a result, the *true* level of wholesale competition is estimated by the interviewees to be between 15-30% of production volumes, which is comparable to the generation control range.

Since big generators exercise their market power in an oligopoly, they conserve this "balance of power", which prevents the appearance of small distributed generation as an important market force, and simply not supporting some other important Smart Grid features, including intensive energy efficiency efforts and demand response.

On the other hand, the Government also favors the current situation. Market architecture, based on large generators, *seems* to support well its goals of preserving a "manageable" energy system, including market financial stability (8 years guaranteed return on investments, including the investor`s interest, etc.). On the contrary, distributed generation and demand response are not considered as "reliable" options and generally are viewed as a threat for United Energy System (UES) reliability and cross-subsidization (see a more detailed discussion in the "Generation" Section). The only exemptions are limited self-generation for smaller consumers that are unable to connect to the grid (including "isolated" – islanded – energy systems such as those in Siberian towns, etc.) and for those consumers that require a high level of reliability – such as hospitals.

And there is no sign of change. The government plans to further develop large generation. As one interviewee mentioned, there are Ministry of Energy plans to invest as much as RUR60 billion in new large generation facilities.

### MT #4: Non-Transparent and Distorted Pricing Mechanism

Direct Government interference in market pricing mechanisms, an inefficient capacity market that lacks true competitive capacity selection[x] are further aggravated by non-transparent and distorted pricing on both the wholesale and retail markets (see also "Cross-Subsidy" Section).

On the wholesale market the money is "redistributed" to power generating entities that remain under Government control – through price caps, *averaging* of prices on energy from different *types* of generation facilities, and other artificial wholesale market pricing mechanisms. The beneficiaries of this policy are nuclear and large hydro power plants, and so-called must-run generators – thermal power plants (TPPs) who are unable to successfully complete the capacity market admission procedures (competitive capacity selection). The other primary beneficiaries of this "redistribution" are the networks.

One of the stakeholders provided a good illustration of this distortion in pricing. TPPs constitute more than 65% of all installed capacity in Russia. But due to current market mechanisms, their part in the total *revenue* is slightly more than 45%, while their share in total *income* is only 25% - substantially less than three years ago.

These *artificial nonmarket pricing* practices have led to wholesale prices being among the lowest when compared to those in Europe (see fig.1 below).

On the other side of this pricing mechanism are network tariffs. Under the current market model, rates for the network services are strictly regulated by the Federal Tariff Service (FTS) through price limits set at the Federal level, and *are considered* to be high. The regional regulators determine local tariffs within limits, fixed by FTS. As *some* interviewees stated, these high network tariffs create a further price distortion, despite industry experts disagree with this point of view.

Final and most influential non-market pricing mechanism is cross-subsidization (see "Cross-Subsidy Section), that explains the fact that retail electricity prices for commercial and industrial (C&I) customers in Russian are disproportionally high - keeping in mind very low average wholesale prices (see fig. 1, 2). Since high prices for residential consumers are viewed by the Government as socially (and politically) unacceptable, a cross-subsidization between commercial and industrial and residential segments is used to sponsor the general population. The result is that residential prices are just 73% of C&I prices and *the lowest* in comparison with the USA and EU.

**Fig.1. Composition of the industrial prices in € per 1 kWh (2010)**

| | wholesale | network | total (incl.VAT) | % to 2009 |
|---|---|---|---|---|
| Russia | 0,0251 | 0,0292 | 0,0641 | 141,5 |
| EU states | 0,0668 | 0,028 | 0,1222 | 134,0 |

**Fig.2. Average Retail Price of Electricity to Ultimate Customers in € per 1 kWh (2010)**

| | residents | % to 2009 | PPP | % to 2009 | industry | % to 2009 | res./ind. rate, % |
|---|---|---|---|---|---|---|---|
| Russia | 0,0466 | 106,2 | 0,1232 | 106,7 | 0,0641 | 141,5 | 73% |
| EU states | 0,1593 | 97,1 | 0,1811 | 83,2 | 0,1222 | 134,0 | 130% |
| USA | 0,0877 | 110,1 | 0,0877 | 110,1 | 0,0521 | 106,1 | 168% |

From the point of view of this study, "redistribution" of funds to government-owned generators and networks, network tariffs and cross-subsidization are depriving the ability and the incentives to make efficient Smart Grid investment decisions and make Smart Grid cost/benefit analyses difficult.

## Mt #5: Regulators are not ready for Significant Changes in Current Market Rules and Regulatory Framework

Regulators are strongly suspicious and uncertain about significant changes in the current market rules and regulatory framework, even if it could result in driving forward the development of Smart Grid technologies.

There are several reasons for such approach. First of all, current market mechanisms and regulations *seem* to "work well", providing an acceptable level of power system functionality, reliability and maintaining social stability, while guaranteeing the interests of the markets biggest actors. Secondly, as some experts mentioned in private conversations, stakeholders are afraid of significant changes since the risks of its implementation are huge, whereas final results and cost-benefit ratios are unclear. Finally, some decision-makers are simply not aware of alternative solutions due to their lack of expertise and lack of communication with the scientific and expert community.

But, whatever the reason, no *noticeable* motivations and incentives are shown by the Government bodies for true large-scale market and regulatory reforms that could support intellectualization of the Russian energy sector.

## MT #6: Retail Market Rules Impede Distributed Generation Deployment

Currently, retail market rules minimize opportunities for the consumer to choose whether to stay connected to the distribution network, join the micro-grid, or develop their own generation, limiting its installed capacity to 25 MW. Generators exceeding 25 MW are obliged to sell all of their energy into the wholesale market and to then re-purchase it at the market price, which is considered by some interviewees to be *inconvenient and inappropriate*. Therefore, small self-generators are either not eager to enter the wholesale market, or seek to escape from it by splitting their generating capacities into portions of less than 25 MW.

In addition, according to the existing retail market rules, distributed self-generators cannot sell excess energy into the grid, thus eliminating a substantial portion of potential distributed generation benefits (See also the"Generation" and"Energy Efficiency" sections). As a result, there are cases when a Chief Power Engineer, having surplus capacity, may prefer to sell it *directly* to neighbouring consumers such as vendor *kiosks* (very small shops) instead of reselling these surpluses to the grid.

These rules are a significant deterrent to the introduction of innovative technologies and should be modified to create competition among wholesale generation and local generating resources; provide gradual involvement of consumers into the decision-making process; capitalize on distributed capacity reserves; and reap the full benefits of distributed generation.

## Mt #7: Lack of Ancillary Service Market Regulations

A significant obstacle to Smart Grid investments on both the consumer and network levels is the lack of ancillary services markets (which de-jure were created after the reforms). As was repeatedly emphasized by interview participants, the reason is the lack of legal and tariff incentives and mechanisms to involve the consumer in the energy market. This also relates to allowing consumers to make "smart decisions" aimed at reducing energy consumption, as well as using prosumer`s[xi] distributed generation facilities for providing grid stability and reliability, supplying energy during peak hours, etc.

An important measure to support the interests of residential consumers was the adoption on April 1, 2012 of *Governmental Regulation #877* which aims to improve relations between retail market participants. Despite some weak points, it allows elimination of unjustified incomes of guaranteed suppliers, reduction of electricity prices (tariffs) for all consumer groups and the gaining of maximum benefit from implementation of energy efficiency measures on the demand side through adoption of smart grid technologies.

Another important decision of the Government, aimed at turning the market towards the consumer, was the adoption of new retail electricity market rules, signed on May 04, 2012**.** These rules allow consumers to optimize their load curve, remove limitations in the volumes of electric power purchased from the wholesale market, as well as compensation to guaranteed suppliers for sales allowances when changing the seller. The document opens the opportunity to increased competition in the industry, market liberalization, removing barriers for the consumers entering the wholesale market and, thus, is a driver promoting implementation of intelligent technologies.

### MT #8 Fragmentation of the Power Market Regulatory Framework

Among organizational problems, aggravating market barriers to the introduction of the smart grid is a strong fragmentation of the market infrastructure**.** A formal *liberalization* – while de-facto *fragmentation* – logic prevails over technological and even economic reasons. According to interviewees, after the liquidation of RAO UES the market has been "filled" with too many regulators that make decisions based on their vision of the situation. This situation often leads to conflicting decisions, while private *special* interests are said to be left behind. The absence of a single "responsibility" regulating center (or *highly coordinated* centers) in the energy industry legal environment impedes organization of smart grid deployment in the Russian power sector.

One step towards a solution to these problems was a Governmental decision in May, 2012 to transfer the Interregional Distribution Companies (MRSKs) under Federal Grid Company of United Energy System (FGC UES, transmission grids) control. And despite in final November 2012 rule the President decided to transfer all governmental stocks in FGC UES (79,55% of all FGC stocks) to a new company, created on the basis of MRSK Holding – JSC "Russian grids" – this doesn`t change the logic.

The same could be said about 2012 vice-premier for energy Alexander Dvorkovich initiatives to coordinate better energy industry development.

Though it is not clear now what would be the best solution to solving infrastructural problems, 2012 governmental decisions evidences positive changes in the mentality of authorities. This process should result in more efficient modern regulatory policies with a greater degree of coordination.

## 3. EFFICIENCY

***EE#1: Policy Makers Concerns about Distributed Generation Harms Generation Efficiency***
***EE #2: Inability of Prosumers to Sell Excess Energy to the Grid***

***EE #3: Grid`s Equipment is Physically and Technologically Outdated, Networks are Poorly Maintained***

***EE #4: Insufficient Investment Resources for Monitoring and Accounting Systems and Inadequate Cost-Benefit Analysis***

***EE #5: Absence of Proper Data and Data Management Methodology***

***EE #6: Insufficiently Developed Regulations and Rules for Implementation of Existing Laws and Norms***

***EE #7: Smart Metering Regulation Gaps***

***EE #8: Illiteracy, Proper Information and Expert Support for Decision-making on Energy Conservation Solutions***

***EE #9: Undeveloped market of Energy Efficiency Services***

***EE #10: Lack of Qualified Personnel, Methodology and Training of Decision Makers on the End-Use Side***

***EE #11: Problems in Getting Access to Credit Capital for Energy Efficiency Projects***

***EE# 12: Current Regulations do not Incentivize Consumers to Increase their Load Density***

***EE#13: Lack of Policy Coordination***

Energy efficiency is one the most important outcomes of an intelligent energy system, which is enabled by new technologies, supporting policy and regulatory environment. Smart Grid enabled energy efficiency will extend through all energy subsectors:

- generation – where decentralized distributed generation can complement more efficient large power plants;
- transmission and distribution networks – by lowering physical losses and optimizing transmission regimes;
- end-use - where energy consumption would be reduced and managed (through pricing signals and other market and regulatory incentives) – which will also lead to systemic effects for the overall energy system.

The significance of energy efficiency for Smart Grid policies in
Russia is exemplified by huge energy intensity (a common index measuring energy consumption per unit of gross domestic product) of the national economy, which is 2.5 times greater than the global average. According to expert estimates the housing sector consumes nearly twice as much energy in the form of heat and hot water as European countries with similar climates, and more than twice as much electricity. While energy intensity has dropped in several industrial sectors, it remains stubbornly high and has even increased in others. The Russian Ministry of Energy[xii] estimates that energy losses due to ineffective end-use are about 35%. Secondly, the old age of thermal power generation facilities and equipment (see also Section "Generation") results in low average efficiency estimated to be 26%, well below the international average of 41%. Finally, losses due to the aging electicity transmission and distibution networks are also sizable and are reported to be 11% nationally, and up to 30-40% in some regions.

It is estimated that more than 40% of primary energy resource consumption in the country may be conserved – an amount equivalent to 420 million tons of fuel equivament (by other independent estimates – about 370 million tons of standard fuel) (see table 1).

**Table 1. Energy Conservation Potential by Sectors**

| | **Energy conservation potential** (million tonnes of standard fuel) | **Share of present consumption** |
|---|---|---|
| Industry | 119 | 55% |
| Electric power sector | 88 | 43% |
| Residential | 76 | 55% |
| Transportation | 54 | 28% |
| Heating systems | 36 | 13% |

In order to solve this problem the Russian Government set a *target* of reducing energy intensity by 40% by 2020 (in comparison to 2007 levels). The 2009 Federal Law #261 on Energy Conservation and Energy Efficiency provides the legal and regulatory framework and a set of economic incentives to support needed activities. Also, a new 10-year national (State) program on energy conservation was approved by the Government with total investments of RUR 9,532 trillion[xiii] (about $318 billion USD). The goal of the program is to reduce energy intensity by 13.5% by 2020 (i.e. well below the *normative* target, set in Federal Law #261).

Though Russia clearly stands to benefit from improved energy efficency in every stage of the energy sector value chain, there remain many disincentives for the deployment of Smart Grid technologies that will enable it to do so. As in most countries, few of these impediments are technology related. Rather, they result from a complex mix of current wholesale and retail market rules and regulations, tariff policies and methodologies, and cross subsidies that co-exist in the Russian energy sector.

The following discusses key impediments to Smart Grid enabled efficiency improvements in generation, networks and end-use that were identified by stakeholders interviewed by the joint Russian-American team.

## GENERATION

### EE #1: Policy Makers Concerns about Distributed Generation Harms Generation Efficiency

A recurring theme introduced by the smart grid stakeholders interviewed for this project was the potential for distributed generation to improve the efficiency profile of the Russian generation fleet.
Stakeholders enumerated the potential benefits of distributed generation – including combined heat and power units (CHP) – as follows.

- Thermal efficiencies of modern CHP's reach 80% and make them economical to operate at a wide range of industrial, commercial and government facilities.

- The investment costs for CHP distributed generation units are relatively small, providing a quick return on investment.
- They provide the host facility with the ability to rapidly modulate its energy consumption from the grid in response to planned and forced outages or pricing signals.
- And, stakeholders discussed numerous benefits of distributed generation to the transmission and distribution networks.

Several policy impediments to greater use of distributed generation were identified during the interview process. Among them were concerns of regulators and transmission grid officials that its proliferation would affect the reliability of UES and it`s social functions – cross-subsidization (see the ”Generation” and ”Cross-Subsidy” Sections for a detailed description). This position affects greatly both strategic and operational decision-making on federal level, affecting discussions on distributed generation issues as energy efficiency measure.

It is not surprsing then, that the 2009 Frederal Law on Energy Efficiency and Conservation has no provisions on tax or other fiscal incentives to promote distributed generation, including CHP - as there are for other energy efficiency investments.

### EE #2: Inability of Prosumers to Sell Excess Energy to the Grid

A serious obstacle to energy efficiency and more intelligent methods of power control is the inability of self-generators to sell "official" surplus energy to the grid (see also ”Market” and ”Generation” Sections). Being unable to legally benefit from optimal load control, self-generators are deprived of efficiency incentives to reduce energy consumption, and use demand response mechanisms, and, as a result, do not see improving energy efficiency worth doing. By some estimates (see also later in the text) only in Moscow up to 150 MW could be freed up if needed market instrument would exist – thus pointing out that for now energy from these sources are used in not optimal way.

## TRANSMISSION AND DISTRIBUTION

### EE #3: Grid`s Equipment is Physically and Technologically Outdated, Networks are Poorly Maintained

The intellectualization need of the Power Network is particularly relevant. About 2/3 of the power equipment is physically worn out due to insufficient investments over the last 20 years. Together with shortage of high-qualified industrial professionals – especially those with important competences and knowledge about cutting-edge technologies – this situation forms strong impediments to both investments and installations of the most *efficient* modern equipment (See also “Grid Modernization” Section) and optimization of grid operations. In turn, high losses in electric networks and poor network maintenance are negatively affecting the financial stability of utilities, reducing their ability and desire to invest in complex modern solutions – instead of simple, but highly needed actions.

It should be mentioned that this situation may appear as a *driver* for smart grid efficiency development – *if* an ambitious strategy and program for grid renovation would be adopted with sufficient resources (See also “Grid Modernization” Section).

## EE #4: Insufficient Investment Resources for Monitoring and Accounting Systems and Inadequate Cost-Benefit Analysis

Interviewees stated that the reduction of network losses could be one of the primary rationales for Smart Grid technology, creating a need for extensive monitoring systems– especially on the distribution level.

This issue is also of utter importance, since some stakeholders hope to use grid monitoring systems (together with methodology) as a means to lower reserve requirements, imposed by the System Operator (SO). For now the SO requirements are mostly technically driven, causing huge capital investments by all actors. The hope is that visibility – and predictability – of the grid would help to promote a more *economically-driven* approach to the reliability issue.

Actual developments differ greatly. FGC UES, a financially stable company which owns only a minor fraction of all grids, has a special successfull Program for Rising Visibility and Reliability (so-called PPNIN) for depolyment of monitoring systems on substations, as well as other inititatives for grid monitoring. A multimillion effort, PNIN started in 2006 and as for 2012 was close to completion. Distribution networks and utilities were less successful since they lack resources for a full-scale visibility program. Huge investments are needed, since Russian distribution networks are extended and are not properly monitored.

A special Federal program or cost-sharing with networking companies is needed in order to solve this problem.

## EE #5: Absence of Proper Data and Data Management Methodology

A parallel issue cited repetitively by the interviewees– is that one of the primary impediments to improving network operations quality and functionality is the need for reliable and adequate data and methodologies for calculating losses and safety regulation in power networks. Lack of it – as well as associated regulations - prevents growth of investment in the most advanced technical solutions and technologies for network development (including AMI and Demand Response systems). Experts mentioned that the use of a proper methodological approach to monitoring and metering the quantity and quality of electricity supplied at the metering points on the borderline between generating and network facilities, as well as between network facilities and consumers could lower losses by 20%.

### END USE

According to expert estimates, nearly a quarter of the total energy saving potential comes from the housing and public utilities sector, which has a greater portion (64%) related to end-use heating caused by extremely inefficient technologies and equipment, and results in significant losses in heat supply. Energy consumption in this system can be reduced by 52% which opens *some* prospects for Smart Grid technologies.

But this goal requires more active involvement of consumers in modern energy saving technologies and appliances such as AMI, software solutions and other intelligent monitoring and accounting systems. In parallel with rising energy effcicency, modern IT-applications, used for end-use purposes, are the first step towards establishing end-to-end cooperation among all energy efficiency actors - generators, energy and retail companies, and consumers, which could result in increased "transparency" of services, reduction of overloading of thermal and electrical networks, optimal loads, and safe energy supply.

## EE #6: Insufficiently Developed Regulations and Rules for Implementation of Existing Laws and Norms

Despite support for energy efficiency from the Office of the President and Russian Government in the form of enabling legislation[xiv] and the State program for energy efficiency[xv], one of the biggest impediments for energy efficiency policy in Russia is insufficiently developed rules and guidance for *implementation* of the existing laws and regulations.

In particular, provisions of the Federal Law #261 established energy service performance contracts (ESPCs). However, currently, mechanisms for internal pricing, record keeping and rules for sharing economic benefits are not developed and included in the provisions of power services between the service provider and the customer. At the same time, this is one of the key questions concerning the practical use of energy conservation in the Russian economy. The absence of reliable standards for conducting energy savings performance contracts makes it more risky for the customer, as well as, for the service provider.

The same could be said about the methodology and approaches to energy efficiency. By expert estimates, the use of some of the energy efficient or energy conservation technologies are often only delivering minor effects – especially in heat and ventilation solutions. The reason is a non-systemic approach to energy conservation. For example, energy-conserving windows could be placed in apartments or houses, which are itself were built without regards to heat conservation; or an efficient heating system is installed in the house – while huge heat loses occur in the hot water transportation system. The same “non-systemic” approach (but in fewer cases) is seen in electric power conservation solutions.

## EE #7: Smart Metering Regulation Gaps

Stakeholders specifically expressed concern about poorly elaborated regulations for ownership of information, data transparency and accessibility of monitoring equipment (including that of consumers) as an important factor in the process of reducing technical losses in transmission and distribution (See more detailed in the “Data and Analytics” Section).

## EE #8: Illiteracy, Proper Information and Expert Support for Decision-making on Energy Conservation Solutions

There is a lack of literacy and awareness among consumers about the rules and requirements for energy efficiency set by the law and other legal documents, and of the need to increase their role in improving efficiency. And there are neither incentives, nor recognized benefits from introducing the Smart Grid technology that would enable energy efficiency on the customer side. This is illustrated by the fact, that many ocnsumers are still very suspicions about new practices, considering them as a way to force customers to pay unmotiveted high prices.

Information support for energy efficiency is also far from perfect. In the case of households - people are not able to get qualified informational assistance regarding energy conservation in their units, on their household appliances, etc. Even if entrepreneurs have a common vision regarding the existence of potential savings due to energy efficient behavior, the expenses involved in searching and selecting optimal technological production processes may be too high to decide in favor of energy efficiency projects.

However one industry official mentioned that in general private businesses have a much more pragmatic and *effective* approach to energy efficiency, while restrictions appears because of lack of qualified services on the market. For example, it is true for specialized energy consulting and audit, since only a relatively small number of companies deliver really up-to-date solutions (see below).

### EE #9: Undeveloped Market of Energy Efficiency Services

Current market for energy efficiency services is estimated by stakeholders to be about RUR60 billion (as for 2011) or $2 bln. But as some experts and industry officials' estimates, this is only 10% or so of gross *potential* demand for such services. Further development of the market and implementation of cutting-edge technologies and solutions is impeded by lack of competences among service providers, resulting in lower technology *culture* and unsystemic approaches. Industry experts estimates that as much as 50% of energy efficiency companies have both technologically and technically unoptimal, semi-amateurish solutions, while only top-20 (or even less) market actors delivers really complex, advanced and systemic ones.

This situation has different reasons: relatively young age of the industry itself; low culture of some commercial and industrial end-users; lack of proper information (see also above), etc. One stakeholder also told, that a high number of state-owned enterprises also is another major factor impeding development of energy efficiency market. In his opinion this type of enterprises is less interested in really complex and effective solutions – since making profits for them is not an issue of economizing or optimization, but rather federal contracting.

### EE #10: Lack of Qualified Personnel, Methodology and Training of Decision Makers on the End-Use Side

Some interviewees highlighted the lack of qualified personnel on energy efficiency for C&I customers – including that for investment planning. This reduces the potential for both decision-making and practical realization of associated actions.

In order to solve this problem higher level education and planning standards are needed, as well as regulatory requirements on the government side and continuity of federal energy efficiency policies. Only time and supporting efforts (for example, engaging investment decision-makers in real energy efficiency projects) could provide conditions for creation of new professional class.

### EE #11: Problems in Getting Access to Credit Capital for Energy Efficiency Projects

he employees of Russian banks do not have sufficient knowledge of the possibilities of energy efficiency improvements and the specifics of funding such projects and are often unable to competently communicate with clients on this subject, and also face difficulties in evaluating projects. As a result, the risks of energy efficiency projects are overestimated

### EE# 12: Current Regulations do not Incentivize Consumers to Increase their Load Density

Government decision No. 877, taken in April 2012 is aimed at improving relations between suppliers and consumers. Despite some strong points, it has cancelled differentiation in installed capacity utilization hours, which eliminates the incentives for consumers to increase their load density and causes greater risks for supply companies to not sell all the power they buy on the wholesale market at the peak of consumption.

### EE#13: Lack of Policy Coordination

Some experts mentioned that a lack of coordination – or a single decision-making center – for Smart Grid and power industry decision-making is still another impediment for the realization of proper strategy, rules and regulations for energy efficiency. There is a lack of coordination of the various areas of legislation: urban development doesn't relate to power supply system development; legislation on Government procurements doesn't contain requirements for energy efficiency, etc.[xvi]

Work on removing the above listed impediments is constantly conducted in Russia with varying degrees of success. It's important to keep in mind that all described problems are interrelated. On one hand this gives a positive effect, because achieved progress in elimination of one of the impediments will influence the others. On the other hand, though, solutions to the problem require using a complex approach, in which it's important to be clearly aware of the components of the whole problem, their interconnections and the nature of their mutual influence.

# 4. CROSS-SUBSIDY

*CS #1: Subsidizing Residential Consumers at the Expense of C&I Consumers*

*CS #2: Pot-Mixture Tariffs Destimulate Investments and Use of New Technologies*

*CS #3: Cross-Subsidizing of Electric and Heat Energy at CHP*

*CS #4: Maintaining Reserves of Unused Generation and Network Capacities*

*CS #5: Populism and Short-Term Approaches of Regulators*

*CS #6: Absence of Powerful Sponsors for Changes*

*CS #7: Absence of a Clear Implementation Plan for Eliminating Cross-Subsidies*

The absence of market conditions coupled with weak tariff policy and the low income level of most Russian citizens has created a destabilizing set of explicit and hidden cross-subsidies in the energy sector. Cross-subsidization is a type of price discrimination and income redistribution, and results in setting prices for certain players above the level of marginal costs in order to set prices below the marginal costs for others.

Cross-subsidization is a serious and long standing problem of the Russian energy sector, resulting from the diverse mix of technical, economic, social and political factors.

During the interviews, a traditionally high volume of cross-subsidization in Russia was stressed as one of the central obstacles to Smart Grid technology deployment. Interviewed experts and stakeholders estimated the volume of cross-subsidization in the national energy sector to be at the level of ca. RUR180-200 billion (ca. 10% of the total industry revenue) with an annual consumer's bill for electricity being appr. RUR 1.8 Trillion. The biggest subsidies go to the residential sector – ca. RUR40 billion per year. These huge financial expenses are generally imposed on small and medium businesses, which are unable to provide self-generation or get special price conditions from energy and T&D companies.

Cross-subsidies take several forms – at the level of industrial/commercial/residential consumers, geographical, and within industry (small business pays proportionally more than medium-sized and large, etc.). The following are the main types of existing cross-subsidies in the energy sector:

- Subsidies to the residential consumers at the expense of commercial and industrial (C&I) consumers.
- Subsidizing electricity production at the expense of heat production at CHP facilities.
- Subsidy for consumers of electrical energy by the consumers of heat from CHP facilities.
- Subsidizing a provision of the reserve electrical capacity at the expense of the electricity cost.
- Subsidizing the cost of maintaining the heat capacity and heat reserve at the expense of the costs of heat/

Below is a discussion of a number of drivers and impediments related to cross-subsidies and its influence on Smart Grid Deployment in Russia:

### CS #1: Subsidizing Residential Consumers at the Expense of C&I Consumers

Subsidizing of the residential sector at the expense of commercial and industrial consumers is aimed at keeping electricity tariffs at a socially acceptable level. It is both explicit (the formation of the tariffs) and implicit (limited and over-limit natural gas prices).

Despite the obvious *social* benefits, this practice significantly increases the financial burden of C&I consumers, especially small businesses, and according to some interviewees negatively affects the competitiveness of Russian businesses, export potential, and growth in GDP.

The most important effect of cross-subsidization is that it discourages Smart Grid – including energy efficiency - investments on the demand side since the end user, in general, is *less financially incentivized* to do so. This effect is even stronger since residential consumers generally *view* energy costs as being *irrationally high*, even if they are currently underpaying their true value. And the Government is still concerned about supporting vulnerable populations – e.g. through the so-called "social consumption rate".

The problem is further aggravated by the fact that suffering C&I consumers are often not part of the market – so they have no legal opportunity to affect their prices. This also confirms the opinion of the interviewees that legislative support of consumer involvement in the decision-making process is one of the most important challenges facing the development and implementation of Smart Grid technologies in Russia.

### CS #2: Pot-Mixture Tariffs Destimulate Investments and Use of New Technologies

Wide adoption of "pot-mixture" tariffs (tariff calculations based on *averaged* prices of generated energy) in the Russian power industry, as a whole, imposes significant restrictions on the process of making investment decisions on new energy technologies. Such tariff calculation method do not accurately reflect the technology costs for the production and distribution of electricity and heat from the CHP and boiler rooms, as well as fuel costs for their production. As a result it is often more beneficial to pay an average "pot-mixture" tariff for electric heating and a small compensation for the loss in technological power lines, rather than to build modern fuel-efficient CHP or to implement energy efficient technologies (including heat pumps, solar water heating installation, etc.). The reason is that, despite the substantial economy in primary fuels, a payback for these technologies could be approximately 10 years due to the lack of a ROI mechanism for heating. In this situation some “smart” and potentially very useful solutions in heat and power facilities also become senseless, since averaged pot-mixture tariffs make ROI unpredictable.

Undifferentiated prices also do not create proper price signals for consumers, thus not forcing them to lower their energy intensity and making investments in Smart Grid and energy efficiency technologies unprofitable.

### CS #3: Subsidizing Electric Energy Production at the Expense of Heat Production at CHP

A common hidden subsidy is applied to CHP, which is currently one of the most challenging issues facing the industry.

A so-called "physical method" of calculating electricity and heat production costs has been used in Russia for years. It is based on re-allocation of a certain part of the fuel costs from the electricity to the heat. Historically, this originated from Soviet times, when this practice was considered acceptable due to the low income of the general population and was even mistakenly [xvii] believed to be scientifically sound. Despite originally "physical method" was intended to make the electricity cheaper, in reality, it only led to higher fuel consumption per unit of heat produced. The size of subsidizing electric energy production at the expense of heat is estimated to be as much as 30% of the fuel cost and overheads that are allocated in proportion to the fuel referred to the electrical energy.

Another subsidy for *consumers* of electrical energy by the consumers of heat from CHP is hidden and the least known type of subsidy. Popular belief contends that thermal energy production from CHP is unprofitable when compared to the production of electrical energy and that the State must subsidize the production of heat from the CHP. However, some studies suggest that from a quarter to a half of fuel spent on heat production at a CHP facility goes to electricity generation for consumers not using heat from that CHP. Heat energy produced by a CHP at a temperature of $40^0$C is often a "complementary product" of the electricity production since it doesn't contain a fuel factor and properly speaking should be free. However, the distribution companies (network companies) charge for heat supply to reduce electricity prices and decrease circuit losses. This makes prices for electricity from CHPs much cheaper.

Conservation of the abovementioned subsidies do not create favorable conditions for reducing energy intensity and improving efficiency of electric power and heat production, adoption of new generation and intelligent technologies as well as energy efficiency practices on consumer side.

### CS #4: Maintaining Reserves of Unused Generation and Network Capacities

Maintaining unused generating capacity reserves, including long-term (over 2 years) reserve capacity, is a heavy financial burden that may be borne by either a consumer who pays the cost of providing long-term capacity reserve, or the owner, who possesses huge reserves of power and has no real prospects for growth in demand for them.

For example, there were situations where a consumer with its own generation is also connected to the network to ensure emergency power supply, if necessary. In this case, other consumers connected to the network will need to subsidize these capacity reserves ensuring the necessary level of reserve and reliability.

Subsidizing a provision of the reserve electrical capacity at the expense of the electricity transmission cost is a common form of cross-subsidization of system reliability and secure electricity supply. Variable costs of the network company caused by idle losses and heating are insignificant and do not exceed 20-25% of generation (expert estimates). However, the basic costs of the network company are fixed capacity costs to maintain different kinds of technological reserves: super balance hot and seasonal reserve capacity, off-peak intrabalance capacity to win the summer off-peak consumers, declared (claimed) reserve capacity of the future periods, long-term reserves etc. Determining the amount of such reserves is a quite difficult task which requires a specific methodological approach. In order to simplify these calculations, the charges for provision of these services to ensure system reliability and security of supply are laid in the cost of service of the network companies, System operator and Commercial operator as a premium charge to the cost of transmission of electricity and power.

Consumer facing these extra costs might not be eager to bear them. In that case a network owner would need to cover them, which will inevitably stimulate him including all costs to maintain capacity reserve into electricity transmission cost. This, in turn, will lead to kind of concealment of these costs and lack of incentives to their identification, evaluation and consistent decline.

Subsidizing a provision of the reserve heat capacity at the expense of the heat production is another common form of cross-subsidization caused by the lack of a methodical approach to determine the costs of heat reserve required to ensure reliability and security of the heat supply. The costs to support reliability of the heat supply are nearly the highest, varying within 30-150% of the cost to maintain capacity, and the least evaluated. Lack of a proper methodology to classify and evaluate the costs to maintain heat reserve capacity leads to large distortions in the real cost of thermal power and heat, caused by exemption of the costs to ensure reliability of heat supply from, or their transfer to, other cost items using administrative intervention. These real cost distortions lead to more inelasticity in tariffs, and to the “pot-mixture” mechanism of their evaluation which makes Smart Grid cost/benefit studies difficult.

The key problem here is the lack of methodology and regulation for proper heat reserve calculations, while no real and powerful actions are taken by regulators and industry to change this situation. Consumers facing these extra costs might not be eager to bear them. In that case, a network owner would need to cover them, which will inevitably stimulate him to include all of the costs to maintain capacity reserves into the electricity transmission cost. This, in turn, will lead to a kind of concealment of these costs and lack of incentives to their identification, evaluation and consistent decline.

The abovementioned issues, caused by gaps in the regulation and methodology**,** further distorts both investment decision-making and customer`s willingness to deploy Smart Grid solutions.

## CS #5: Populism and Short-term Approaches of Regulators

The authorities always sought to avoid cross-subsidies - there were times when it even tended to decline, and the growth rate of residential prices outpaced that of industries, being twice higher in absolute value. The power industry is an actor that is perhaps most interested in eliminating cross-subsidization, that is preventing the completion of the electricity reforms through distortions on the wholesale competitive market, regulated retail market, price distortions, and the transition of large consumers toward self-generation that creates a headache to the Ministry etc. However, the last few years were characterized by a sizeable increase in volumes of cross-subsidies with the Government protecting the population from rising tariffs (despite simultaneously burdening businesses and holding back its development).

The reason for this is due to a more populist approach of the authorities: instead of developing policies for creating long-term economic growth and stimulating business activities (also as a means to solve social problems) the stake is on protecting social stability, even if it harms the economy.

## CS #6: Absence of Powerful Sponsor for Changes

Today, inconsistent policies on cross-subsidization make many stakeholders quite satisfied with it. Large generators are interested in pot-mixture tariffs; regional leaders escape from making controversial "unsocial" decisions by supporting single flat tariffs and cross-subsidization; regional regulators get an opportunity to reallocate funds raised from the cross-subsidization at their sole discretion; and the federal Government still accents social stability. So, there is no sense for these stakeholders to change practices which may cause prices to rise, but would result in long-term perspective in deployment of Smart Grid technologies and multiple economic and societal benefits. Considering this, a move from cross-subsidies toward new transparent accounting technologies and price calculations through implementation of AMI, demand side management and other Smart Grid technologies is expected to meet a hidden or explicit resistance from these stakeholders.

Imperfect market rules are also a rationale for preserving cross-subsidization. In the situation of true competition "free" (i.e. after elimination of cross-subsidies) retail prices would not rise significantly, or would even possibly decrease – but in an oligopolistic market this is not the case. But, again, there are no powerful stakeholders that are interested in radically changing the situation.

## CS #7" Absence of a Clear Implementation Plan for Eliminating Cross-Subsidies

The latest Governmental long-term development prognosis for 2030 provides for the elimination of cross subsidies by 2020 when the rates for the population would exceed those for industrial consumers. However, this elimination which is quite normal in western nations does not explain how it would be put into practice in Russia and seems to be questionable. As for 2012, no *detailed* study, modeling or planning process was initiated by regulators.

# 5. GENERATION

According to the officials involved in the formation and regulation of power sector policy development, the scope of intelligent network implementation should cover all stages of the path from generation to the consumer as an integrated system. Since "smartening" of large generation remains a challenge, in this chapter we concentrate on *Distributed Generation*, which is considered to be the basis for a "smart" energy system.

The development of distributed generation (incl. micro-grids and CHP) is an essential component of the Smart Grid, supporting the principles of wide involvement of active consumers into the demand response process, energy efficiency and renewable generation. Among praised benefits of the distributed generation are

- Demand-side self-generation also provides emergency reserves to improve the quality and reliability of power supply and reduces the load on the main network under normal operation. The development of small distributed energy facilities has a strong potential for improving the reliability of the UES due to the large number of distributed generators that can be grouped into virtual power plants by Smart Grid technologies and provide capacity reserves.

- Small generating units provide high maneuverability (with a load-off/load-on range of up to 100%), which enables them to smooth out the peaks and half-peaks of power consumption and provide efficient Demand Response to address planned or forced outages and price deviations. Flexible integration into the network and energy market enhances the role of the consumer in managing the power system that enables them to choose the source of power supply under a substantial increase in tariffs.

- With the optimal use of electric power and heat and with modern equipment the fuel efficiency in modern cogeneration plants reaches up to 80-90%, resulting in a reduction in the cost of both electricity and heat. The location of power generation sources close to consumption nodes allows avoiding large transmission losses and makes possible the use of local fuels and renewable energy sources.

- Modular design of small generation units reduces construction period and costs, resulting in a relatively short payback period (2-to 5 years) and quick ROI for the investor. It also provides less operational expenditures and makes it easier to make

***GEN #1: Regulators, Policymakers and FGC UES Concerns that Distributed Generation Development would Cause Atrophy in the UES and its Social Functions***

***GEN # 2: Absence of Direct Governmental Support for Distributed Generation***

***GEN #3: Federal Long-Term Planning Process is Biased toward Large Centralized Generation***

***GEN #4: Inadequate Attention to Economics of Power Generation and Substituting Solutions***

***GEN #5: Restrictions for Fuel Supply for Distributed Generation***

***GEN #6: Grid Architecture does not Allow for a Two-Way Flow of Electricity***

***GEN#7: Inability of Prosumers to Sell Excess Energy to the Grid***

***GEN #8: Grids are Prohibited to Have Own Generation Capacities***

***GEN #9: Absence of Proper Data and Methodology Defers Replacement of Inefficient Generation***

***GN # 10: Lack of Proper Energy Efficiency Methodology on the Generator Side***

technical upgrades, as well as to comply with more stringent environmental requirements.

Essentially, small distributed generation does not have a clear definition. To a great extent it can be defined as generating facilities with unit capacities of 25 MW or less. These facilities include both traditional fossil fuel technologies and renewable energy sources.

In Russia, the historic bias towards large generators has resulted in minor attention and investments in small generation. As a result, in Soviet times the demand for small-sized generators was stunted, leading to a lack of domestic manufacturers and technologies. But several decades ago, after a hundred years' development of large power plants and centralized power supply around the world, a vector of power development in Russia began to change towards the development of distributed energy resources, though it is still in the early stages of its development.

According to the majority of interviewees, in the near future commercial and industrial, partly residential consumers will begin large-scale deployment of their own generation capacities and energy efficiency solutions. This trend is due to a number of reasons including:

- Rising prices for electricity for C&I consumers and burdening connection fees;
- High level of depreciation of large generating capacities (the average age of power plants exceeds 33 years. It is estimated that over 170 GW of generating capacity had reached its effective retirement age by 2010) and distribution networks (see also "Grid Modernization" section), which lowers consumer`s reliability;
- A lack of sufficient capacity reserves compared to the growing energy consumption due to small and medium business development and housing and public utilities modernization[xviii];
- the need to provide emergency capacity reserves for national energy *sensitive* and strategic facilities;
- An inability to ensure reliable centralized power supply for 2/3 of Russian territories, that have no chance to get access to centralized generation sources;
- Cross-subsidies (See "Cross Subsidy" Section), that make distributed generation economically viable;
- Substantial charges for excessive consumption or underutilization of the forecasted power, etc.

Today's steady trend of increasing output by small-scale power generation facilities provides a good indicator of large consumers gradually moving toward development of their own generation. For example, in 2007-2008 4 GW of small scale power generation was installed – with an additional 4.5 GW in 2010. In turn, in 2009, an additional 3 GW of small generation was commissioned (compared to only 1 GW of newly commissioned centralized power facilities). Despite share of large enterprises` power plants in total power generation capacity of Russia was just under 6% by the end of 2011, its generation increased by 4.5 (in comparison to 2010), while overall power generation in Russia increased by only 1.5%. As for 2012 the total share of small power generation is 17 GW (roughly 8% of the total installed capacity), while the annual power output of these power plants reaches 5% of the total electricity production in the country.

According to expert estimates, the average capacity of small power stations is approximately 340 kW.

Despite these optimistic forecasts and trends, the interviewees mentioned a number of very serious impediments to the greater use of distributed generation in Russia (see below).

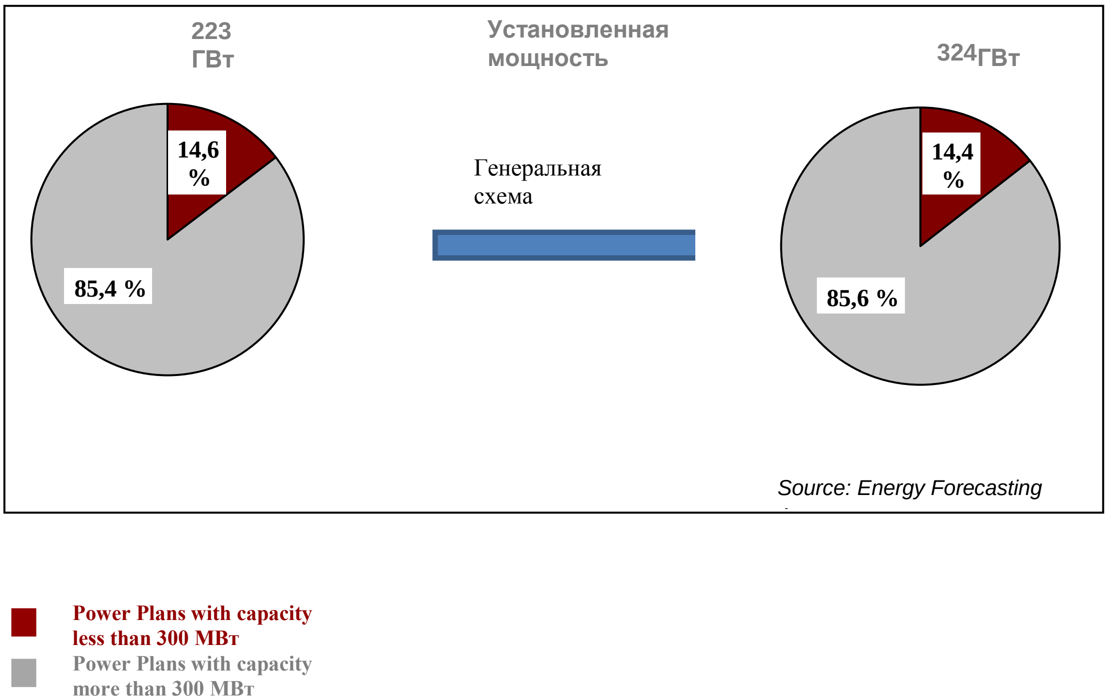



**Fig.2. Small/ distributed energy development according to the Master Plan's prognosis up to 2030.**

## GEN #1: Regulators, Policymakers and FGC UES Concerns that Distributed Generation Development would Cause Atrophy in the UES and its Social Functions

The Ministry of Energy, FGC UES and some other stakeholders are still against Distributed Generation development. Their most important concerns are the following.

Several stakeholders expressed concern that increasing distributed generation will lead to reliability and integrity problems of UES. If regional markets are successful in developing distributed generation and the micro-grid ideology small consumers will be able to divert load from the high-voltage networks, thus affecting the reliability of the entire UES, as the complexity of the network increases.

In this case, particlulary acute concern was expressed by policy officials and the operators of the national transmission and distribution networks, since the Ministry of Energy and FGC UES

hold the preservation of the UES in high priority. “The United Energy System promotes the unity of the economy” and, “increased self-generation would harm reliability” were two quotes in answer to a question on the benefits of distributed generation. There were also comments of the industrial policy-makers that self-generation is not a “silver bullet” to resolve problems of network reliability.
During interviews and following discussions a specific concern was expressed by the *Transmission Operator* about deployment of small generation technologies in Russia. With a roughly equivalent number of substations compared to an average European country, the size of area in Russia exceeds that in other countries many times, which results in a weak network topology requiring extensive large-scale development. For example, there are as few as only two HVAC transmission lines of 500 kV laid through the whole Central and Eastern Siberia. In the opinion of the Transmission Operator, this makes construction of large generation and network facilities a higher priority than the development of small/distributed energy.

An issue of even greater concern is a threat posed by distributed generation to the Government’s ability to excercise social policy via the UES. The UES provides nearly universal access to electricity and is the infrastructure upon which the government excerises an intricate system of cross-subsidies for the benefit of socially vulnerable populations (See ”Cross Subsidy” Section). If commercial and industrial customers leave UES for distributed generation they will in fact *remove* the source of subsidies to residential consumers. Stakeholders also pointed out that this scenario would result in a loss of revenue and stranded assets.

These concerns reverberate throughout the energy economy in the form of additional policy impediments to distributed generation. Some experts even mentioned the possibility of Government`s regulatory restrictions on it, *if* the decentralization process will pose a real threat for UES integrity and the cross-subsidy system.

### GEN # 2: Absence of Direct Governmental Support for Distributed Generation

As a result of strong suspicions by policy-makers, there is no Federal or regional financial, tax or regulatory support or technical assistance for construction of Distributed Generation facilities. It is especially true for renewables (solar, wind, etc.) - despite numerous discussions, Russian Government and Presidential statements, as well as, a normative goal of having 4.5% of distributed renewables in 2020 set in the Masterplan for Generation Faciliites Allocation.

This results in restraints of Distributed Generation development (especially in the residential sector, and small and medium energy companies), less than optimal investment decisions, as well as losing possible systemic effects for UES.

Only in the fall of 2012 projects of new regulations in support of renewables were placed for a discussion by the Ministry of Energy. These regulations envisage use of capacity supply agreements for new renewable generation construction.

## GEN #3: Federal Long-Term Planning Process is Biased toward Large Centralized Generation

Unlike western nations, development of the Russian power sector is guided through use of the so-called Masterplan for Generation Facilities Allocation. The Masterplan is a federal obligatory document, created in public-private partnership and regulating (sanctioning) allocations of all large generation facilities in Russia up to the year 2020 and beyond (up ot 2030), and their access to the grids and gas resources.

Some interviewees identified the masterplanning process itself as an impediment to Distributed Generation. Because of UES's focus on big generation, the Masterplan does not recognize generators under 300 MW.  The result is that hosts of prospective distributed generation units find it difficult to obtain permits for plant sighting, access to the network and natural gas (for gas fired facilities). The process of obtaining these various permissions includes five steps, and each stage requires various procedural fees. As a result, it can take up to 1.5 years to obtain building permits  which demotivates potential distributed generation capacity hosts.

The financial aspect is an important factor too. Masterplan participants are not interested in small Distributed Generation development since it would have a direct effect on the allocation of investment funds aimed at the development of power facilities included in the Masterplan. It is important to note that Government plans to invest in new big generation are as much as RUR60 billion (See "Market" Section)

Not surprisingly, according to existing forecasts in the Masterplan's share of small and medium-sized generation facilities wouldn`t change in 2010-2030 time period.

## GEN #4: Inadequate Attention to Economics of Power Generation and Substituting Solutions

The current masterplanning and regulation process also leads to a situation where  generators *under* 300 MW and 110 kV networks are not *visible* to the distribution network operator. As a result, it is unable to observe the value of Distributed Generation and Demand Response programs implemented by consumers and other Smart Grid technology benefits. The investments required to make the grid visible through Smart Grid technology are sizeable and not available. Therefore, rather than consider different Smart Grid options, the System operator and the FGC UES opt for new central station generation as the solution to reliability problems without addressing the potential benefits of Smart Grid-related technologies.

New regulations are being put in place now to direct the System Operator to take economics into account, as it is supposed to provide price signals for new generation investment. This could provide further impetus for investment in distributed generation. It is also necessary to adopt in the near future legislation to allow companies to correlate their future investment plans with the most efficient modern technologies.

## GEN #5: Restrictions for Fuel Supply for Distributed Generation

A major market problem for the development of small consumer-owned generation is the conflict of interest between market participants – competitive generators and fuel market regulators. Most regional generation does not have free access to fuel resources and strongly depends on access to gas pipelines. For example, the first (European) pricing zone is dominated by natural gas sold by Gazprom at subsidized, regulated prices protected by the State. Because independent power producers are unable to purchase gas on the competitive market they anticipate a tripling of the price for gas, from today's $60 per $m^3$ to $210-220 per $m^3$. This has an extremely negative effect on their competitiveness and is becoming a serious obstacle to the development of distributed generation in the regions.

## GEN #6: Grid Architecture does not allow for a Two-Way Flow of Electricity

An impediment for using distributed generation facilities to improve reliability and support the market lies also in the grid architecture, which does not allow for a two-way flow of electricity.

## GEN#7: Inability of Prosumers to Sell Excess Energy to the Grid

Market potential of Distributed Generation is further constrained by the absence of selling mechanisms for excess energy (See also “Energy Efficiency” Section).

The situation also causes a significant additional need for capital investments in generation – since existing generation capacities cannot be used for support of UES operations. In this case we should recall an estimate, made by one of the stakeholders, that in Moscow alone about 150 MW could be freed up from existing consumers and sold into the market if there was an incentive to do so (for comparison: Mosenergo – the biggest power supplier to Moscow - has 8.75 GW of installed capacity).

## GEN #8: Grids are Prohibited to Have Own Generation Capacities

The Smart Grid ideology accents the use of a peer networking principle, with which every access point in the network can be identified both as a consumer and as a generator. However, in accordance with the existing Russian rules of the wholesale power market - generation, transmission and distribution are to be separated from each other.

One stakeholder cited the *Law#36 on the Transitory Period of the Russian Power Sector* as an impediment to Distributed Generation. The law prohibits any networking legal entity to combine within the boundaries of a single price zone its transmission activities with activities in the sphere of power production and trade, as well as to own generation facilities, even small distributed, to meet reliability requirements. Because the grid is unable to own Distributed Generation, and the market structure is biased against it, the grid cannot realize the reliability benefits offered by distributed generation.

## GEN #9: Absence of Proper Data and Methodology Defers Replacement of Inefficient Generation

The lack of a modern methodology to determine the size and location of capacity reserves to balance the system, and gaps in the normative legislation do not encourage the withdrawal of inefficient generation. It burdens consumers with extra costs to maintain it and causes end-use prices being, notwithstanding temporary governmental provisions, permanently higher than they could be. In Russian realities it also means a higher cross-subsidy burden for other consumers.

It also impedes replacement of these inefficient generation capacities by technologically advanced generation facilities, intelligent management or energy storage systems (as substituting solutions).

## GN # 10: Lack of Proper Energy Efficiency Methodology on the Generator Side

Another important problem, indicated by all of the interview participants, is a lack of a systematic approach when developing a methodology for assessing the effectiveness of measures to improve efficiency and reduce the energy intensity of the Russian energy industry. It is necessary to eliminate significant gaps in the development of industry-wide standards for introducing smart technologies for small CHPs. There is no clear definition and calculation methodology of energy efficiency and energy consumption that can be used in all of the regions; there is a lack of indicators for combined heat and power production assessment. All of this requires the implementation of a country-wide system of Key Performance Indicators (KPI) at the level of consumption.

## 6. CONSUMER PARTICIPATION

*CP #1: Mechanisms of Pricing on Power and Capacity Market*

*CP #2: "The Imposition" of Tariffs to the End User*

*CP #3: The Limitations Imposed by the State on Market Price Volatility*

*CP #4: Problems of Residential Participation through Energy Efficiency and Demand Response*

*CP #5: Absence of Scientific and Methodological Approaches and Financial Support for Consumer Participation in Load Management*

*CP #6: Law Restricts Cooperation between Retail and Energy Companies*

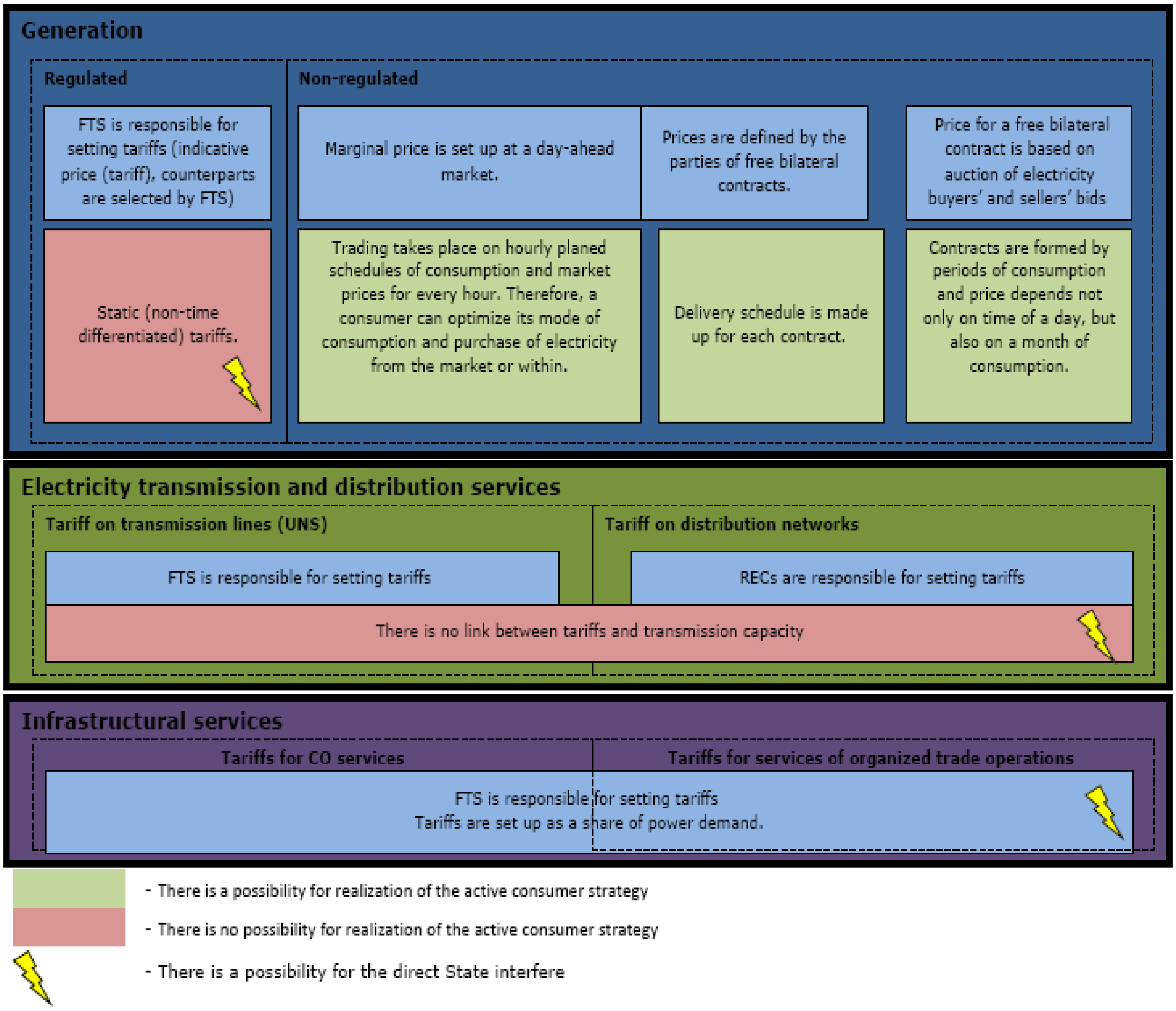
*CP #7: Lack of a Universal Methodology of Demand Management for Grid Companies*

The Smart Grid radically alters the role of the consumer. From the present position of the passive market participant who just conforms with the conditions formulated by energy companies, the consumer becomes a key stakeholder of the modern energy system, using the prosumer model and/or demand response instruments. The consumer impact on the power and capacity market is different, however, when considering its role in the development of Smart Grid technology. There are two significant forms of consumer participation: commercial and industrial participation in markets, and residential participation through energy efficiency and demand response/demand management, which are enabled by Smart Grid technologies. These two parts of consumer participation will be considered separately.

Let us assess in more detail the possibility of consumer participation in the markets at all levels.

As it can be seen in Figure 1, the development of a consumer's strategy to actively participate in the wholesale and retail markets lies in its ability to adjust its consumption on an hourly basis and form an hourly supply depending on a flexible schedule of consumption.

**Fig.1. Potential for Motivation of Active Consumers on the Wholesale Market of Electric Power (Capacity)**



Assessment of the potential of an active consumer strategy for industrial and commercial users in the retail market is shown in Fig. 2. It includes the ability of a consumer to use a metering interval (by hours) of its consumption.

Fig.2.Potential for Motivation to "Activism" of Industrial and Commercial Consumers of Retail Market of Electric Power

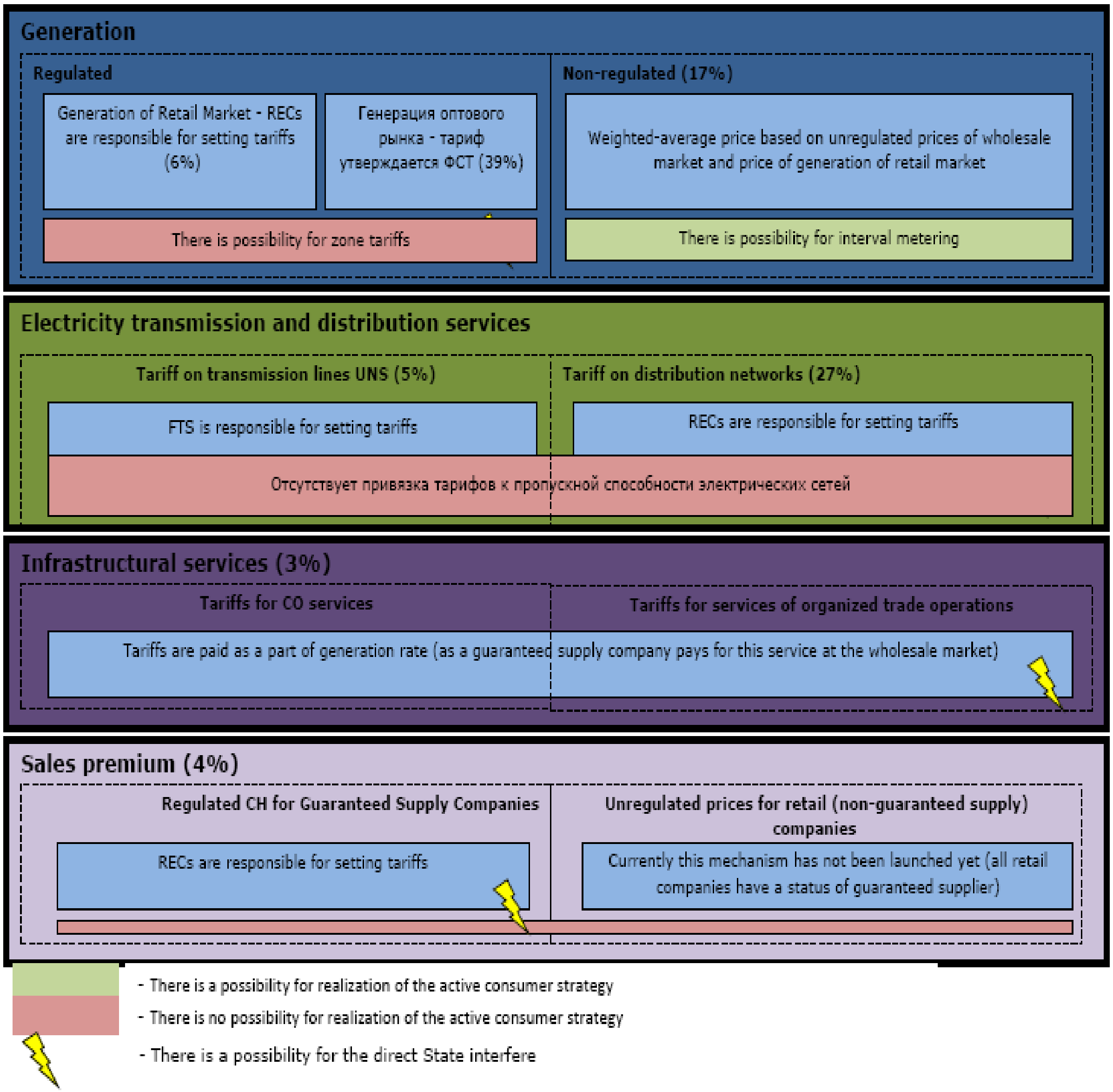
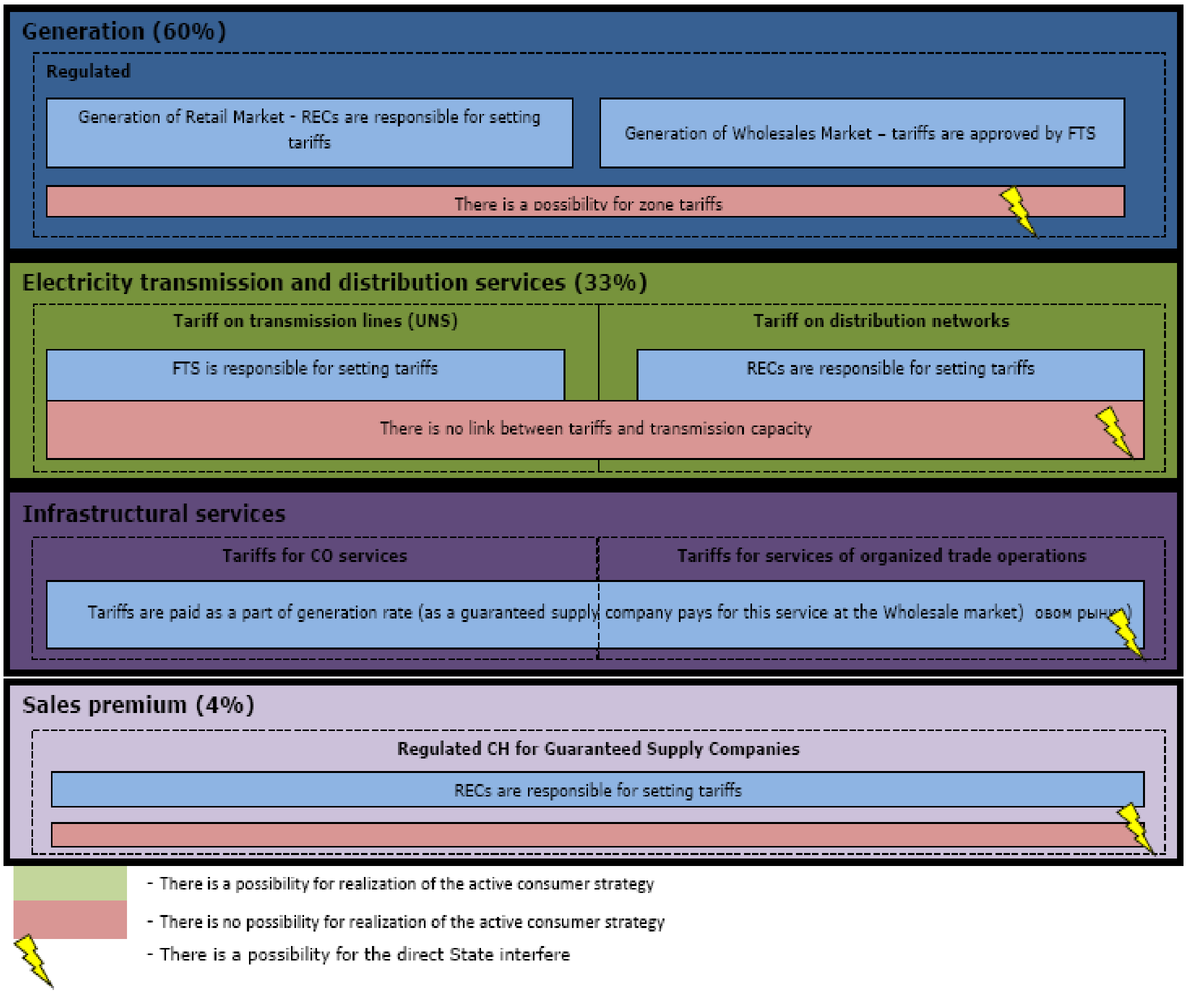


**Fig.3 Potential for Motivation to "Activism" of Population**




But all possibilities of consumers for now have no chance to materialize, since the Russian power sector and the market model are "tailored to the producer". The consumer's interests and rights are not taken into account in the current structure of the industry and the market. Under current market rules and legislation the consumer is considered as a depersonalized "source for financing" of energy companies and is not an *"active"* participant in the power and capacity market. The only exception is major consumers who are buyers in the wholesale market (about 100 companies).

## CP #1: Mechanisms of Pricing on Power and Capacity Markets.

Existing market and pricing models limits the possibility of active consumer participation. For example, the spot market is scheduled on the day ahead. Consumer deviations from planned consumption are penalized on the balancing market. This ensures that the consumer is unable to change their workload and electricity demand during the day because it will deviate from the planned hourly consumption.

In the retail market, possibility to implement the strategy of active consumers partly exists because there are zone tariffs in the tariff menu, promoting power conservation and consumption schedule smoothing. In addition, there are consumers that use a time-based accounting system.

## CP #2: "The Imposition" of Tariffs to the End User

In the retail market all the consumers buy power at rates not lower than those of guaranteeing suppliers. And since price-setting applications are submitted on the wholesale market for all energy volumes, purchased by guaranteed suppliers, final consumers have no possibility to affect the tariff and to plan their own costs. The fact is that the retail end user is not involved in the formation of its volume prices. Its application is «price taker»- that is, they can`t affect the price, and therefore can't plan their expenses in advance. And it eliminates the incentive to manage its own consumption.

## CP #3: The Limitations Imposed by the State on Market Price Volatility

Currently in Russia, in accordance with the rules of the wholesale market, the commercial operator monitors the rate of growth of the market prices for electricity in each of several defined price zones. When growth exceeds the proscribed limits established by government regulation in a particular zone, a special pricing regime is imposed (price smoothing). Price regulation reduces the level of competition, limiting the possibility and desirability of new generating sources on the residential consumer premises, demand response and some other Smart Grid features.

### CP #4: Problems of Residential Participation through Energy Efficiency and Demand Response

Residential participation though energy efficiency and demand response is one of the most significant drivers of Smart Grid technology development. However, in Russia, the development of these practices and technologies is on a very low level and prevents [1] expanding the use of intelligent technologies.

The main reasons for this are:

- Insufficient implementation guidance for current *Federal Law #261* on energy efficiency and the national program (including unclear sharing of profits by energy service contracts);
- Low level of consumer education on energy efficiency options;
- Lack of economic motivation for *residential* consumers due to cross-subsidization and absence of trust to energy companies;
- Lack of administrative mechanisms to force demand response and energy efficiency implementation;
- Lack of financial mechanisms,
- Gaps in regulation related prosumer model and demand response (see also discussion on these issues in "Energy Efficiency" and "Grid Modernization" Sections), etc.

Work on removing the abovementioned impediments is constantly conducted in Russia with varying degrees of success. It's important to keep in mind that all of these problems are interrelated. On one hand this is positive, since progress in the elimination of one of the impediments will influence the others. But on the other hand, the solution to problems require a more complex approach, in which it's important to be clearly aware of the components of the whole problem, their interconnections, and the nature of the mutual influence.

### CP #5: Absence of Scientific and Methodological Approaches and Financial Support for Consumer Participation in Load Management

Peak load reduction, compensation of demand curve failure, load flow shifting and a flexible schedule of load flow usage are the most effective and widely used methods of load management. Almost all of these methods more or less were widely used until 1990. However, in recent years, a new phase of the creation of mechanisms for load management started because of the development of the power and capacity markets (partially these mechanisms were discussed above in considering the assessment of the potential "activity" of different categories of consumers).

Large-scale implementation of the above mentioned mechanisms requires conducting a detailed study of the distinctive features of industrial, residential, and other classes of consumers. This study should be aimed at selecting those groups that have the greatest possibility to manage their daily consumption. As part of load management, energy intensive industrial enterprises with abrupt load changing operation shedding schemes including the Russian Railways Company, electric public transportation systems, customers which need to optimize their consumption of reactive power for their electrical receivers, and others should be identified as the most significant groups.

It makes sense to create mechanisms (financial incentives) for flexible load scheme usage for residential and utility customers based on the customers' voluntary consent to level down the standards of the quality of their energy service. The development of this mechanism will incentivize the growth of demand for the Smart Grid technologies, since its implementation in the modern power market will be ensured by the special equipment for individual power load control.

According to the opinion of the interviewed companies, the obstacles to implementing load management programs are a serious deterrent to their development, and the most significant of them are associated with mechanisms for launching and motivating load management programs.

### CP #6: Law Restricts Cooperation between Retail and Energy Companies

Specificity of the Russian conditions of load management programs implementation consists of a predominant role of regional grid companies as operators, which develop, promote and motivate these programs – Instead of joint actions of network, retail and energy companies. But cooperation between retail and energy companies is prohibited by the law.

### CP #7: Lack of a Universal Methodology of Demand Management for Grid Companies

For successful implementation of these programs, it is necessary to develop a universal methodology of demand management for the power grid companies; some administrative and regulatory enforcement actions would be required at the first stage, as for the grid companies, and also for some consumers. The latters are energy-consuming enterprises that possess (according to the mandatory energy audit) a considerable amount of unrealizable potential for energy efficiency growth and (or) regulating capabilities to improve load shedding schemes, which is one of the most important factors for industrial energy-consuming reduction. (See “Energy Efficiency” Section)

# 7. BEHAVIORAL NORMS

Behavioral issues, including values, are of utter importance, since they affect not only adoption of Smart Grid technologies, but also political courses, that are made with reference to popular visions and consideration.

***BN #1: Residential Consumers Lack Understanding of Energy Markets, Efficiency and Smart Grid Benefits***

***BN #2: Regulators Lacks Understanding of Energy Systems and the Smart Grid***

***BN #3: Absence of Energy Efficiency Values and Practices of C&I Customers***

***_BN #4: Absence of Common Terminology in Smart Grid***

***BN #5: High-Level of Non-Payments***

## BN #1: Residential Consumers Lack Understanding of Energy Markets, Efficiency and Smart Grid Benefits

A major impediment to consumer participation in the development and implementation of the Smart Grid in Russia is the residential consumer's lack of understanding of energy markets and its rules and possibilities. Residential consumers are alienated from the electricity market, and because of that, do not understand the potential offered by dynamic pricing possibilities and the benefits of managing their own energy consumption, etc. In other words, their motivation to adopt Smart Grid technology is extremely low. Also, a consequence of this poor understanding is a general opinion among residential consumers that electricity costs are too high, even if they are underpaying the true cost according to the assessment of electric utilities. In part, this is a heritage of the Soviet and Post-Soviet era subsidization policy, which made residential consumers think about electric power as something cheap and affordable, whereas treating rising electricity prices as corporate or government unfair “tricks” to get more money from citizens.

Another problem is the low level of awareness of citizens about the rules of, and requirements for, energy efficiency which are laid down by the Law #261 and other normative and legal documents (even Moscow polls on energy conservation and energy efficiency show that 2 out of 3 people are completely ignorant about it).

In this regard, some measures are being taken to improve consumer knowledge and increase their understanding of the importance of the introduction of innovative technologies including:

- Some regions launched a 24-hour free hotline to support residents on energy conservation and efficiency as a tool to raise their awareness and to provide feedback.
- Within the framework of the Working Group on Energy Efficiency of the President`s Commission on Modernization and Technological Development a new service was launched called the "Energy Efficiency Calculator" for regions of Russia, where consumers can enter data and get an estimate of the effects from the implementation of several energy conservation measures.
- An intensive campaign in mass media, on the billboards of the biggest cities, etc. is launched by federal and city authorities for better informing citizens about importance and possibilities of energy efficiency. These efforts get financial support from vendors of light bulbs and other energy efficient goods, equipment and solutions.

The situation is aggravated by a lack of consumer understanding of the potential benefits that may be brought about by the installation of meters and other Smart Grid solutions. This underlies their disbelief that the meters can provide substantial savings.

To solve this problem, consumers must be better informed about the introduction of intelligent devices and the benefits they provide in terms of collecting information, data processing, the management of loads, as well as, maintaining reliable accounting and reducing electric power costs.

The same could be said about the Smart Grid in general – there is an obvious lack of consumer understanding of the effects, possibilities and goals of the Smart Grid.

### BN #2: Regulators Lacks Understanding of Energy Systems and the Smart Grid

As some interviewees mentioned, introduction of "smart" technologies is strongly impeded by the lack of industry regulator`s understanding and in-depth knowledge about:

- Strategic development problems and challenges of the Russian power sector;
- Electric power and heat production technology;
- Electricity market rules.

The same could be said about the Smart Grid in general, since regulators and decision-makers often lack understanding of the possibilities and benefits afforded by Smart solutions.

An excellent example of that is the vision held by regional leaders of Federal policies to promote Smart Meters installations and to develop stricter accounting rules. Not so rare they see it as “exploitation” or a “conspiracy” by natural monopoly network companies to increase prices.

In this case only extensive educational, training and “Smart Grid enlightenment” efforts are needed – including pilot and demonstration project to provide regulators with objective data on real Smart Grid benefits and realities.

### BN #3: Absence of Energy Efficiency Values and Practices of C&I Customers

Large Russian customers’ values and behavioral norms seriously affect the consumers’ participation in development of Smart Grid technologies in the field of energy efficiency and load management (see also “Energy Efficiency” Section). Among them are:

- Energy management orientation toward an extremely short capital cost of energy efficiency repayment period (1—2 years);
- Lack of price competition on the domestic markets for industrial products.
- Ignoring inexpensive energy efficiency projects (even if owners don’t have money for expensive projects)
- Underestimating cost management in order to increase profits.
- Indifferent approach to any form of innovations which are not associated directly with the increase in production and sales.

Some stakeholders also mentioned lack of interest of state-owned companies in extensive energy efficiency measures, since cost reductions do not have for them as big importance, as for private businesses.

### BN #4: Absence of Common Terminology in Smart Grid

During interviews, it was noted that there is an absence of a unified approach to the terminology in terms of Smart Grid deployment in Russia and the need was expressed to develop a conceptual understanding of what a "Smart Grid" is. Today, every stakeholder interprets the Smart Grid in its own and very separate way, which lowers the possibility of cooperation and coordination of efforts.

Among market participants, there is also no consensus about the domain of Smart Grid applications. Some interviewees consider the "smart technology" as a high-voltage grids business; others understand it should cover all stages of the path from the producer to the consumer's home, etc.

Some interviewees agree that it is appropriate to develop a single legislative text through the use of a common information model (CIM), which will strengthen the technological relationship between a large numbers of existing documents, combining them into a single conceptual informational system. This will facilitate the establishment of unified rules of interaction and terminology for all participants in the process.

### BN #5: High-Level of Non-Payments

The Association of Guaranteed Suppliers and Retail Companies estimates that the total amount of non-payments in the retail market is about RUR150 billion, which is equivalent to one month of the whole power sector electricity production.

Even though this is mostly a social problem, in the future, changing the non-payment culture could become a significant problem, since the population considers prices as being too high or viewing power not as a commodity, but social welfare.

# 8. DATA AND ANALYTICS

## I Accounting and Physical Monitoring Data

The current situation in the industry led to a number of negative developments caused by the absence or fragmentation of data on energy supply and consumption, and the imperfectness of the data analysis methodology.

1. As mentioned in previous sections, a crucial indicator of the efficiency of electric power networks and retail companies is power *losses* and, in particular, *commercial losses*, which are a significant factor affecting technological failures in the network and the reliability of power supply. The estimated actual loss of electricity in Russia comprises 130 billion kWh, or 13.6% of the network. The total reserves in the electric networks of Russia is 25-35 billion kWh, or 19-27% of the total energy losses taking into account all network companies providing services of power transmission. [xix]

The main reasons for commercial losses are accounting system errors, billing losses and losses due to theft[xx] of power resulting from unauthorized connection of customers, violation of the connected circuits and meter integrity; distortion of measurement, etc. There is a high ratio of commercial and physical losses in Russian grids, as it was argued earlier

***DA #1: Customers are not Incentivized to Deploy AMI and Smart Meters***

***DA #2: Regulation and Administrative Provision Gaps in Smart Meter Installation***

***DA #3: Customers are Suspicious of Smart Meter Installations***

***_DA #4: Regulation Gaps in Smart Metering and Smart Meter Information Ownership***

***DA #5: Smart Metering Methodology Gaps***

***DA #6: Abuses in Accounting Device Installations***

***DA #7: Lack of Standards and Other Technical Regulations for Smart Meters***

***DA #8: Lack of Coordination in Data Reporting and Acquisition***

***DA #9: Unpreparedness to Analyze and Store Future Smart Grid-Enabled Data Arrays***

2. The crisis in Russia over the past two decades has led to increased problems related to consumer demographics and, consequently, to inaccuracies in the accounting of power consumption and losses.

For example, until early 2000s most power systems experiences problem of so-called "abandoned" customers. Abandoned customers are end-users that are not listed on the balance sheet of any organization. These residents do not pay for the electric power and heat supplied to their houses. Currently, this problem is being solved, but it illustrates the existence of serious problems with the study of statistics of the consumer.

Interviewees were unanimous in stating that today's absence of a relevant data acquisition and analysis system impacts customer outages, and leads to gaps in assessing the reliability of power supply and financial losses of consumers. The problem also affects energy efficiency.

3. In some cases, the lack of necessary accounting data allows for certain parts of the electricity consumed by small industrial and commercial customers to be attributed to domestic consumption. This contributes to uncontrolled and inefficient electricity consumption by these entities leading to another, yet relatively rare ("backward") type of cross-subsidization when subsidies for small industrial and commercial consumers are at the expense of the residential sector.

4. Deficient accounting systems and practices have also had a negative impact on behavioral aspects causing a poor business and consumer culture, where the net supply of energy sales are artificially underestimated and underreported resulting in  a rapid increase in commercial losses.

5. The power grid companies, unable to directly install meters on the premises of the customer, are not able, due to the lack of the necessary consumer demographic data, to calculate the usage profile of the customer, based on meter measurements, and to actively manage its workload.

6. When assessing the value and volume of damages from accidents or outages in the network - consumers apply now for compensation to the network company. However, there are no modern methods of estimating these damages. The available methods are similar to SAIDI and SAIFI. Today, an adequate commercial accounting of consumers is not established due to inappropriate network topology. This makes SAIDI/SAIFI calculations difficult and influences reliability. The metric currently used by the Ministry of Energy is the impact of outages on social stability, i.e., the ice storms of the winter of 2010 that resulted in prolonged outages for residential customers in the Moscow region.

7. Insufficient data to evaluate the cost of the losses and damage of disconnections of customers is at present one of the most important challenges facing the Russian energy sector. The lack of **a** methodological framework and the statistical data to calculate and analyze reliability of consumers` electricity supply is raising the issue of system reliability costs. Therefore, prior to deployment of Smart Grid technologies, there is a need to develop a data acquisition system about financial damages on the consumer side, as well as, a system

methodology to assess the cost of reliability events to customers, and to evaluate Smart Grid economic performance.

Even though the problems caused by data acquisition and analysis gaps are significant, the current situation is seen by some experts as a *driver* for massive deployment of Smart Grid solutions throughout the energy industry. On the corporate side, AMI and Smart Meters would promote network reliability, operational efficiency as measured by a reduction in losses, and financial stability – thus also stimulating investments in Smart Grid technologies. In parallel, on the consumer side, it would spur energy efficiency, active involvement of consumers in demand response and demand management systems, and *could* cause gradual reduction in end-use tariffs that would also help gradual removal of cross-subsidization.

However, the current norms and regulations associated with Smart Grid technology impede AMI and smart meter deployment.

### DA #1: Customers are not Incentivized to Deploy AMI and Smart Meters

Current market rules, regulations and tariffs (see “Market”, “Cross-Subsidy” and “Consumer participation” Sections) minimize the incentives for customers to optimize their energy consumption. And as was discussed in the “Energy Efficiency” and “Behavioral Norms” sections, the energy conservation literacy, practices and regulations are at the developmental level. Therefore, the ultimate residential consumer *economic* reason for AMI and Smart Metering is absent or not an imperative. The consumer`s lack of understanding of the Smart Grid and its potential benefits also contributes to the problem.

In order to diminish this factor, most of the interview participants stressed the need for an incentive program that would provide the customer some discounts on their electric bill as part of the compensation for higher expenses.

### DA #2: Regulation and Administrative Provision Gaps in Smart Meter Installation

The successful deployment of Smart Meters and other AMI is still principally impeded by the absense of regulatory and administative support (including possible decisions to make these installations in the consumer premises *obligatory*).

There is a substantial gap in the regulatory framework regarding the development of a program on incentives for, and motivation of, residential customers for installing meters. But, due to the lack of administrative requirements, implementation guidance and financial incentives for consumers**,** Smart Meter installations are still only seen as a good will of companies and consumers, and that is not an optimal solution. The distribution companies are unable to communicate directly with the customer and it is neither required, nor incentivised in the process.

Together with the financial limitations of utility companies, this explains that the rate of Smart Meter penetration on the consumer side is very limited. For now, only pilot installations are made – mostly by Interegional Distribution Networking Companies (MRSKs). The Belgorod AMR (automated meter reading) project based on intelligent “Neuron” meters can be mentioned as a successful example of Smart Meter deployment. One of its important advantages is the use of a multi-tariff menu and two-way interface supporting bi-directional communication with consumers. The project provides installation of ca. 160,000 Neuron meters. The same could be said about URAL IDGC`s"Smart Accounting" Project in Perm City, where about 50.000 Smart meters were installed (Russian "Matritsa", "Energomera" and "Merkuriy" systems, as well as French "Sagem" and US "E c helon" solutions).

To solve the issue of regulatory and administrative gaps a special Ministry of Energy Program of commercial accounting of electric energy is in place, but it is still far from completion.xxi There is also a special federal program "Calculate. Economize. Pay" under the auspices of high-level Presidential Commission for Modernization and Technological Development (See "Grid Modernization" Section) but its results should be analyzed and systematized in order to get needed requirements and propositions for regulations.

### DA #3: Customers are Suspicious of Smart Meter Installations

A great impediment to the development of new regulations and to the deployment of AMI is customer illeteracy and their suspicions about final AMI goals. It is widely believed by consumers that once the Smart Meters are installed consumer bills will significantly grow.
It should be mentioned that requiring the installation of Smart Meters and tightening the norms for them is seen even by some interviewees as a way for natural monopolies to raise prices (See also "Behavioral Norms" Section).

### DA #4: Regulation Gaps in AMI and AMI Information Ownership

The lack of clear and transparent rules for accounting data leads to difficulties with a proper accounting and estimation of losses, affecting supplier's efficiency and profits. Suppliers are forced to compensate power delivery shortages to consumers from their profits. And since the network companies tend to lower losses by maximizing the reported amounts of power delivered to the customers (using "specific" interpretation of meter readings), suppliers are forced to use alternative accounting.

Along with mutual mistrust this leads to *parallel* installation of metering devices in areas of responsibility of both companies. This causes not only excessive capital expenditures, but also blocks the possibility of dynamic pricing and other Smart Grid features of demand response.

The problem could be solved through regulations. But still, the regulation does not specify who owns the meter – customer, marketing company, or the network company. So, there is neither a *primary* owner of the information who determines the *correct* accounting data, nor a methodology guaranteeing the transparency and accuracy of accounting.

### DA #5: Smart Metering Methodology Gaps

An important theme periodically raised during the interviews was also the lack of appropriate practices and methodologies for the use and analysis of AMI data.

This is particularly troubling when speaking about measuring the efficiency of operations *throughout* all segments of the energy industry. For example, the absence of reliable and relevant *analysis* of data of final consumption adversely affects the ability of generators to select the most appropriate live generating equipment configuration, plan and forecast load; the ability of transmission companies to provide optimal operation control and prevent accidents; and the ability of energy companies to optimize daily demand, etc.

### DA #6: Abuses in Accounting Device Installations

The potentially negative effect on AMI deployment could have numerous cases of abuse at the regional and local levels: overpricing by monopolists of the cost of accounting devices when they are installed on the demand side; imposing all sorts of "oppressive" terms and conditions that mislead people, for example, by claiming that accounting devices should allegedly be replaced every three years, etc. Such cases are being investigated by the federal authorities and the Ministry of Economic Development has already responded to the challenge by extending the gas metering installation program until January 1, 2015, and the remaining devices byJuly 1, 2013. The corresponding legal act will soon be considered by the State Duma. But still, the abovementioned abuses will certainly hinder the promotion of intellectual technologies among residential consumers.

### DA #7: Lack of Standards and Other Technical Regulations for Smart Meters

Some interviewees mentioned, that another problem for deployment and use of AMI and Smart Metering in Russia is absence of approved unified standards and protocols for data transfer between data concentrators and meters of different manufacturers. New interoperable standards will not be adopted unless there is a huge market demand and increased installations or a legal requirement. But interview respondents do not feel Russian purchasers possess the buying power necessary to make this happen.

Another issue is lack of security provisions (both regulatory and technical) for data transfer, including cryptography, and other issues, associated with technical requlations and standards of smart metering.

### DA #8: Lack of Coordination in Data Reporting and Acquisition

In order to remove the data and analytic barriers to the introduction of smart grid technologies legal norms and regulations should be improved to increase the coordination between reporting entities, respondents and regulators, and to increase the data reliability and transparency at all levels (state, regulatory, regional, local). Some of the most important impediment here are:

- The lack of completeness and accuracy of the information provided (especially after the reorganization of RAO UES) due to both objective difficulties[xxii] of the data acquisition process, and an unwillingness of the utilities to disclose this data;
- Overlaps and duplication of data reporting.

### DA #9: Unpreparedness to Analyze and Store Future Smart Grid-Enabled Data Arrays

Modern engineering solutions, new requirements in the IT structure of the grid (Smart Grid, Smart Meters), changes in business processes and new ways of working with clients generate huge amounts of data, which grow at such a rate that its collection, storage and proper use are now considered as a serious problem. The main problems are:

- Inability of today's IT-technologies and network protocols to cope with the increase in hyper volume traffic due to the introduction of Smart Grid technologies (e.g. Smart Metering). A change is needed in strategic thinking, approaches to data management and a more in-depth understanding of ongoing trends to avoid being swallowed by data flows;
- Lack of proper methodologies to analyze important consumer trends and system parameters, algorithms and IT solutions for data analysis (multi-dimensional databases based on mathematic modeling; interoperable data exchange formats; technology of business analysis);
- Absence or inadequate development of the Smart Grid Segment of the Russian IT Market, and an almost total absence (except for ROSATOM – Russian State Nuclear Corporation – companies) of supercomputing technologies;
- Absence of regulations supporting continuous expansion of the collected information dataflow lists and other data acquisition processes;
- Uncertainties in data ownership issues;
- Inconsistency and gaps in the regulatory framework related to the protection of sensitive personal information and regulating data disclosure.

Solving these problems would help to increase reliability, stability, efficiency, financial parameters of the energy sector and will also support informed investment decisions of stakeholders on Smart Grid technologies.

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It should be mentioned that there are industry efforts to solve the problems outlined above. Along with grid visibility programs (such as the already mentioned PNIN of FGC UES or MRSKs Smart Meter deployment pilots), leading utility companies are starting to create analytical centers that help structure data streams – including data from smart meters and smart networks – that would ensure their more effective and reliable operation.

#### II Evaluation of Economic and Social Benefits of an Intelligent Energy System

Along with *smart accounting* evaluation of the economic efficiency of intelligent energy systems, a serious Data and Analytics challenge lies in the evaluation of economic efficiency of intelligent energy systems. This problem requires both *technical* and *conceptual* approaches.

First of all, in order to support national Smart Grid efforts a more correct cost-benefit analysis should be made, including modeling of different economic development scenarios (Business-as-Usual vs. Smart Grid). And to do that, more extensive and *accurate* data is needed – both accounting and technical (see above) and economic. In the latter case, a new methodology for calculating long-term indirect losses, costs and benefits should be developed.

The Russian Academy of Sciences in 2011[xxiii] conducted an EPRI-like cost-benefit analysis of Smart Grid technology deployment in Russia (in the Concept for Intellectual Energy System based on an Active and Adaptive Grid). It concluded that by 2030 Smart Grid technology benefits may amount to RUR 5 trillion in the form of improved reliability and indirect economic effects in the national economy, while needed investments are RUR2-3 trillion. But some key stakeholders expressed the opinion that insufficient data on the reliability costs and a lack of general economic recordings from power and related industries may cause these estimates to be inaccurate. Since cost-benefit analysis represents an important step in strategic decision-making, this problem should get a high-level priority.

The lack of available data about the social benefits was also named by interview participants as an important issue for the successful promotion of Smart Grid technologies in Russia. This includes job creation, introduction of a new range of energy services, easing price-tariff policy, mitigating cross-subsidies and lightening of the price burden on certain categories of consumers. Absence or inadequacy of such data and analyses undermined the interest of consumers and society in Smart Grid technologies and prevents formation of social support for intelligent energy system development.

# 9. SMART GRID INVESTMENT ENVIRONMENT

Despite numerous drivers for investments in Smart Grid solutions (high T&D losses and accounting problems, depreciation of grid and generating facilities, reliability issues, etc.), in general, the Smart Grid investment environment is still far from optimal. As deliberately mentioned in the previous sections, the Russian energy market is still in transition and has numerous problems, regulations and guidance for Smart Grid implementation is either neutral, or adverse to Smart Grid investments.

Several key *general* impediments are discussed below.

***SGIE #1: Lack of Economic Stimuli for Innovative Development***

***SGIE #2: Market and Regulatory Restrictions on Distributed Generation, Energy Efficiency and AMI Systems***

***SGIE #3: Absence of Coordinated Vision***

***SGIE #4: Absence of Coordinated Investment Efforts***

***SGIE #5: Rising Regulator`s Requirement for Reliability***

***SGIE #6: Weak Ecology Policy***

## SGIE #1: Lack of Economic Stimuli for Innovative Development

As mentioned in the “Market”, “Energy Efficiency”, “Cross-Subsidy” and “Consumer Participation” Sections, today’s market rules, tariff mechanisms, federal “manual control” interventions, cross-subsidization, etc. make investments in Smart Grid-related solutions risky, often unprofitable or with unpredictable ROI and time periods for investment return. And there are no *natural* market stimuli for Smart Grid investments, since the market is distorted or non-existent.

The situation is even worse for public companies since their investment programs depend on Governmental and Presidential priorities and requirements on the one hand, and federal socio-economic (including tariff) policies on the other.
In 2010-2011, in order to stimulate innovation activities, the President and Government issued several important regulations and semi-obligatory “recommendations”. In terms of Smart Grid development the most important of them were:

- 2009 Federal Law #261 on Energy Efficiency;
- 2010-2011 President`s and Ministry of Economic Development directives on working out and approving of Programs for Innovative Development (so-called *PIRs*) by public companies (including ones with 25-50% public share). PIRs are high-level strategic documents, directing R&D, educational, some production, technology deployment and commercialization issues (including financial parameters).

Since the PIRs are monitored on a yearly basis by the Ministry on Economic Development, and is in many cases a *political* document (reflecting a company`s compliance with federal policy), this resulted in the introduction of new technologies, an increased attention to energy efficiency, renewable energy and Smart Grid issues. As a quantitative result, in 2008-2012, R&D of public energy companies rose 35 times to RUR 22.3 billion, while R&D intensity – almost 20 times (to 2.6%) – mostly due to 2010-2012 increases.

But still, this new stake on innovations did not create a stable and predictable investment environment for Smart Grid development, since neither market nor other economic impediments, nor did imperfect rules and regulations disappear. More than all, *quality* of this tremendous growth of innovation-related activities is still questionable – because it was not an organic process, but was forced by t federal authorities.

Even more troubles with investments have tariff-dependent companies. An indicative example is the FGC UES. When the RAB tariff system was introduced in the Russian energy market, the FGC `s investment program was defined at the RUR950 billion levels for 2010-2014. But the Government intervened (through “manual control”) into the market and artificially lowered tariffs. The consequence of that was the diminishing of the FGC investment program down to RUR504 billion for 2012-2014 or RUR20 billion per year less. In late 2012 another intervention in tariff calculations leads to further 30% reductions in investment program. Such fluctuations make any investments less predictable, and thus, less economically viable.

Lack of economic stimuli is also actual for end users. In terms of residential consumers, cross-subsidization eliminates an economic sense for Smart Grid solutions, while C&I customers often found themselves in the situation, when the existing market rules or regulations do not let them reap all Smart Grid economic benefits (See “Energy Efficiency” and “Consumer Participation” Sections). And no mechanism for attracting consumer investments is elaborated.

Thus the formation of a positive Smart Grid investment climate through complex market, regulatory, educational and other activities of federal and local authorities is still the case. A new comprehensive Smart Grid strategy is needed to address these *economic* impediments and resolve existing contradictions.

### SGIE #2: Market and Regulatory Restrictions on Distributed Generation, Energy Efficiency and AMI Systems

Numerous market and regulatory restrictions are imposed on investment activities associated with Smart Grid (see also “Market”, “Energy Efficiency”, ‘Generation” and other Sections), distorting both decision-making and making less predictable ROIs, etc. Among them:

- Pot-mixture method and other “artificial”, distorted tariff calculations;
- Current principles of Masterplan for Generation Facilities Allocation development (bias to large generation);
- Federal Law No.36 “On the specifics of electric power industry functioning during the transition period, introduction of amendments into certain legislative acts of the Russian Federation and repeal of certain legislative acts of the Russian Federation due to the adoption of the federal law "on the Electric Power Industry" imposes a ban on the possibility of the owner even of a small distributed generation to acquire any network assets necessary to ensure the required level of reliability.

There are also other de-facto restrictions or limitations due to imperfectness of market and regulation rules (see other Sections).

### SGIE #3: Absence of Coordinated Vision

In most countries, the long-term development of the energy industry is under the patronage of the State. A good example of that are the USA efforts for Smart Grid development – NIST and DOE framework initiatives, long-term R&D programs, etc.

In Russia, after the reform of RAO UES of Russia, there is no real center for coordination and technological development of the electric power industry (See also "Market", "Grid Modernization" and other Chapters). The Energy Strategy of Russia for 2030 defines only *key directions* of the development of the industry. However, it does not form a clear vision or understanding of the future grid, as well as instruments and plans for its implementation. In particular, there is no vision of how new technology solutions will be integrated into the current system and how a new Smart Grid will be managed in the future; what is the configuration (and directions of evolution) of future "smart" markets; etc.

The situation is aggravated by decentralization of responsibility and decision-making in the energy sector. The formerly united industry is now split into more than 6,000 companies with different forms of ownership and business organization. Less than optimal regulatory and market rules and the traditional lack of cooperative potential among businesses in post-reform Russia prevent effective cooperation in important investment projects. And there is no real political will of the Ministry of Energy to spur cooperation and diminish risks through administrative or regulatory mechanisms (See also "Market", "Education" and other Sections).

An attempt to create a common conceptual framework for Smart Grid development was made by FGC UES, which initiated and supported development of the so-called Concept for the Intellectual Energy System with Active-Adaptive Grid in 2011. This Concept was envisioned as an industry-wide document, and was sent for reconcilement to other industry actors. But, firstly, only the Main Provisions finally became subject for negotiations, and, secondly, this process didn`t yet affect investment or R&D programs of other actors.

### SGIE #4: Absence of Coordinated Investment Efforts

The same situation is seen in the investment activities of companies in the energy sector. In this situation cooperative R&D, pilot, deployment and other investment efforts, as well as, investment decision-making are neither coordinated, nor made in cooperation.

Indicative from this point of view are results of expert monitoring of PIRs implementation in 2011. PIRs innovation projects (mostly R&D) were analyzed in order to reveal common topics and directions of research. And despite numerous common or overlapping R&D topics were identified among different PIRs – *not even one* common project (involving two or more companies) was initiated or prolonged in 2011.

Smart Grid-related projects and programs are no exception. Almost all public companies in the energy sector incorporated the intellectual power projects in PIRs. However, until now, no one has conducted a systemic analysis of industry efforts in this field. A cursory examination of the programs and interviews with participants of the projects shows the **major intersections** on one hand, and, on the other hand, absence of practical cooperation and a *will* for it.

Numerous attempts are made to overcome this impediment:

- Through personal liaison between R&D and other corporate leaders;
- Through participation in Government and President-inspired cooperation formats (Technology Platforms, President`s Agency for Strategic Initiatives, R&D Director`s Club under supervision of the Ministry of Economic Development, etc.);
- Through "recommendations" (de-facto obligatory document) of Ministries of Energy and Economic Development and other forms of activity;
- Recently – through Vice-Premier Arkadiy Dvorkovich attempts to form a coordinated innovation policy for industry (See also "Grid Modernization" Section).

But still, the effects of these efforts are not very impressive, while successes are explained more by *personal activities* of responsible corporate leaders, than by systemic national-wide efforts.

A good example are efforts to coordinate the industry`s innovation activities through establishment of the Technology Platform[xxiv] for Intellectual Energy System of Russia in 2011, which features more than a hundred companies. No effective mechanisms of interaction between companies within the Platform have so far been found (companies do not want to "give up" their activities for a "third party"), while the activities of the Platform are not ambitious and effective since it lacks both corporate *and* Ministerial support (financial, administrative, etc.).

### SGIE #5: Rising Regulator`s Requirement for Reliability

There is an objective to improve network reliability by reducing the number of cut-offs of consumers and losses by 25% (equivalent to 40 billion kWh). And Federal requirements and penalties for non-compliance to this requirement now have become much tougher. If earlier fines for failure to comply with the Government performance reliability targets were 2% of the gross income – now they have grown to 15%. The reasons for this are: a) the high level of Russian grids depreciation, which makes them vulnerable to technological failures (especially in winter); b) very low temperatures lasting for over half a year; c) attention of Government to security of energy supply and associated social risks.

Experts expressed an opinion that high network depreciation, strict reliability requirements and penalties create an increased risk for investors, who may prefer carrying out technical modernization and refurbishment instead of implementation of innovative technologies in development of the power network.

## SGIE #6: Weak Ecology Policy

As for now, environmental regulation and especially its implementation in Russia cannot be compared with ones in Western nations: there is no cap-and-trade or other $CO_2$ reducing obligatory provisions, feed-in tariffs for renewables, ecology standards for industry and the transportation sector (for fuel use, emissions of dangerous substances, etc.) are less strict, etc. This situation de-stimulates use of modern renewables, partly energy efficiency and other Smart Grid features – since it affects the investment process, where environmental considerations are rarely considered as an important factor.

A good example of this is distributed generation. Since it is easier for regulators and big industry actors to use a centralized generation model, the positive environmental effects of distributed energy sources are almost never taken into account.

Some requirements for ecological provisions in the PIRs are formulated by the Ministry of Economic Development, and all public energy companies have shown good progress in achieving these goals. Calculations were made of how PIR projects lower $CO_2$ emissions or diminish other negative impacts (for example use of territories for energy objects). But still these activities are very limited in effect and are essentially more an *associated* efforts, than a systemic approach to environmental policies.

The same could be said about the normative goal of rising renewable generation (excluding large hydro) up to 4.5% of all power produced in 2020 – which is fixed in the Masterplan for Generating Facilities Allocation. The implementation of this provision lacks Federal supporting instruments (feed-in tariffs, subsidies, etc.) and implementation guidance.

Country Officials (The State Duma and the Ministry of Energy) feel the need to develop measures to stimulate investment in improving the environmental performance of the power facilities, including through government subsidies. But for now, the regulatory framework is still not elaborated.

# 10. EDUCATION

***ED #1: Uncoordinated Approach to Energy Industry Educational Policies***

***ED #2: Universities Lack Skills, Knowledge, Competences and Infrastructure for Perfecting their Educational Practices***

***ED #3: Weak Links between Education and Technology Innovation Activities***

***ED #4: Outdated Educational Standards, Inefficient Efforts and Lack of Coordination to Prepare New Ones***

***ED #5: Absence of Educational Standards and Courses for Specialties Needed for the Smart Grid***

According to the Ministry of Energy of the Russian Federation, the situation with the staff in the energy sector is characterized by a general shortage of skilled workers and engineers. The projected annual power industry demand for specialists (including training) until 2015 will comprise 12.3 million people and during the 2015-2030 period 15.8 million persons. More than that, the existing structure and direction of training specialists do not meet the needs of the industry and needs a serious revision.

The leading power companies, such as FGC UES, IDGC Holding, RusHydro, in cooperation with relevant universities, actively recruit young people into the industry, create personnel pools of young specialists, and invest in educational facilities and infrastructure. This process has received mixed evaluations, but demonstrates good progress – which indicates that training and recruiting of specialists for *current* technical and technology needs is more or less a solvable issue. But it does not encompass all of the needed specialties.

Much bigger challenges are seen in the training and recruiting of specialists needed to support Smart Grids development and operation, since:

- New technologies, changes in the energy system and conditions of energy industry operations requires development of new complex skills, knowledge and competences;
- Educational institutions need new educational methods, practices, standards, courses – and a comprehensive approach for their development, while reforming of Russian educational institutions needs to continue and their efficiency is generally low;
- Abovementioned problems and processes are aggravated by the fact that only basic technology and market development trends are seen by educators and industry leaders. So no precise requirements could be formulated for long-term educational activities.

## ED #1: Uncoordinated Approach to Energy Industry Educational Policies

Even though much has been done in previous years to reform and support educational institutions, the Ministry of Education and Science and the Ministry of Energy educational efforts are insufficient to provide the needed support and framework conditions for the development of new skills and competences.

One of the main reasons is the absence of a coordinated position among industry actors on competences for future needs. In USSR these efforts were executed by the Ministry of Energy and after 1991 – by RAO UES. The “Split” of RAO UES leads to some disorganization of educational activities and industry requirements for the educational system, while the Ministry of Energy has failed to lead the initiative. Federal funds investment in education and training was also insufficient. All of this has led to the inefficiency of public training and the educational system. A sign of this are the huge investments made by Russian businesses (in general) in training and education - RUR500 billion (about $15 billion; the Ministry of Education and Science estimates) – more than public investments.

Recently, a special coordination mechanism has been formed between the Ministry of Energy, Ministry of Education and Science, educational institutions and energy companies, which could help solve this problem.

### ED #2: Universities Lack Skills, Knowledge, Competences and Infrastructure for Perfecting their Educational Practices

In expert opinion, and some stakeholder`s estimates, universities also didn`t take a lead in catching industry trends, being concentrated only on financial survival – getting more corporate and ministries` funds in times of stranded budgets while minimizing “expenses” – by reproducing or just modifying old courses and educational standards.

According to the companies one of the reasons for this is a lack of direct responsibility of universities for the professional characteristics of their graduates, as well as, a lack of assignment of graduates. For example, as one industry representative pointed out, less than half of energy department graduates enter power or network companies.

An even more problematic situation is in the Smart Grid specialties. “Smart” technologies and competences are only discussed in a "piecemeal" fashion within individual courses. There is no comprehensive system of education on the Smart Grid in the vast majority of universities and faculty members are generally unaware about the latest developments in this sphere.
This situation can be explained by several reasons:

- Immature Smart Grid market in Russia;
- Insufficient industry demand for Smart Grid specialists and solutions, lack of targeted federal and corporate support for education and training – due to the fact that Smart Grid policies and practices has only now evolved in Russia;
- Unclear trends, absence of shared vision and national coordinated efforts, which makes the formation of comprehensive courses difficult;
- Small and inefficient cooperation with foreign research and educational institutions, which could help create such courses and supporting activities.

### ED #3: Weak Links between Education and Technology Innovation Activities

The development of courses, standards and educational activities is further impeded by weak links between education and technology innovation activities.

Unlike the USA or EU, the Soviet – and then Russian – education system was oriented mostly on the production of skilled manpower, not R&D. The latter function was generally located at industrial and academic research and technology institutions. So, students at Russian universities *generally* are still not involved in actually developing modern Smart Grid technologies and do not have the needed competences.

The situation is worsened by the above mentioned problems with universities skills and research infrastructure. An additional impediment is an insufficiency of interfaces between industry, academia and universities[xxv] - including industrial R&D organizations, proper regulatory support, etc.

This is why linkages between corporate research laboratories and educational institutions are weak and ineffective, and energy companies – as it was put in the interviews – experience serious problems with forming cooperative relations with science and educational institutions.

During the past 2-3 years Russian Presidents and Government has applied administrative resource to recreate innovative infrastructures for key industries – including research universities, but the process is extremely slow going and its effects are questionable. For example there is a de-facto normative requirement for public companies to rise their expenditures on R&D in universities (for now they are about 0.75-1.5 – 5-7% of corporate R&Ds). But pouring of these new financial resources is not coincided with strict requirements for universities and are growing too fast, so that it does not spur rise of *quality* of universities` R&D.

This situation is aggravated by a weak integration into a system of international university cooperation, which significantly reduces the possibility of acquiring new competencies from foreign partners.

The solution to these problems requires integration of all components of professional and vocational education chain, ranging from companies and the Ministry of Energy and ending with educational institutions, as well as growing international cooperation and creating more strict approach to national research universities development.

### ED #4: Outdated Educational Standards, Inefficient Efforts and Lack of Coordination to Prepare New Ones

One of the most serious problems of Russian Government policy is outdated educational standards. The existing standards are designed without taking into account the new requirements of the industry and are based on a basic list of competences, which has not changed for many years. Power companies are working directly with educational institutions and initiating universities to include the development of additional competences. Such specialized programs are being implemented, as it was said in the interviews, in most of the major power companies, primarily in JSC «FGC UES», OJSC «MRSK Holding», OAO «Rushydro», etc.

Meanwhile, updating and changing these standards remains a problem. First, universities, as it has been said before, do not have the required competencies. Second, the work of the companies and the Ministry of Energy with universities on the standards has no systematic character. Third, the willingness of universities to be flexible and adapt to the new requirements of companies in the power sector is decreasing. The reason is the rapid growth of federal funding for universities, and the forcing of public companies to increase R&D in universities without symmetric growth of the practical requirements to the work of the scientific community.

Rising efficiency of standard development and modernization, changes in educational programs of all levels requires coordination and systematization of industry efforts under guidance and coordination of the Ministry of Energy.

Interviewees mentioned that only now The Ministry of Energy started preparatory work for standards development with energy companies. A decision has been made to cooperate on this issue with the Russian Union of Industrialists and Entrepreneurs (*RSPP*, one of the biggest Russian business associations). The ministry made an obligation to use standards, developed by RSPP with support of industry associations and professional societies as a basis for federal educational standards and professional educational programs.[xxvi]

### ED #5: Absence of Educational Standards and Courses for Specialties Needed for the Smart Grid

Smart Grid specialties appear not only on the cutting edge of new technologies and practices, but also on the borderline of different *current* disciplines. But no educational courses or standards for these new or "borderline" specialties are in place and educational institutions lack specialists on these topics. The most troubling points are:

- Absence of education on integrated energy and information systems (Smart Grid encompasses both disciplines and practices);
- Absence or insufficient education on system modeling and high performance computing for energy industry and system engineering – including life cycle management of equipment;
- Weak economic education of engineers and researchers: Currently, economic knowledge is limited by minimal competences of a feasibility study of projects and investments. Not every university has professors that can teach the system of market relations in the energy industry and reflect the problems caused by the necessity of introducing Smart Grid technologies;
- Marketing and sociology for power companies' officials are almost never studied. Typically, energy companies hire such specialists from the labor-market, and then invest substantial funds in their retraining in the frame of continuous education;
- Standards are weakly oriented to train specialists in the field of energy saving and energy efficiency of companies, at the base of which should be competences of demand management and improvements in the efficient use of resources.

# 11. GRID MODERNIZATION

The electric power grid is a base for Smart Grid technology implementation, as the grid infrastructure should ensure the possibility to realize all functions of a new concept. Industrial experts point out that for now the grid infrastructure is not ready for the full-scale Smart Grid technologies implementation.

The nature of grid modernization in Russia is determined by its history: the power system of Russia (the USSR) was developing as a unified one with a high level of strategic planning and operation centralization, which ensured the most efficient industry operation and development. As a result, Russian power grids are significantly different from those in the U.S. and Western Europe by their structure, topology, voltage types used, regimes, automatic control types and other parameters and qualities. In distinction from other international world power systems, the power system of Russia provides:

- Parallel operation of power plants for the combined daily load curve of regional customers
- Unified dispatch capacity reserves
- Unified dispatch administration of the power plants and network installation.

The high-powered real-time Automated Dispatch Control System (ADCS or SCADA according to the European terminology) not only on the level of energy enterprises, but also on the level of regions and the whole country is a factor which seriously influences implementation of Smart Grid technologies.

On one hand, it provides some kind of credits for the Russian power sector for the implementation of Smart Grid technologies, as the task of technological integration and/or coordination of isolated local power grids was completed primarily (at the beginning, a priori). On the other hand, experts identify a number of obstacles in the way for implementation of the Smart Grid technologies and realization of new functions of the power system:

***GM #1 High Ratio of Grid Equipment Depreciation and Contradiction between Modernization and Innovations***

***GM #2 Rising Regulator`s Requirement for Reliability***

***GM #3 Lack of High-Level Industry Coordination***

***GM #4 Lack of a Unified System of Normative-Technical Requirements and Technical Policy in Support for Development of the Energy Sector***

***GM#5 Lacks of a Unified Approaches, Development and Deployment Policies among Key Network Companies***

***GM # 6 Geographical Differences as Requirements for Standard Projects***

***GM #7 Regulatory Gaps***

***GM #8 Technology Gaps on the Side of Russian Vendors***

***GM # 9 Underdevelopment of Financing Mechanisms for Network Upgrades***

***GM #10 Lacks of Skilled Workers Ready to Work with Smart Grid Technologies and a Lack of System of Education and Training.***

***GM #1. Integration of Energy and ICT Technologies, Competences and Practices***

## GM #1 High Ratio of Grid Equipment Depreciation and Contradiction between Modernization and Innovations

Key efficiency indicators of the Russian energy system (share of losses in T&D sector, share of innovative equipment, etc.) is 2-2.5 times less than in most developed economies.

Evaluating the technical condition (state) of grids, experts point out, that for today depreciation ratio of capital goods of national power grids in general is about 62% (for FGC UES Grid – 48.5%) with machinery and equipment depreciation ratio as high as 73% (for FGC UES – 70%), installations - 58% (for FGC UES – 37,8%). As of today depreciation of MRSK Holding Grid is around 69%[xxvii].

These high depreciation ratios are explained by insufficient investments in grid modernization in 1990s and use of technologically obsolete equipment for considerable part of new construction and renovation projects at the end of 1990s-beginnig 2000s. And it is important to note that because of lack of investments, technological gaps and urgent need for renovations very diverse equipment was installed on grid facilities, while still technologically outdated.

Meanwhile high depreciation ratio and use of *diverse* and technologically outdated equipment prevents use of most advanced Smart Grid solutions, since new equipment and technologies should be compatible with old ones, which is not always feasible. Problem could be solved only through huge investments and extensive program of pilots across Russia, including microgrid construction (for real-life testing new equipment, its compatibility, etc.). But due to some financial and market limitations (see "Market" Section) as for 2012 only several and mostly large-scale pilot projects were in place or ready to start: in the United Energy System of the East (Elga Ugol and Vanino Energy Clusters, etc.) as for FGC; and Belgorod "Smart City", Yantarenergo, Perm Smart Metering Project and some others of Holding IDGC. Ambitious plans for pilots were heralded in FGC UES Program for Innovative Development (2012 version), but they are still in conceptual, not in investment phase.

Still observed excessive attention paid to modernization process (mostly old equipment replacement) also create some additional challenges for Smart Grid development. It derives resources from essential system-wide technology *innovations* and impedes realization of new strategy and practices of grid *renovation*.

It will take years to overcome this impediment. Currently Russian Ministry of Energy prepared the Draft of "The Program of Modernization of the Russia Power Industry up to 2020" with planed financing at the level of RUR8.2 trillion (about USD270 mln). About 40% out of this amount will be spent for the grid modernization. [xxviii]

An optimal balance between equipment, systemic and technology modernization should be found. Advocates of Smart Grid development in Russia were able to significantly expand the frames of the Program to ensure technological continuity during the transition from existing to new power generation technology at the lowest possible costs. But much more is needed – considering also regulators approaches to grid development.

## GM #2 Rising Regulator`s Requirement for Reliability

There is an objective to improve network reliability by reducing the number of cut-offs of the consumers and losses by 25% (equivalent to 40 billion kWh). And federal requirements and penalties for non-compliance to this requirement have now become much tougher. If earlier fines for failure to comply with the Government performance reliability targets were 2% of the gross income – now they have grown to 15%. The reasons for this are: a) the high level of depreciation of Russian grids that makes them vulnerable to technological failures (especially in the winter); b) very low temperatures lasting for over half a year; c) the attention of the Government to security of energy supply and the associated social risks.

Experts expressed the opinion that high nertwork depreciation, strict reliability requirements and penalties create an increased risk to the investor, who may prefer carrying out technical modernization and refurbishment instead of implementing innovative technologies in development of the power network.

### GM #3 Lack of High-Level Industry Coordination

As many interviewees mentioned, after the termination of RAO UES Russia's energy industry still lacks coordination or a single decision-making center. This results in the lack of a shared vision, shared responsibilities, and fragmented decision-making and investment processes in Grid Modernization. There is no clear understanding of future development mechanisms, instruments enabling energy industry functioning, as well as a regulatory and normative base for this process.

As for 2012 there were at list 3 bodies and institutions, claiming the role for Smart Grid development coordination (regulatory, conceptual or organizationally) across all industry subsectors. Among them are Russian Energy Agency and its Technology Platform for Intellectual Energy System of Russia, non-for-profit institution "Invel", FGC UES and others – not considering Ministry of Energy. But actual successes in industry coordination of all these actors were at best moderate (see also "Smart Grid Concept" and Market" Sections).

In the federal level only now New Vice-Prime Minister for energy Arkadiy Dvorkovich expressed in October 2012 clear and practical interest in rising coordination of power industry innovation policies, but as for now the process is done in a more bureaucratic mode, than on industry consensus or goodwill. Thus, effectiveness of these efforts is yet to be evaluated.

Some federal technical coordination and leadership efforts are seen on the practical level too. For example in 2009 a new federal project "Calculate. Economize. Pay" under the auspices of high-level Presidential Commission for Modernization and Technological Development was initiated in support of Smart Metering initiatives. (The project gets full support of IDGC Holding, its subsidiary Ural IGGC and CJSC "KES" Energy Company). However, despite it has great significance for 2012 Ural IDGC Smart Metering Program in Perm city, the Commission still did not initiated other large-scale Smart Grid initiatives. So, in order to affect coordination of the Smart Grid initiatives significantly, all federal efforts need to be scaled up and be systematized.

All of these factors greatly impede the transition to Smart Grid technology and makes the process of its development and deployment unclear and uncoordinated – creating additional risks of technical de-harmonization, investment failures, etc.

## GM #4 Lack of a Unified System of Normative-Technical Requirements and Technical Policy in Support for Development of the Energy Sector

This problem is one of the most acute. It includes a lack of:

- National standards for power equipment which take into account the new requirements for this equipment, as well as national standards for power systems reliability, and of data transfer from smart meters (See also in "Data and Analytics" Section).
- Technical, safety, electromagnetic and environmental compatibility requirements for power equipment.
- Normative-technical support in the area of modern power equipment;
- Technical requirements for diagnostics of modern power substations and transmission lines equipment;
- Requirements for power quality, clear division of responsibility between the actors according to the degree of their influence on power quality.
- Still absence of officially adopted unified standard and protocol for data transfer (preferably IEC 61850).

This de-coordination and de-synchronization of technical policy spurs all over energy sector: between companies and between different industry subsectors (e.g. between grid companies, grid and generating companies, etc.) and between energy companies and customers.

Several attempts were made to overcome this situation. One of that is a respective effort of G.M.Krzizanovsky Energy [Power] Research and Development Institute (ENIN). But as for 2012 these practice did not reap enough successes.

Meanwhile, according to the interviewee's point of view, it is necessary to develop a *system* of federal standards for Smart Grid technology development. Effectiveness of this process depends on cooperative efforts of all industry actors with high-level support and coordination of government bodies – similar to DoE, NIST and EPRI efforts in the USA. But cooperation is traditionally a weak point of the Russian business community, as well as guidance on behalf of the Ministry of Energy and other regulators.

Today, there are only limited efforts in this direction – although they are more and more meaningful. In particular, FGC UES initiated in 2012 the development of a reference Smart Grid architecture (a NIST-like initiative) for a pilot project in the Energy System of the East – with extensive communication with industry experts and actors. New legislation is announced where network companies, customers and marketing companies would be defined as Smart Grid market participants, which should ease the standardization process, at least in the AMI segment. New coordination initiatives are started by Vice-Premier A.Dvorkovich (see also above). However, a more comprehensive, sustainable and consistent measures are needed to solve existing problems.

## GM#5 Lacks of a Unified Approaches, Development and Deployment Policies among Key Network Companies

Programs to implement Smart Grid technology are not in agreement on a number of priority areas in two key energy sectors –power transmission and distribution:

- Priority development of individual technologies and their solutions;
- Deadlines for their implementation
- Compatibilities of technological solutions.

FGC UES has the Smart Grid Development Concept as a guiding document while as for 2011-2012 IDGC Holding was only engaged in formalization of this document without any obligations to use it.

The prospective plans for the development of Smart Grid technologies also vary significantly in different sectors of the power industry.

For example, at the level of the backbone network infrastructure of FGC UES there are plans to create a 100% automated system. At the same time, IDGC Holding general plans also include fundamental improvement of system automation, but its implementation is going slower. If the 110-220kv networks are largely automated, "intellectualization" of the distribution networks of 6, 10, 20, 35 kV are at an extremely low (basic) level. As a result, the effects of automation at the network level as a whole will be significantly lower.

This has had a negative impact on the deployment of Smart Grid technologies and development of Smart Grids technologies in Russia.

Only in 2012, after decision of Russian Government to merge these two companies, positive solutions of this problem get some prospects. The new company (as decided in November 2012), JSC “Russian Grids” would appear in first half of 2013. But still the development and implementation of practical mechanisms for coordination of technology and innovation policies of these two companies will take at least a year.

## GM # 6 Geographical Differences as Requirements for Standard Projects

The other side of the problem of the non-synchronized technological development of the industry is the need for a differentiated approach to the deployment of Smart Grid technologies, depending on the location and characteristics of the network infrastructure.

In the European part of the country, the electric network is developed to a larger extent and is, basically, a complex multi-contour structure providing a high enough level of reserve capacity and capable of serving the region’s large load centers. One peculiarity of the electric network structure in the West, Center, and South of Siberia is the significant length of the transmission lines due to territorial the remoteness of the major industrial and power centers, emphasizing the priority to reduce transmission losses. The electric network in the East of the country is the least developed, and has a low level of reserves that prioritizes the development of distributed generation technologies in this region.

From the point of view of the development of Smart Grid technology this creates additional difficulties in developing model solutions, taking into account the specifics of the region, the possibilities of their interconnection, and getting the maximum effect from their integration into the Unified Energy System.

## GM #7 Regulatory Gaps

Implementation of several Smart Grid programs (such as Smart Metering in Perm) and analysis, made by several vendors that consider entering Russian market with energy storage and other Smart Grid technologies, points on important regulation gaps, preventing development and deployment needed technologies. Among them most important are the following gaps in regulations:

- For active consumers and Demand Response and Demand management.
- For prosumers and energy storage solutions (for energy arbitrage and system services). In Russian regulations there are two distinct definitions – for load-controlled consumers and for generators that do not coincide, thus preventing both models to actualize.
- Real-time or near-real time market and other corresponding issues (see “Market” Section for a more detailed analysis) and others.

Solution for this problem lays in extensive piloting program and coordination of industry efforts in order to change current or create new regulations. However lack of federal support and leadership, as well as current low cooperation ability of companies hinders this process.

## GM #8 Technology Gaps on the Side of Russian Vendors

Technology gaps of Russian vendors, as well as absence of production of several equipment types in Russia create some impediments for deployment of Smart Grid technologies too. For example experts expressed opinion, that use of electromechanical devices instead of STATCOM systems in the grids was motivated by the fact that Russian companies do not produce neither power electronics, nor STATCOM systems (industry officials fear that operations of these systems couldn`t be properly supported).

To solve this problem an extensive programs for technology and production localization are in place among all industry actors, supported by normative goals to raise share of Russian vendors in equipment acquisitions of energy and infrastructure companies.

## GM # 9 Underdevelopment of Financing Mechanisms for Network Upgrades

The primary financial mechanism currently being used by network companies is moving toward rate-making based on return on invested capital (RAB regulation). Despite all of its advantages, it cannot be regarded as the only source, because all the burden of the costs for innovations will fall directly on consumers. Introduction of RAB regulation leads to the growth of tariffs for the transmission and distribution of power and therefore should be accompanied by more stringent requirements for their effectiveness.

There is a lack of complementary financing instruments in addition to the RAB regulation.

First of all it could be one of the most effective and most used international mechanisms of co-financing: attracting consumers' funds. Its development in Russia can allow the partial reallocation in dynamic volumes of the investment load on the tariffs of network organizations.

At the same time, the search for the best financing instruments is complicated by the significant difference in profitability and the risks of long-term investments in regulated and competitive activities, which makes difficult to attract investors to modernize the network (this aspect is addressed in the Market section).

The draft Russian Power Industry Modernization Program by 2020 offers a solution to the problem through the attraction of external resources to the capital markets via mechanisms of corporate and project financing (loans, bonds issuance, shares emission), as well as other mechanisms for strategic investments (for example, co-financing together with large consumers).

### GM #10 Lack of Skilled Workers Ready to Work with Smart Grid Technologies and a Lack of System of Education and Training.

This problem is relevant both for on the job training and for the system of professional education (discussed in detail in the Chapter Education). According to one interviewee, it will be impossible to provide the necessary numbers of workers for the maintenance of power facilities, working according to the technologies which are mostly in use today.

### GM#11 Integration of Energy and ICT Technologies, Competences and Practices

Globally, as most interview participants believe, a gradual integration of energy and information technologies is a future challenge. For now this educational, technological and competences segment is underdeveloped. The ultimate goal is the development of an integrated energy-information network.

For example, new specialized information portals will provide real-time data and analysis about all stages of power production and consumption (peak load shift, volume of losses, resource consumption, centralized and distributed generation data, power interflows data, transmission capacity, security of energy supply, etc.) and manage complex energy systems.

In solving this problem the most attention should be paid to educational programs and standards and new R&D efforts, since they form the knowledge and competences basis of future developments.

However as for now only moderate successes in development of new appropriate educational courses and educational standards are made by Russian universities. General analysis of key energy universities reveal that there is no proper "IT in energy" courses for *modern* technologies and prospective industry needs.

Some advances are made with support of industry. For example, in December 2012 IDGC Holding, JSC "System Operator of UES". En+ Group (generator) and Energy Forecasting Agency signed Memorandum with recently established Skolkovo Institute for Science and Technology in support for research and educational activities in the area of Modeling, Analysis and Design of Energy Systems. Important communications are also made between FGC UES and Moscow National Research Nuclear University (MIFI), Moscow Institute of Physics and Technology (MFTI, so-called Fizteh), etc.

But again a more systemic, federal-level approach should be enacted in order to reap full benefits of such effort

# ANALYSIS OF OVERCOMING SMART GRID IMPEDIMENTS IN THE UNITED STATES

## INTRODUCTION

The overarching problem confronting the US electric power system is three-fold: declining reliability, increasingly inefficient use of capital, and an industry paradigm that fails to prevent both. The Smart Grid strategies being discussed and employed in the US will address these problems, but there are impediments to their implementation.

The declining grid reliability, and economic inefficiency, in the US electric power system has **significant consequences for** commercial and industrial customers  Studies indicate that **declining reliability from outages and power quality issues** in the commercial and industrial sector result in business losses estimated to be from $80 billion to  $150 billion per year. Commercial and industrial customers pay approximately $200 billion of the nation's total electricity bill of $369 billion, an amount equivalent to 55%. An additional $100 billion cost to these customers results from outages and power quality deficiencies.

The expectation of consumers is that the electric power industry makes efficient use of capital because, in the end, the US consumer is providing this investment through payment for electricity.  Today, the generation asset utilization rate is 45% (Figure US-1) and the transmission asset utilization rate is slightly less at 43%, based on actual energy produced and transmitted when compared to design capacities.

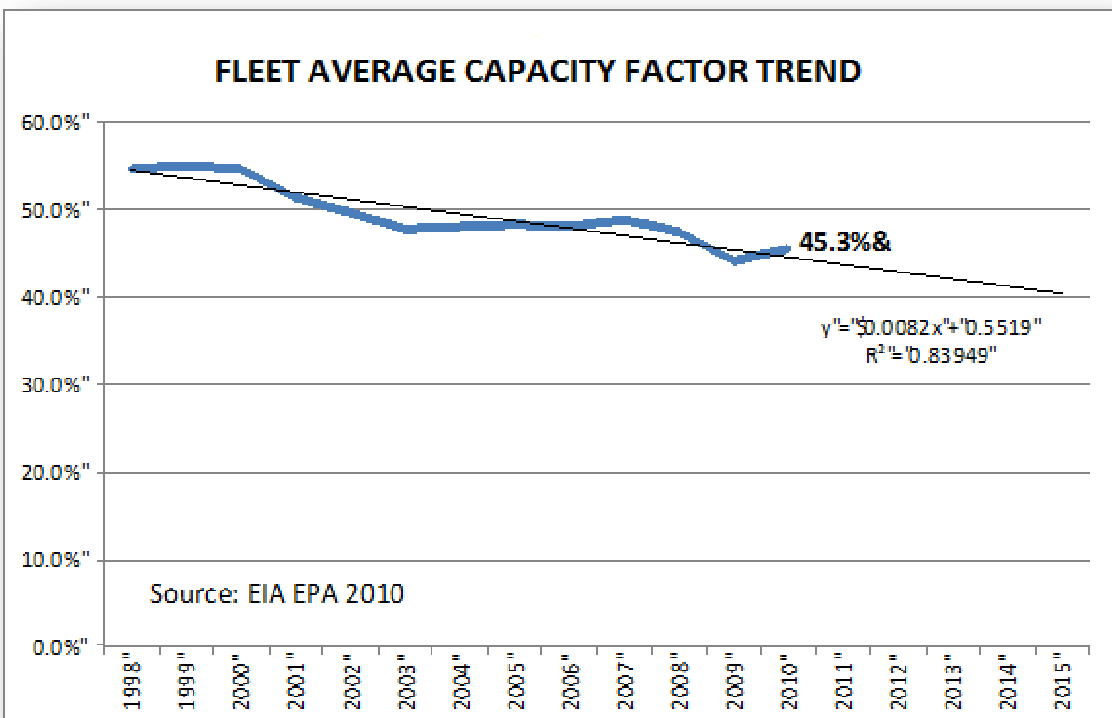


Figure US-1Bulk Power Fleet Average Capacity Factor Trend

Consumers' expectations for high reliability allows the industry to maintain high capital expenditures and a low asset utilization rate, thus lowering capital efficiency for reasons of reliability. It seems intuitive that the cost of high reliability would be lower capital efficiency. In contrast, the US electric power system demonstrates both falling capital efficiency and falling reliability.

This trend, which features a long-term increase in generation capacity and a long-term decreasing capacity factor is unsustainable in the US**.** The declining trend in generation fleet capacity factor is a heavy cost burden on consumers. The fleet capacity factor (see Figure US-2) indicates that for every 1 MW of power at the point of delivery, the industry must build and operate (and consumers fund) 2.2 MW of capacity at the point of production.

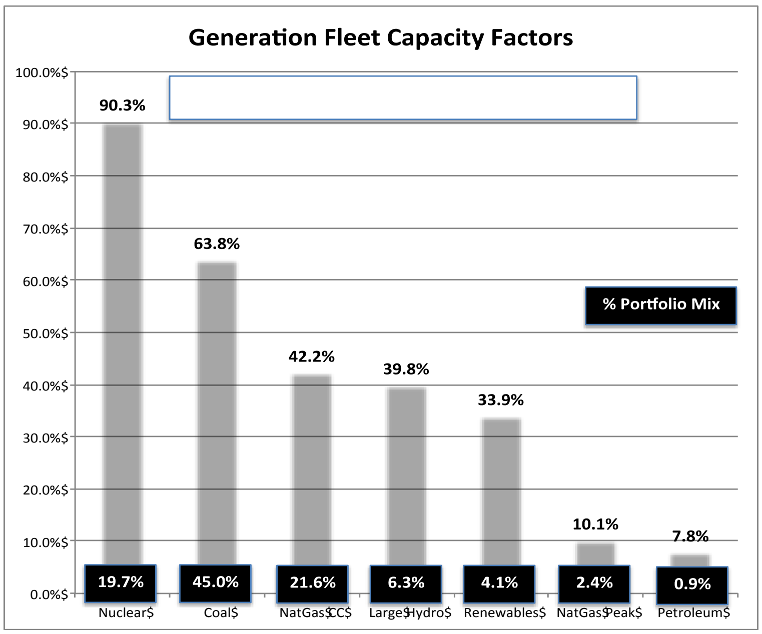


**Figure US-2: 2010 US Central Station Generation Fleet Capacity Factors by Type**

This issue is not a technology issue, but one based in traditional perspectives about generation and its vision about the complete portfolio of generation.

Investor-owned utilities (IOU) provide electricity services to 70% of the nation and are regulated by state public service commissions. The commissions regulate a rate of return on investment by the IOU, which is founded in a cost-basis. The cost-basis is essentially a sum of the investments made over time to build electrical infrastructure. As infrastructure assets depreciate, the cost-basis decreases and the IOU is motivated to invest in more electrical infrastructure to maintain the depreciating cost-basis. This is the primary contributor to the declining asset utilization since 1980. The bulk electric power system reliability and interstate commerce of bulk power have been regulated by federal authorities. Until the advent of organized wholesale markets in the last decade, federal regulation focused on reliability, with little attention to economic efficiency of the system. With the advent of organized markets, economic efficiency is now part of the equation at the bulk power level for 60% of the nation.

The third part of the overarching problem is the industry paradigm common among regulators and utility leaders dating back to the Public Utility Holding Company Act (PUHCA) of 1935. PUHCA was enacted to encourage large utility investments in electric power infrastructure, which have long payback periods, by protecting exclusive territorial rights of the utility. The goal was to electrify the nation for commerce and the public good. There is no question that this endeavor was an economic and social success. However, the US was essentially electrified by 1980, leaving regulators and industry with a **"build assets" culture.**

There were no system performance requirements established in PUHCA, as its purpose was to build, not necessarily perform efficiently. Thus, the 45-year culture established an institutionalized inefficiency of sorts. It will be difficult to change the long-standing regulatory approaches, utility business processes, decision points, and stockholder perspectives on utility company value. A change would require regulatory and industry concurrence about establishing and enforcing electric power system performance against metrics encompassing reliability, capital efficiency, and emissions.

In hindsight, the "build assets" culture could have transitioned to a "system efficiency" culture in the 1980's. Unfortunately, federal and state policies continue to support the build asset culture, and fail to drive economic efficiency in the electric power system. With declining asset utilization, declining reliability metrics, and increasing costs, the US needs to develop and implement new policy for economic efficiency and reliability of the system.

The following analysis of the impediments and drivers in the US considers the power system and stakeholders. The analysis combines previous analyses and detailed interviews with industry leaders across the entire spectrum of industry stakeholders. The analysis focuses on views held in common by multiple stakeholders and previous research, and thus are not attributable to a single source.

*Regulatory – Regulators have limited resources to address new Smart Grid concepts.*

*Market – Smart Grid will create new opportunities to integrate the wholesale and retail markets.*

*Consumer – Education is needed to help customers understand and support Smart Grid concepts and opportunities.*

*Technical – Smart Grid success depends on the integration of processes and technologies to achieve optimization goals.*

*Social / Society – The Smart Grid vision provides for substantial societal benefits by optimizing around the key value areas.*

*Operations –The decentralized Smart Grid operating concept enables better optimization.*

*Education – New skills are needed to support the new Smart Grid concepts—additional education will be required at the university as well as OJT levels.*

# 1. SMART GRID CONCEPT

The smart grid is a complex "system of systems" and has been defined in a variety of ways. The US Department of Energy (DOE) began its Smart Grid concept development efforts in 2005 as part of its Modern Grid Initiative (MGI). Concepts were developed around seven Principal Smart Grid Characteristics:

- *Enable* active participation by consumers
- *Accommodate* all generation and storage options
- *Enable* new products, services, and markets
- *Provide* power quality for the digital economy
- *Optimize* asset utilization and operate efficiently
- *Anticipate & respond* to system disturbances (self-heal)
- *Operate* resiliently against attack and natural disaster

Additional Smart Grid definition and functionality was codified in the Energy Independence and Security Act of 2007. This law incorporated the concepts developed by the MGI and expanded the depth of detail in describing the functions of the Smart Grid.

This early DOE work established the general concepts of a Smart Grid, but recognized that this vision and associated concepts was merely a framework from which regions, states, and electric service providers could begin to develop their specific Smart Grid vision and roadmaps. From the beginning, it was clear that "one size does not fit all" given the diverse considerations that exist across the US.

These diverse considerations present challenges to the development of the Smart Grid across the US. Although the vision and concepts developed by DOE provide a standard framework for the Smart Grid, extensive additional effort is required by the electric service providers to develop company- specific visions and roadmaps, work with regulators and customers to gain their understanding and alignment, decide on specific process and technology changes, manage the staff to accomplish their routine activities in addition to building out the Smart Grid, and lead the substantial change management effort required for such a large endeavor.

**SGC #1: The Objective of the Smart Grid is not Clear to All Stakeholders.**

**SGC #2: Smart Grid Performance Goals and Metrics are not Available at the Federal, State and Local Levels.**

**SGC #3: The Lack of Standard and Simplified Road-Mapping Methods Diminishes the Potential for Actionable Smart Grid Policies and Projects.**

**SGC #4: Ineffective Change Management Prevents Alignment of Smart Grid Stakeholder Visions.**

**SGC #5: Residential Consumers are not Seeing the Benefit of Smart Grid in States without Retail Choice.**

**SGC #6: Current Research Initiatives Are Insufficient to Drive Next Generation Smart Grid Technologies**

## Impediments and Issues

The Smart Grid transformation represents a major change to how the US grid will be planned, designed, operated, and maintained. Customers will experience changes in how they interact with their electric service provider and how they will manage their consumption. A successful Smart Grid transition will provide substantial opportunities and benefits to both individual consumers and society as a whole.

One of the most significant challenges to a successful utility Smart Grid transition is managing the changes that will be experienced by all stakeholders. The first step is to gain a common understanding among all stakeholders. The complexities of the Smart Grid make even this quite difficult.

A number of issues in the Smart Grid Concept area have been identified:

**SGC #1: The Objective of the Smart Grid is not Clear to All Stakeholders**. Although a great deal of work has been done to communicate the benefits (and costs) of the Smart Grid to stakeholders, its overall objective needs to be further developed and communicated.

**SGC #2: Smart Grid Performance Goals and Metrics are not Available at the Federal, State and Local Levels,** but are needed in key metric areas to align the various stakeholders to a common set of outcomes.

**SGC #3: The Lack of Standard and Simplified Road-Mapping Methods Diminishes the Potential for Actionable Smart Grid Policies and Projects.** These methods should address the technical, regulatory, economic, customer, and cost recovery aspects of the proposed Smart Grid project plan and should be vetted with key stakeholder groups.

**SGC #4: Ineffective Change Management Prevents Alignment of Smart Grid Stakeholder Visions.** The Smart Grid transformation represents a significant change management challenge. Most transitions that create significant change fail if fundamental change management steps are not followed.

**SGC #5: Residential Consumers are not Seeing the Benefit of Smart Grid in States without Retail Choice**. Retail energy suppliers in states with retail choice are advancing Smart Grid concepts rapidly and are providing residential consumers with many new choice and options.

**SGC #6: Current Research Initiatives Are Insufficient to Drive Next Generation Smart Grid Technologies.** Additional research and development is needed to ensure that commercialization of the processes and technologies needed in the future is achieved in time to meet Smart Grid milestone dates

**Analysis**

### SGC #1: The Objective of the Smart Grid is Not Clear to All Stakeholders.

Defining the objective of the Smart Grid is necessary to gain the interest of its stakeholders. Key value areas have been identified and include creating the intelligence and capability to optimize:

- ***Reliability*** in terms of frequency and duration of service disruptions and the quality of power
- ***Economics*** for the electric service provider, its consumers, and society
- ***Efficiency*** in the production, delivery and consumption of energy
- ***Security*** and robustness of operations both physical, and cyber
- ***Environmental*** impacts and opportunities to incorporate clean energy technologies
- ***Safety*** for workers and the public

Clearly these value areas are not always in alignment and therefore the challenge is to optimize around them in a manner that meets agreed-to priorities and goals. The degree to which each value is

improved will depend on the agreed-to optimization criteria, i.e., a common understanding of which values have the highest priority.

Defining the optimization priority and criteria and gaining consensus may be different by region, state and even at the electric service provider levels. For example, is there a standard regulatory model that best supports optimization? Should the wholesale market model be applied at the distribution level? Is improving the economics of the Smart Grid more important than developing new methods for improving its environmental stewardship capabilities? Do any of the key value areas "trump" others? Should a specific stakeholder group have more "say" on the optimization criteria, i.e. the consumer, the regulator, the electric service provider?

### SGC #2: Smart Grid Performance Goals and Metrics are not available at the Federal, State and Local Levels.

Once the optimization criteria are known, it is necessary to identify specific goals and metrics to guide the Smart Grid transformation. Some goals are best applied at the national level if their achievement is common to all smart grid visions. Caution should be exercised to ensure that goals and metrics that are dependent on the outcome of Smart Grid road-mapping efforts at the regional, state, and electric service provider levels are left for those entities; otherwise stakeholder alignment may not occur. Fundamental Smart Grid goals and metrics aimed at defining how best to optimize the key value areas have not been identified at the national level.

### SGC #3: The Lack of Standard and Simplified Road-Mapping Methods Diminishes the Potential For Actionable Smart Grid Policies and Projects.

The Smart Grid Maturity Model (SGMM) is an example of a proven tool for assisting electric service at the state level, a number of states have implemented renewable portfolio standards (RPS) and Energy Efficiency standards and some are discussing standards for peak load reduction. These will help define the Smart Grid optimization criteria for the value areas in which they apply. Standards at the national, state, regional, and electric service provider levels are needed to drive the Smart Grid road-mapping process such that the specific smart grid vision and implementation plans maintain alignment with the overall objective of the Smart Grid.

The work done by DOE's Modern Grid Initiative was a good first step, but additional guidance is needed to assist in the development of specific roadmaps and implementation plans. Standard and simplified road-mapping methods are needed to address the gaps in understanding and decision-making that exist between the Smart Grid concept level and the project plan or implementation level. These methods should address the technical, regulatory, economic, customer, and cost recovery aspects of the proposed Smart Grid project plan, and should be vetted with key stakeholders groups. Roadmaps should be actionable.

The Smart Grid Maturity Model (SGMM) is an example of a proven tool for assisting electric service providers in defining their specific Smart Grid vision, goals, and implementation plans. The SGMM process (used by > 130 utilities worldwide to date) consists of two facilitated workshops with the key stakeholders at the electric service provider. The first workshop establishes a consensus on the current level of maturity and the second workshop establishes a consensus on the desired future state. Both workshops cause the staff to consider not only the perspective of the electric service provider, but also the perspectives of the regulator, customer, and society. The gaps between the current state and the desired future state are then analyzed to identify the actions needed to achieve the agreed-to aspirations. The well-vetted output can then be used to develop project plans and budgets suitable for the executive strategic planning process. Unfortunately, only about 5% of the 3,300 US utilities have employed Smart Grid road-mapping methods.

Finalization of Smart Grid project plans should be linked with corporate and committed external goals, provide flexibility to allow for new solutions that are identified in the future and create room to maneuver when plans must change or unexpected events occur.

### SGC #4: Ineffective Change Management Prevents Alignment of Smart Grid Stakeholder Visions.

The Smart Grid transformation represents a significant change management challenge. Transitions that create significant change often fail if the following change management steps are not followed:

- ***Understanding*** to ensure that all stakeholders comprehend the change and how it affects them. Significant effort is required to give stakeholders an opportunity to listen and ask questions, etc. until a common understanding is achieved.
- ***Alignment*** requires all parties to listen to each other, understand areas of disagreement, and demonstrate flexibility in negotiation without giving up on the objective.
- ***Motivation*** is needed to create the interest in stakeholders to advance from the agreement state to the action state. Results will be achieved when these first three steps are successfully completed.
- ***Coaching*** is critical when results are first achieved to provide reinforcement that efforts are consistent with the project objective(s).
- ***Metric monitoring*** is needed to ensure continued success. Exceeding expectations should be rewarded and corrective actions taken when progress falls below the expectations defined by the metrics.

Communication and collaboration are very important throughout the life of the transformation. Creating forums to share best practices and lessons-learned, identifying barriers and solutions, and addressing key technical and policy issues across the broadest possible spectrum of constituents is one way to improve collaboration among stakeholders. Comprehensive consumer education efforts are also needed to engage the customers who have a major voice in the Smart Grid stakeholder community.

Gaining understanding, alignment, and motivation among all stakeholders is a challenge because not all stakeholders believe they will benefit—in fact some believe they may be losers. For example, some shareholders expect to see a positive impact in earnings and stock price, consumers expect to see new options and lower prices, generators may see additional competition for production, regulators may not have time or resources to address needed changes to regulations, investor-owned utilities may be concerned about loss of kWh sales, etc.

The consistent application of an effective change management program that addresses these fundamental aspects is essential to create and sustain results that are consistent with Smart Grid objectives.

### SGC #5: Residential Consumers are not Seeing the Benefit of Smart Grid in States without Retail Choice.

Retail energy providers (REP) in states with "retail choice" are advancing Smart Grid concepts rapidly and are providing residential and small commercial consumers with many new programs. Retail energy providers in states like Texas are accelerating the deployment of Smart Grid processes and technologies. For example, one interviewee related how REP are offering pricing programs similar to the cell phone model (free Saturday's, reduced evening rates and other time of use pricing, etc.) to create value to residential customers that is difficult to accomplish in regulated states. REP process metering data from smart meters into bills, reach out to residential consumers to gain their subscription, and deliver services that are currently difficult for electric service providers to offer.

In regulated states (without retail choice), the agility of electric service providers is limited. For IOU's in particular, the concerns over cost recovery and the complexities of the regulatory processes greatly slow the progress and flexibility that are readily provided by REP in the deregulated states.

### SGC #6: Current Research Initiatives are Insufficient to Drive Next Generation Smart Grid Technologies.

The Smart Grid vision is a long-term vision—many years will be needed to fully implement it. Many of the processes and technologies that are needed in the future are not yet commercialized. Additional research and development is required in these areas to ensure that technology commercialization meets Smart Grid milestone dates. Some examples of technologies include the operation of electric vehicles in the "vehicle to grid" mode, widespread application of Phasor Measurement Units (PMUs), microgrid design and operation, and the possible use of Regional Distribution Organizations (RDOs) to support the operation of a decentralized grid where the dispatch of distribution level resources (sources and load) will be required. Possible future applications of combined heat and power resources should also be evaluated for use in the US.

## 2. MARKETS

One of the Smart Grid Principal Characteristics defined by DOE is "Enable new products, services and markets". This characteristic addresses markets from two perspectives. First, the Smart Grid is expected to create an infrastructure that supports economic development. Second, electricity markets that are leveraged by the Smart Grid will also provide market forces that continuously optimize the power system across the five key value areas of reliability, economics, efficiency, environment, and safety.

Organized wholesale markets in the US preceded the Smart Grid transition and stand to benefit substantially as the Smart Grid matures. Retail electricity markets, on the other hand, have not yet achieved the same level of maturity. Additionally, the linkage between wholesale and retail markets is generally weak.

Substantial opportunity exists in the Markets area and is expected to be realized as the integration of wholesale and retail markets continues.

*MT #1: Dichotomous Wholesale and Retail Electricity Markets Discourage the Benefits of Smart Grid Technology Deployment.*

*MT #2: Inefficient Coordination Between Wholesale and Retail Markets Impedes the Development of the Smart Grid.*

*MT #3: Smart Meters are of Little Value to the Consumer without Time of Use (TOU) Retail Electricity Market Rates that Reflect True Prices.*

*MT #4: Current Retail Rate Structures are a Substantial Mask on the True Costs of Delivered Electricity and Skew the Smart Grid Business Case.*

*MT #5: Only States that have Undertaken Deregulation are able to Accrue the Smart Grid Benefits Afforded by Retail Energy Providers (REP).*

*MT #6: Uncertainties Related to Energy Efficiency, Demand Response, Consumer-Owned Generation, and other Smart Grid Enabled Behaviors Challenge Planning Processes and Make Questionable the Long Term Benefits of Smart Grid Investment.*

*MT #7: Inconsistent Coordination among Federal, State And Local Regulators Impedes Development of Smart Grid Technology.*

**Impediments and Issues**

**MT #1: Dichotomous Wholesale and Retail Electricity Markets Discourage the Benefits of Smart Grid Technology Deployment.** As the Smart Grid evolves to a more decentralized operating model, where generation and load resources on the distribution system are economically dispatched in concert with the needs of the transmission system resources, there will be greater need for these two markets to interact.

The wholesale markets have evolved substantially in the US. Many lessons-learned and best practices have been identified that should be helpful to its integration with retail markets and to the Smart Grid transition in general. But, a complete and efficient integration of the wholesale and retail markets faces a number of challenges in the US.

**MT #2: Inefficient Coordination Between Wholesale and Retail Markets Impedes the Development of the Smart Grid.** A number of barriers exist that prevent efficient interaction between markets. Regulatory jurisdictions and policies are complex and often unclear. Pricing mechanisms in the wholesale and retail markets are not aligned to support efficient inter-market operation.

**MT #3: Smart Meters are of Little Value to the Consumer without Time of Use (TOU) Retail Electricity Market Rates that Reflect True Prices.** Many industry stakeholders see the advanced metering infrastructure (AMI) as the foundation of the Smart Grid in the US, and this has been the industry focus for the last 5 years. Smart meters without smart pricing will provide only limited value and will not allow for coordination between the wholesale and retail markets

**MT #4: Current Retail Rate Structures are a Substantial Mask on the True Costs of Delivered Electricity and Skew the Smart Grid Business Case.** Flat rates create cross-subsidy. By far, the majority of US consumers live under a flat retail rate structure; "flat" meaning that the rate does not change throughout the day, or among days, or seasons, or in some cases years.

**MT #5: Only States that have Undertaken Deregulation are able to Accrue the Smart Grid Benefits Afforded by Retail Energy Providers (REP).** The role of retail energy providers in states with retail deregulation is to act as a broker for the electric service provider's delivery customers. In this role, the REP becomes the link that coordinates the wholesale and retail markets. Unfortunately, REP only exist in the few states that have undergone deregulation.

**MT #6: Uncertainties Related to Energy Efficiency, Demand Response, Consumer-Owned Generation, and other Smart Grid Enabled Behaviors Challenge Planning Processes and Make Questionable the Long Term Benefits of Smart Grid Investment.** As the Smart Grid transition moves forward, an increasing number of dispatchable sources and loads will emerge and begin to participate in the market. The long term availability and reliability of these resources create uncertainties in the planning process. Additionally, the degree of customer participation in the market over the long term must be addressed.

**MT #7: Inconsistent Coordination among Federal, State And Local Regulators Impedes Development of Smart Grid Technology.** The Federal Energy Regulatory Commission has actively supported the development of the organized wholesale electricity market. At the retail level, states are regulated by their own Public Utility Commissions, each with different perspectives on Smart Grid and how the markets should interact. Harmonization among the various regulatory bodies is needed to support the coordination between the wholesale and retail markets.

**Analysis**

### MT #1: Dichotomous Wholesale and Retail Electricity Markets Discourage the Benefits of Smart Grid Technology Deployment.

Coordination between wholesale and retail markets is needed to realize many of the benefits of the Smart Grid. A number of barriers limit the degree of coordination. Many of them fall in the regulatory domain.

At the wholesale level much has been accomplished. The wholesale market is regulated by a single entity, the Federal Energy Regulatory Commission, which has supported development of organized markets. RTOs have had adequate time to mature and take advantage of best practices and lessons learned. They have accumulated experience dealing with many of the same issues that face the Smart Grid transition. As a result, wholesale prices are determined in near real time; day-ahead markets are in place; and a number of products are available beyond the traditional energy markets.

At the state level much remains to be accomplished. Each state has its own public utility commission—each with its own priorities, skill sets, interests and perspectives—creating a patchwork of different retail regulatory policies. Commissioners and staff have limited budgets and resources to deal with issues beyond the traditional matters that come before them, i.e. rate filings from utilities under their jurisdiction, customer complaints, etc. They are generally not in a position to fully evaluate the impact of the Smart Grid transition on current regulation or to proactively assess how regulations might need to change to accommodate a coordinated interface between wholesale and retail electricity markets. Even if the state commissions had the resources and priority placed on coordination of the electricity markets it would be a significant challenge to gain consensus among fifty PUCs.

As the linkage between wholesale and retail markets mature through implementation of Smart Grid technologies, RTO operations are enabled to help defer capacity and improve efficiency of dispatch. The use of distribution level resources and systems to serve bulk power ancillary services reduces congestion and peak load. Likewise, with a Smart Grid technology enabled environment, the retail marketplace is better situated to support retail energy providers (REP). Some states have established policies to encourage retail energy providers by establishing goals for specific quantities of energy supplied by them. Many states have established renewables targets for their state's electric power system. In both cases, Smart Grid technology, processes, and systems are the primary enabler for meeting REP and renewable targets with economic efficiency and reliability.

In 2008, the FERC and the National Association of Regulatory Utility Commissioners formed the FERC / NARUC Smart Grid Collaborative to bring the retail and wholesale regulators together. When the Collaborative was originally announced, both FERC and NARUC reiterated their commitment to developing consistent policies for the nation's emerging Smart Grid.

### MT #2: Smart Meters are of Little Value to the Consumer without Time of Use (TOU) Retail Electricity Market Rates that Reflect True Costs.

Prices at the wholesale level are set by the market, but at the state level prices (rates) are generally not market-based. Some experiments have been done at the retail level with dynamic rates that are linked to wholesale prices, but the deployment of dynamic rates, or rates linked to wholesale prices in some fashion, is lagging. Ironically, the deployment of smart meters, which are needed to support the electricity markets in the future, are far ahead of the deployment of "smart rates". Smart meters without smart pricing will provide only limited value and will not allow for coordination between the wholesale and retail markets. Without TOU rates, the smart meter business case is reduced to system benefits.

### MT #3: Current Retail Rate Structures are a Substantial Mask on the True Costs of Delivered Electricity and Skew the Smart Grid Business Case.

By far, the majority of US consumers live under a flat retail rate structure; "flat" meaning that the rate does not change throughout the day, or among days, or seasons, or in some cases years. In contrast to this, electricity costs change as often as every five minutes (locational marginal pricing at the wholesale market level) based on many cost factors, such as weather, fuel costs, competition, wholesale electricity prices, variable program costs, seasons of the year, etc. Retail rates should be based on actual cost of service, which is variable by nature. Moving the nation to retail rates based on the true cost of service should minimize cross-subsidies. Recognizing this cross-subsidy issue, one state is working to “de-skew” its higher rates for commercial consumers (as compared to residential consumers) to better match the cost of service, as well as foster economic development.

Current flat retail rate structures remove the incentives for utilities and consumers to participate in Smart Grid strategies, processes, and technology deployment. These rate structures are based on averages and do not incentivize a reduction in load at critical times. To properly implement time-varying rates or dynamic rates, more granular information is necessary to match each hour’s consumption with its specific price (rate). Generally, this granular information is enabled through smart metering. Without more advanced metering infrastructure, dynamic pricing is virtually impossible. The converse is true as well. Smart meters without “smart” rates are not compelling to the consumer.

Standards are needed to ensure that the communication of market pricing signals and bids / offers are consistent and compatible among wholesale and retail market participants. The resulting prices should be adequate to incentivize customer participation at the retail level.

Market integration will be mature when customer sources and loads can monitor real time and day ahead prices and make decisions on when (and to what degree) to participate in the market, i.e. “prices to devices”.

### MT #4: Only States that have Undertaken Deregulation are able to Accrue the Smart Grid Benefits Afforded by Retail Energy Providers (REP).

A number of states have undergone restructuring or deregulation giving their customers the ability to choose their energy provider. In some states, REP has been successful at accelerating the linkage between wholesale and retail markets (enabled by Smart Grid technology). Unfortunately, REP are not allowed to operate in states that have not deregulated their electricity markets. Figure US-M1 below illustrates the patchwork nature of states that are deregulated as of September 2010.

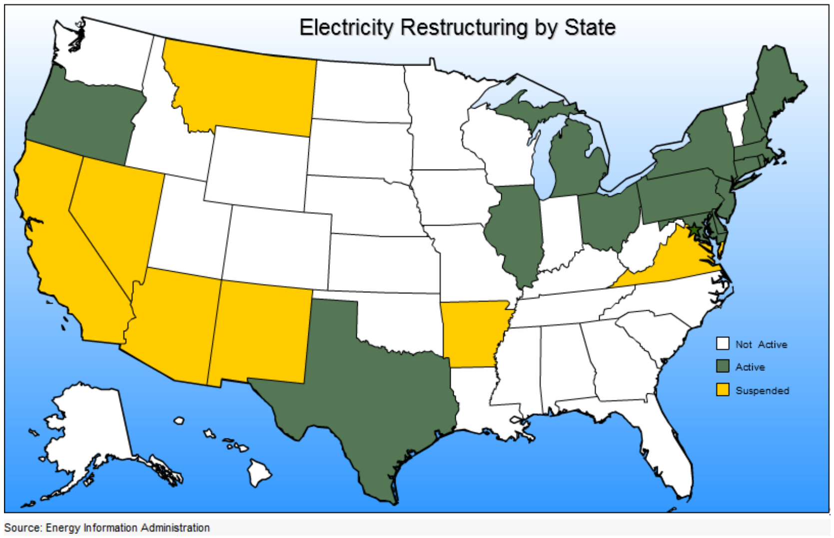


**Figure US-M1: Electricity Restructuring by State**

*http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html*

The role of REP in states with retail deregulation is to act as a broker for the electric service provider's delivery customers. Customers who choose to switch to a different electricity supplier work through the REP to obtain energy supply. The REP contracts with the Regional Transmission Organization (RTO) for energy supply. In this case, the REP becomes the linkage that coordinates the interface between the wholesale and retail markets.

The REP model is very active in some states. Retail energy suppliers are effectively marketing to utility customers and convincing them to switch energy suppliers. Commercial and industrial businesses represent the target customer base for REP to subscribe, but all utility customers are in play. Retail energy suppliers are now offering special time of use pricing programs, including such cell-phone-like programs as "free Saturdays", free evenings, etc. Some REP also provide energy service support to help customers with energy efficiency, heating, ventilation, and air conditioning (HVAC) and distributed generation. The REP model is agile and appears to be successful in its effort to bring the wholesale markets to the retail customers.

Limits have been placed on the REP model. First, they can only operate in states that have deregulated. Interest in state deregulation has declined over the years limiting the areas in which the REP model may be deployed. Some deregulated states in which they do operate have placed limits on the percentage of customers or percentage of utility load that can switch to non-utility provided suppliers.

### MT #5: Uncertainties Related to Energy Efficiency, Demand Response, Consumer-Owned Generation, and other Smart Grid Enabled Behaviors Challenge Planning Processes and Cloud the Long Term Benefits of Smart Grid Investment.

As the Smart Grid transition moves forward, an increasing number of dispatchable sources and loads will emerge and begin to participate in the market. The introduction of these new resources will challenge the system planning process. For example, energy efficiency (EE) and demand response (DR) are alternatives to building new generation; however, the availability and reliability of both are of concern over the long term. The availability of EE and DR depend on whether or not customers decide to offer them to the market. If, in future years a decision is made to not participate, the transmission system may be short of supply.

Another source of uncertainty is the level of market participation by the larger retail customer base. The Smart Grid vision suggests a move to a more decentralized operating model with large numbers of customers (and resources) offering into the market. The impact of this potentially significant customer market participation has not yet been quantified. And, the question of sustainability of that participation is an unknown.

### MT #6: Uncertainties Related to Energy Efficiency, Demand Response, Consumer-Owned Generation, and other Smart Grid Enabled Behaviors Challenge Planning Processes and Make Questionable the Long Term Benefits of Smart Grid Investment.

As the Smart Grid transition moves forward, an increasing number of dispatchable sources and loads will emerge and begin to participate in the market. The introduction of these new resources will challenge the system planning process. For example, energy efficiency (EE) and demand response (DR) are alternatives to building new generation; however, the availability and reliability of both are of concern over the long term. The availability of EE and DR depend on whether or not customers decide to offer them to the market. If, in future years a decision is made to not participate, the transmission system may be short of supply.

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### MT #7: Inconsistent Coordination among Federal, State And Local Regulators Impedes Development of Smart Grid Technology.

The Federal Energy Regulatory Commission has actively supported the development of the organized wholesale electricity market. At the retail level, states are regulated by their own Public Utility Commissions, each with different perspectives on Smart Grid and how the markets should interact. Harmonization among the various regulatory bodies is needed to support the coordination between the wholesale and retail markets. The FERC led the inititial formation of RTOs. A number of FERC orders have been issued that are aimed at facilitating the further development of the wholesale markets. For example, FERC Order 755 requires compensation for regulation services to include a capacity payment and a performance payment to level the playing field among generators and customer owned resources. The role of the regulator has been important in the maturation of how the wholesale markets operate, however, some further optimization of the wholesale markets are possible.

At the state level, regulatory oversight in support of developing retail markets and their integration with wholesale markets is quite limited. Aggregators and RES are active in deregulated states, but continuous regulatory oversight would be helpful to address issues that come up as the aggregators and RES experience them—much like the FERC has done in the wholesale markets. The complexity of having fifty state PUCs makes the reality of providing this oversight quite challenging.

The initial role of the FERC / NARUC Smart Grid Collaborative represents an effective body of regulators that could provide this oversight. A good first step would be to identify the catalog of issues that impact the further development of retail markets and their integration with the wholesale markets. The logical second step would be to identify regulatory solutions that might be needed to resolve them.

# 3. EFFICIENCY

The discussion of efficiency contains several parts including the technical efficiency of specific devices, technology, and plants; End-use efficiency of consumers and their devices and appliances; the impact on business from power quality issues and outages; and the technical and commercial losses across the entire system.

*EE #1: The Most Efficient Smart Grid Technologies are Often Cost Prohibitive*

*EE #2: The Limited Use of Smart Rates Deters End-Use Energy Efficiency*

*EE #3: Regulatory Incentives do not Support Network Efficiency and Reliability Improvements Supported by Smart Grid Technology*

*EE #4: CHP is a Technology that Can Benefit from Smart Grid Technology, but Lacks Strong Federal, State and Local Support*

## Impediments and Issues

### EE #1: The Most Efficient Smart Grid Technologies are Often Cost Prohibitive

Energy storage (a Smart Grid technology), for example, promises to improve system and capital efficiency by accommodating more variable renewables and providing ways to store energy during low cost periods to offset peak demand at high cost periods. The storage technology that is lower cost, however, is also the lower efficiency technology which makes it difficult to make the business case for energy applications of energy storage.

### EE #2: The Limited Use of Smart Rates Deters End-Use Energy Efficiency

There are some utility programs that foster end-use efficiency. For example, one investor-owned utility has rate structures that require commercial and industrial consumers to purchase a load profile (two-part energy and demand pricing) and pay differentials against actual usage differences from the purchased profile. This “smart rates” approach promotes better planning, reduced peak demand, and overall reduced consumption. Unfortunately, such cases are rare in the US.

### EE #3: Regulatory Incentives do not Support Network Efficiency and Reliability Improvements Supported by Smart Grid Technology

The traditional regulatory compact has failed to motivate improvements in system efficiency through reduction of technical and commercial losses.

### EE #4: CHP is a Technology that Can Benefit from Smart Grid Technology, but Lacks Strong Federal, State and Local Support

CHP is a smart grid technology that requires more consistent treatment under current federal, state and local incentive programs. A Smart Grid can ease the interconnection and management of distributed generation such as CHP.

## Analysis

### EE #1: The Most Efficient Smart Grid Technologies are Often Cost Prohibitive

New multi-quadrant inverters are being measured at 97% efficiency (electric out / electric in). Research on new power electronic devices (Smart Grid technologies) shows that the industry could see production versions of solid state transformers (SST) and fault isolation devices (FID) operating at 98-99% efficiencies within this decade.

Energy storage (a Smart Grid technology) promises to improve system and capital efficiency by accommodating more variable renewables and providing ways to store energy during low cost periods to offset peak demand at high cost periods, but this technology has not proven itself broadly. Reporting efficiencies associated with energy storage is confusing. Some vendors report cell or module efficiencies, some report DC system efficiency, and some report AC-AC round trip efficiency. For example, the AC-AC round trip efficiency of energy storage varies from 65% to 85% depending on technology.

The storage technology that is lower cost ($/kW-hr) is also the lower efficiency technology, unfortunately. Thus, it is difficult to make the business case for energy applications of energy storage. For a power application of energy storage as an ancillary service, the higher efficiency technologies are used, but the price of those technologies is significantly higher (2x) than the lower cost technologies. Again, it is difficult to make the business case for power applications of energy storage.

Contrasting this is the need for GW-days of bulk power system high-efficiency energy storage to enable full power system optimization. Due to cost and efficiencies, the technology probably will not be electrochemical energy storage (batteries), but maybe technologies such as high temperature molten salt thermal storage.

### EE #2: The Limited Use of Smart Rates Deters End-Use Energy Efficiency

End-use is a well-understood and well-supported area of efficiency from a regulatory perspective. In some areas, federal initiatives have fostered transformation of lighting, appliances, and heating and air conditioning systems from low efficiency to high efficiency devices. Many states have created programs to incentivize end-use efficiency around energy efficiency devices and weatherization for residential, commercial, and industrial consumers.

In addition, there are some utility programs that foster end-use efficiency. For example, one investor-owned utility has rate structures that require commercial and industrial consumers to purchase a load profile (two-part energy and demand pricing) and pay differentials against actual usage differences from the purchased profile. This “smart rates” approach promotes better planning, reduced peak demand, and overall reduced consumption. Unfortunately, such cases are rare in the US. This program needs to be a fully-examined case study shared across the industry.

### EE #3: Regulatory Incentives do not Support Network Efficiency and Reliability Improvements Supported by Smart Grid Technology

The technical losses in the electric power system are associated with the electrical energy losses from the point of production (output of the generator) to the point of delivery (consumer meter). This includes several areas of loss:

- Central-station generator output is typically transformed up to a transmission voltage – transformer loss
- Additional transformation between a sub-transmission voltage (e.g. 69kV) or lower transmission voltage (e.g. 138kV) and an extra high voltage (e.g. 230kV, 345kV, 500kV, 765kV) for bulk power movement over long distances – transformer loss and line loss between voltages

- Resistance loss over the long distance bulk power transmission – line loss
- Transformation down from the extra high voltage to the distribution voltages (e.g. 34.5kV, 12.5kV) – transformer loss
- Resistance loss over the distribution line from above through the substation to the transformer nearest the consumer – line loss (lower voltages have higher line losses) and resistance loss through the substation
- Transformation down from distribution voltage (e.g. 12.5kV) to the low voltage (e.g. 480V, 240V, 120V) to the point of delivery – transformer loss

The sum of the losses from point of production to point of delivery is ~10% in the US. Roughly, this corresponds to ~$37B paid by consumers, but lost, annually. The sum is a function of the distance between the points of production and delivery, and the number of transformations (up and down). In general, reducing the average distance between the points of production and delivery, plus having a portion of the production resource portfolio be distributed very close to consumers would reduce the losses. In addition, in theory, reducing the average distance between production and delivery would improve reliability.

The traditional regulatory compact has failed to motivate improvements in system efficiency through reduction of technical losses. Such improvements are squarely in the middle of the Smart Grid technology space. Having a federal and state policy for economic efficiency and reliability would foster reductions in technical losses.

While commercial losses (non-payment of bills and energy theft) in the US are generally low, these losses are paid by those consumers who do pay their bills. Using public good charges (commonly referred to as utility "bad debt") observed in most states, the cost of commercial losses is 2% to 3%, or about $7B to $11B annually for the US. Smart Grid technologies provide ways to pinpoint each commercial loss and limit the impact on society with respect to time and amount.

### EE #4: CHP is a Technology that Can Benefit from Smart Grid Technology, but Lacks Strong Federal, State and Local Support

CHP is a smart grid technology that requires more consistent treatment under current federal, state and local incentive programs. CHP deployment in the US is limited for several reasons including high installation costs, a concern over long term reliability, and the lack of support from large investor owned utilities who perceive them as challenges to reliability and as competitors for energy supply.

It is important to understand the value of CHP to consumers and society. For power production, a typical central-station simple cycle natural gas peaking plant has a thermal efficiency of ~36%, a central-station combined cycle natural gas power plant has a thermal efficiency of 45% - 60%, and a CHP application has a thermal efficiency of > 80%. For an industrial consumer this means a lower cost of operation for its power and heat process needs. For society this means CHP contributes significantly less emissions per MW that central-station generation. Since it is a distributed generation application and the value of CHP can greatly be enhanced by interconnection to the grid, deploying a Smart Grid eases the interconnection and management of distributed generation, as well as gaining access for the CHP to provide ancillary services.

# 4. CROSS-SUBSIDY

Cross-subsidy is the term used to represent an imbalance of costs or payments between consumer groups, regions, or market segments. Some common cross-subsidies are:

- Commercial and industrial consumers cross-subsidizing residential bills, or vice versa (this has several forms)
- Paying consumers subsidizing non-paying consumers through a utility public good charge (see commercial losses above)
- Capacity payment market subsidizing an energy market
- Higher infrastructure costs in rural areas being subsidized by suburban or urban consumer bills, or vice versa

A cross-subsidy may not be inherently undesirable. For example, if a municipality intends to foster economic growth in its city, it may have its municipal utility shift more of the electric power system cost burden onto residential customers to lower the costs for commercial and industrial consumers. In this way, the city can encourage growth of existing businesses and the moving of new businesses to the city.

***CS #1: Cross Subsidies are a Disincentive to the Smart Grid Business Case.***

***CS #2: The Patchwork Development of Subsidies at the Federal, State and Local Level Obscure Price Distortion Preventing Policymakers from Effectively Addressing them.***

***CS #3: Fixing Cross-Subsidies is not A Priority in the Regulatory Process and Will Remain a Deterrent to the Smart Grid.***

**Impediments and Issues**

**CS #1: Cross Subsidies are a Disincentive to the Smart Grid Business Case**. Cross subsidies do not represent actual costs and benefits, and can give rise to political factors that skew the marketplace.

**CS #2: The Patchwork Development of Subsidies at the Federal, State and Local Level Obscure Price and Adds Distortion, Preventing Policymakers from Effectively Addressing them.** The relationship between "ability to pay," social impacts, economic (industry) impacts, etc., and the industry's responsibility towards cross-subsidy is inconsistent and unclear at best.

There is an imbalance in regulatory influence between residential, commercial, and industrial consumers. Large commercial and industrial consumers negotiate long-term fixed rate deltas that are not available to residential and small commercial consumers and, at the bulk power level of the electric power system, the capacity market subsidizes the energy market.

**CS #3: Fixing Cross-Subsidies is not A Priority in the Regulatory Process and Will Remain a Deterrent to the Smart Grid.** Unless it is raised as a specific issue, there is little attention paid to a cross-subsidy issue. Generally, there is a consensus that the industry should work toward a neutral cross-subsidy position because this best aligns costs with payments. But, there is also a consensus that fixing cross-subsidies should be done cautiously, gradually, and with transparency.

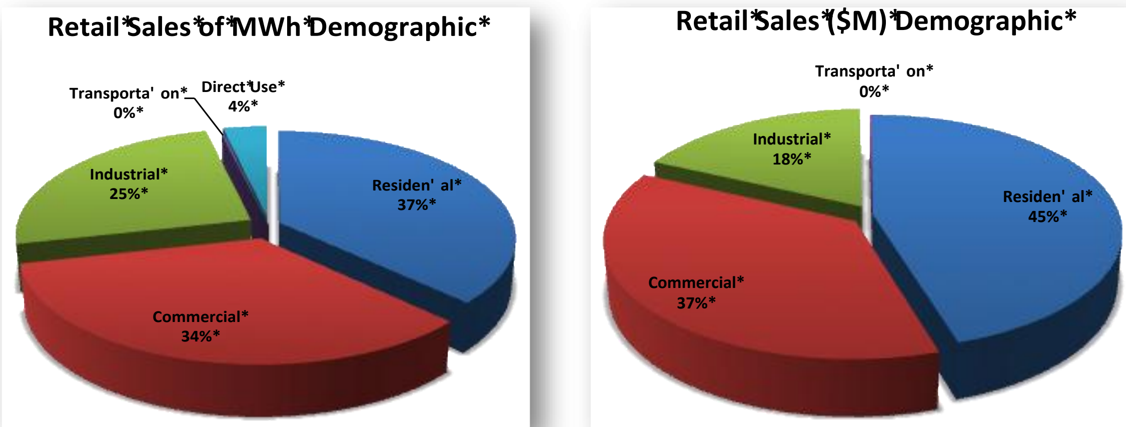
## Analysis

### CS #1: Cross Subsidies are a Disincentive to the Smart Grid Business Case.

In the US, cross-subsidies are not widely discussed, analyzed, or addressed. Cross-subsidies can taint the Smart Grid business case by inaccurately assigning costs and benefits used to make decisions on Smart Grid technology deployment.

Comparing retail sales to electric bills, it is evident the residential sector consumes 37% but pays for 45% of the electricity (see Figure US-CS1). This is cross-subsidy, and whether intentional or not, it is not well understood. This 8% of the nation's total electric bill represents nearly $30B per year. Such cross-subsidy masks true costs of service and the appropriate cost share between consumer groups.

Opinions about cross-subsidy fall into two groups; one, that cross-subsidy should be zero by creating rate structures that reflect the true cost of service, and two, that cross-subsidy should be purposeful. In other words, if a cross-subsidy is created it should be for a specific purpose such as for economic development.




Source: US DOE Energy Information Administration, Electric Power Annual 2010 data

**Figure US-CS1: Comparison of Electricity Consumption and Sales by Consumer Group**

The industry can help reduce cross subsidies by understanding the actual load profiles of customers and the Smart Grid can help better determine load profiles on a routine basis. Today, load profiles for consumer groups are determined through an analysis that may be examined in detail once in five years, and reviewed for anomalies on an annual basis. This affords only gross adjustments in generation, transmission, and distribution planning. Plus, load profiles change hourly or daily in consideration of many factors. The changing nature of the consumer with the rapid growth of renewable energy systems, electric vehicles, demand response programs, and onsite generation renders the annual or 5-yr load profile analysis virtually useless, making the Smart Grid case more compelling.

### CS #2: The Patchwork Development of Subsidies at the Federal, State and Local Level Obscure Price and Adds Distortion, Preventing Policymakers from Effectively Addressing them.

There are many influences that factor into electricity rates in addition to true costs. Much of the influence is local, and nearly all of it is unwritten "policy", such as the:

- views around an "ability to pay" policy,
- policy toward industrial development,
- state or local social policy, and
- state or local residential housing policy.

Inter and intra class cross-subsidies distress and distort price signals at the retail level, thereby skewing the economics of, and business cases for, the Smart Grid. A more nimble grid management system is needed with time-sensitive rates that are more closely tied to actual costs of service. This is the point of the Smart Grid technology suite. The Smart Grid enables a fair and justifiable connection between retail rates and true costs of service.

Some cross-subsidies develop over time as a result of an imbalance in regulatory influence. Many states have consumer advocacy groups who are chartered by the state to protect the residential consumer, and by extension, the fixed and low-income consumers. Such quasi-government ombudsmen work daily to influence the regulatory compact through policy and regulatory action. Large commercial and industrial customers have the influence to negotiate long-term fixed rate deltas with utilities that are not available to residential and small commercial consumers. In many states, commercial consumers have little to no advocacy in the regulatory process, thus commercial consumer bills have increased 30% as residential and industrial rate deals have been structured between regulators and industrial consumers and residential advocates. Over time, such regulatory influences have driven the retail rates and true costs of service even farther apart.

While organized wholesale electricity markets drive a better reflection of true costs in the electricity price, there are cross-subsidies here, as well. Traditionally, the industry has thought in terms of fixed costs being related to capacity costs and variable costs being related to energy costs. In a capital intensive industry the markets have been influenced and structured to treat capacity costs essentially outside the market, and keep only the variable costs (energy component) in the dynamic marketplace. As a result, all costs associated with the capacity component are moved outside the dynamic market, which leaves the energy cost as a variable cost on the margin. The result is an energy component, or energy market, that is under-calling the true costs of service. In this way, the capacity market subsidizes the energy market**.** As more and more consumers self-generate with renewables and incorporate energy efficiency measures, the energy market shrinks. Over the last decade, commercial and industrial consumers have seen a shift in their monthly bills from being dominated by the energy component to one being dominated by the capacity (demand charge and other fixed charges) component. Such distortions are difficult to discern and skew the business case against certain smart grid technologies.

## CS #3: Fixing Cross-Subsidies is not a Priority in the Regulatory Process and Will Remain a Deterrent to the Smart Grid.

In the US, cross-subsidy is considered a small issue. While the $30B per year residential consumer to business consumer cross-subsidy seems like a small percentage compared to the nation's total electricity bill of $369B per year, the cross-subsidy is still being paid. Little attention is paid to the cross-subsidy issue because this issue is not personalized to the individual consumer. The cross-subsidy represents about $238 per year per residential consumer, which is a significant portion (18%) of their average annual electricity bill of $1,325 per consumer. This would suggest that more attention is required at the state regulatory and consumer advocacy level.

All things considered, the cross-subsidy issue in the US is a $30B/year unintended consequence, mainly of flat retail rates. There are cross-subsidies between consumer classes due to a history of special negotiations by influential customers and advocates. There are cross-subsidies between capacity drivers and energy drivers as the nation has spent the last 20 years chasing peak demand with its capital expenditure budget driving up costs. There are cross-subsidies embedded in the flat retail rates that mask true costs of service. (One interviewee likened cross-subsidies to a Gordian knot.) While not truly dynamic, time of use (TOU) retail electricity rates would be the best immediate way to better reflect costs of service.

# 5. GENERATION

Generation is the term traditionally used to describe the large central-station power plants connected to the electric power system at the transmission level. Over the last twenty years, and very much in the background, business consumers have added smaller power plants on their property to improve reliability where the grid is insufficient, and improve their business economics where the grid is too expensive. This large number of smaller power plants at the point of delivery is commonly referred to as "distributed generation (DG)," or "distributed energy resources (DER)". It is almost always on the consumer side of the meter and often referred to as "self-generation". Some of the self-generation at larger commercial and industrial consumer sites takes the form of combined heat and power (CHP) plants where electricity, steam, and hot water are produced for industrial purposes.

*GN #1: The Emphasis on Traditional Large Central-Station Power Plants Undervalues the Benefits of the Smart Grid.*

*GN #2: Large Capital Expenditures by Utilities to Comply with Federal Environmental Mandates Reduces the Funding Available for the Smart Grid.*

*GN #3: Many Utilities are Unaware that Smart Grid Technologies can Enable Large Amounts of Distributed Energy Resources to Connect to the Grid.*

**Impediments and Issues**

### GEN #1: The Emphasis on Traditional Large Central-Station Power Plants Undervalues the Benefits of the Smart Grid.

The large central-station power plant (and associated transmission support) perspective has been the driver for economic and reliability solutions. When greater reliability is required, the traditional fix has been to add more power plants and transmission lines. When a region experiences higher prices, the traditional remedy has been to add more transmission to gain access to large power plants that may be away from the point of delivery. As a result, over the last 13 years, the nation has seen a decrease in asset utilization of the large central-station generation fleet (see Figures US-E1 above and US-G1 below), which adds cost to the consumer. A more intelligent grid (Smart Grid) over time should enable better utilization of the generation fleet.

### GEN #2: Large Capital Expenditures by Utilities to Comply with Federal Environmental Mandates Reduces the Funding Available for the Smart Grid.

In the last five years, the largest capital expenditure by utilities has been retrofitting coal-based generation with better emissions controls to comply with Federal mandates. This has reduced the amount of capital available for Smart Grid investments.

### GEN #3: Many Utilities are Unaware that Smart Grid Technologies can Enable Large Amounts of Distributed Energy Resources to Connect to the Grid.

The distributed energy resources (DER) fleet in the US has grown to 230 GW, yet only 1% of the DER fleet is grid connected.

Since this resource base is located at the point of delivery, there is value in engaging these distributed energy resources to serve local grid needs at distribution voltages. However, vastly increasing DER serving the grid requires new operations tools found in Smart Grid technology.

The majority of the nation's DER fleet is driven by engines that primarily utilize diesel fuel. Operating the existing DER fleet for many hours represents an environmental and cost challenge. However, with Smart Grid technology the integration and use of the DER could be made advantageous to the industry and consumers alike, especially focused on addressing peak demand.

**Analysis**

### GEN #1: The Traditional Large Central-Station Power Plant Perspective in the U.S. Undervalues the Benefits of the Smart Grid.

The declining trend in the generation fleet capacity factor is a heavy cost burden on consumers. The fleet capacity factor says that for every 1 MW of energy per year at the point of delivery, the industry has to build and operate (and consumers fund) 2.2 MW of capacity at the point of production.

This issue is not a technology issue, but one based in traditional perspectives about generation and a lack of vision about the complete portfolio of generation. The following factors will tend to continue this trend:

- Large-scale wind generation capacity factors range from 32 – 39% on average. With the rapid growth of wind generation experienced in the US right now, this will further drive the fleet average capacity factor down.
- Most new transmission additions are to address wind generation growth. This additional cost for low capacity factor generation type compounds the rising costs to consumers.
- The addition of carbon management systems to existing or new coal-based generation will lower the average capacity factor of the coal-based generation fleet, which will drive the fleet average capacity factor down.
- Replacement of retiring coal-based generation with natural gas-fueled generation at lower historical capacity factors will drive the fleet average capacity factor down.
- The addition of large solar generation plants with capacity factors ranging from 22 – 29% on average will help to drive the fleet average capacity factor down.

The decrease in large generation asset utilization is primarily a result of the growth of natural gas fueled power plants, which have lower capacity factors than nuclear and coal-based power plants. For example, the natural gas combined cycle plants used for baseload generation average 42% capacity factor and represent nearly 22% of the central-station generation fleet. While the utility industry is currently enamored with low natural gas prices, high capacity factor performance of large natural gas generation has not been demonstrated historically. In addition, the natural gas fueled peaking generation segment of the fleet is used at 10% capacity factor.

Likewise, with growth of the renewables generation (Figure US-G1) portion of the central-station generation fleet (wind represents 3% of the 4% renewables in Figure US-2) over the last few years, the renewables segment fleet average capacity factor has declined from ~40% to 34%.

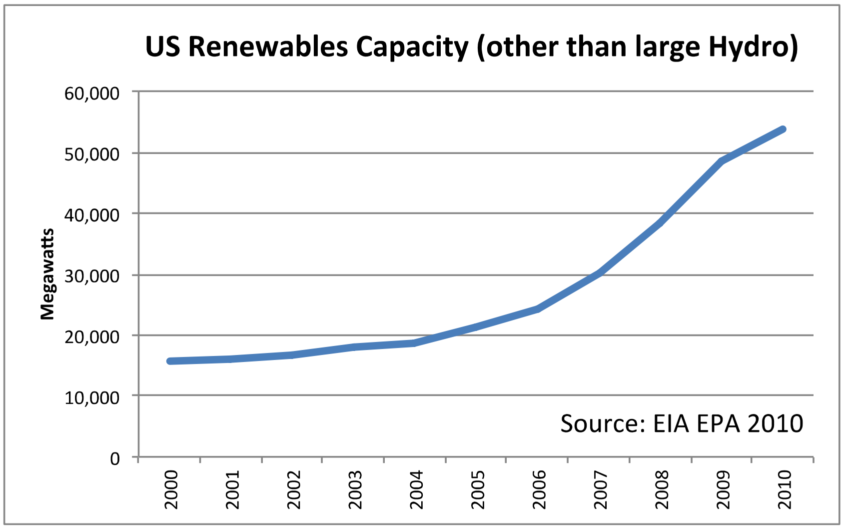



**Figure US-G1: Growth of the Renewable Generation Fleet**

## GEN #2: Large Capital Expenditures by Utilities to Comply with Federal Environmental Mandates has Reduced the Funding Available for Smart Grid Investments.

Some utilities see the increased environmental regulations on fossil generation as driving a 20% - 30% increase in rates to consumers.

Many utilities are evaluating retirements of coal-based power plants due to the growing environmental issues. With a generation-centric perspective, this leads utilities to develop more natural gas-fueled power plants, especially with natural gas prices low in the short term. However, with the projections of increasing natural gas prices by 2016 (according to DOE EIA Annual Energy Outlook 2011 and CME Group Henry Hub Natural Gas Futures), and the historically low capacity factors of natural gas-fueled generation, this utility solution may not be acceptable to consumers since it could increase their costs. This could also be a resource adequacy issue at the regional transmission organization (RTO) level.

## GEN #3: Many Utilities are Unaware of the Benefits of Smart Grid Technologies to Enable Large Amounts of Distributed Energy Resources (DER) to Connect to the Grid.

DER, in the form of consumer-owned generation, could be widely used for capacity reserves and ancillary services today, yet only 1% of the DER fleet is grid connected. The environmental and cost issues associated with diesel fuel (predominant fuel in consumer-owned generation) limit DER use today to short periods of time. However, serving capacity reserves and ancillary services with central-station peaking power plants also represent environmental and cost issues. Operating large power plants on short notice at partial power is not environmentally sound, and building large power plants that operate with an average 10% capacity factor is not economically sound. Dozens of utilities have shifted to operating consumer-owned generation as opposed to central-station peaking plants to reduce peak demand a few hours at a time, for a few times per year, within established environmental limits for an overall cost savings to their consumers.

Many utilities believe that customer-owned generation is not auto-dispatchable. This is true unless the grid is made more intelligent (Smart Grid investments) in order to handle two-way power flow. Several large and small utilities, for several years, have successfully applied Smart Grid technologies to enable real-time auto-dispatchable operations of consumer-owned generation for reducing peak demand and other ancillary services. In addition, with FERC 719, third-party aggregators of such services can have access to the wholesale market to supply these services to regional needs. Transmission system operators see that most of the value in demand response (DR) is capacity value. In general, RTO studies show that half of the DR is behind the meter consumer-owned generation (i.e., DER).

DER, as enabled by the Smart Grid for broader industry value, should be a widely used part of the entire generation portfolio because:

- It is a generation resource base already capitalized by the consumer
- It is distributed at the point of delivery, thus minimizing the costs of delivery
- It is 20% of the cost (conversion) of building new central-station peaking power plants
- It is fast acting and supports multiple services with Smart Grid technology

The chief impediments to widespread use of DER to address peaking demand and CHP to supply distributed base generation in the US are:

- Lack of Smart Grid technologies in the grid to support two-way power flow on the distribution network
- There is no regulatory requirement or regulatory incentive to employing this more cost-effective approach.
- Utility behavioral norm that to be properly controlled, assets must belong to the utility

As the grid is transformed into a more intelligent Smart Grid able to optimize both local and regional resources, less dependence on large central-station generation will result. Because this contradicts the long-standing industry norm of solving reliability and economics from the generation and transmission perspective, this existing industry culture will be a barrier to change. This culture is exemplified in the grid interconnection rules. Most utilities require detailed interconnection studies for new generation, regardless of size, to assure reliability of the grid with the addition of a new resource. Only a few utilities recognize that the interconnection process can be simplified for small generators in accordance with standards such as UL-1741 and IEEE-1547. While the earliest versions of IEEE-1547 actually causes the consumer-owned generation to turn off during a loss of grid power, the most recent additions to this national standard are recognizing the value of maintaining sound generation resources during a loss of grid power. Also, a result of the long-standing industry culture is the lack of expertise within the commercial and industrial consumer engineering staff to understand, evaluate, and design grid interconnections for their DER.

# 6. CONSUMER PARTICIPATION

One of the Smart Grid Principal Characteristics defined by DOE is "Enable active participation by consumers". Moving from today's centralized operating model, supplied by large centralized power plants, to a more decentralized model that depends on distributed energy resources (distributed generation, distributed storage, and demand response) is one of the fundamental changes created by the Smart Grid. A decentralized operating model cannot be achieved without extensive consumer participation since many of the distributed energy resources are expected to be consumer-owned.

Successfully achieving a decentralized operating model fully depends on the participation rate of consumers. Without consumer participation, markets won't develop, deployment of distributed energy resources will be limited, opportunities to improve system operation and asset utilization will be limited, and some of the opportunities to improve the robustness of the grid will be lost.

To date, the Smart Grid focus has neglected the consumer. Enabling active participation of consumers is a difficult task. Electric service providers, regulators, educators, and vendors must fully understand the customers' needs, desires, and issues. Acquiring such understanding requires direct interaction with them. A number of forums are reaching out to consumers to better understand their views. For example, the Smart Grid Consumer Collaborative (SGCC) has done extensive work to understand the customers' viewpoints regarding the Smart Grid.

Consumer education programs must be developed. To be effective these consumer education programs must educate and present a compelling Smart Grid value proposition to motivate educated consumers to action. Realizing the value proposition will require the consumer to take the initiative of new controls and options that will be made available to them.

***CP #1: Consumers are Largely Unaware of Compelling Consumer Oriented Benefits of Smart Grid Technology.***

***CP #2: The Emphasis on the Network Benefits of the Smart Grid Obscures the Potential Consumer Oriented Benefits.***

***CP #3: Policies, Incentives and Programs do not Sufficiently Encourage Consumers to Adopt Smart Grid Technologies.***

In short, the pathway to consumer participation includes three steps:

- *Create Understanding* of Smart Grid concepts and issues through effective communication, listening, education, and debate
- *Create Alignment* using a collaborative approach and by allowing consumers to impact the direction of the Smart Grid transition in their respective areas or regions
- *Motivate* by presenting the value proposition in moving forward, the costs and penalties of doing nothing, and demonstrating interest in consumers' questions and concerns along the way.

**Impediments and Issues**

Relative to Smart Grid, the needs, desires, and issues vary by customer class (residential, commercial, and industrial), by demographics, and by location, which further complicates the consumer engagement process.

### CP #1: Consumers are Largely Unaware of Compelling Consumer Oriented Benefits of Smart Grid Technology.

A lot of work has been done to identify and monetize the individual consumer value proposition and so far it has not been overly compelling. The societal benefits that result when consumer participation reaches a tipping point is substantial and should be presented to consumers as a part of the complete consumer value proposition.

### CP #2: The Emphasis on the Network Benefits of the Smart Grid Obscures the Potential Consumer Oriented Benefits.

Consumers require education on all aspects of the Smart Grid that impact their relationship with the electric power system. Smart Grid concepts are complex and customers have never had the control capabilities, options, and opportunities that the Smart Grid is expected to provide. Effective consumer education programs that connect with and motivate consumers are needed.

### CP #3: Policies, Incentives and Programs do not Sufficiently Encourage Consumers to Adopt Smart Grid Technologies.

Effective methods are needed to encourage consumers to participate in new programs, technologies, applications, and other opportunities enabled by the Smart Grid.

**Analysis**

### CP #1: Consumers are Largely Unaware of Compelling Consumer Oriented Benefits of Smart Grid Technology.

A logical first step in gaining consumer participation is to better understand the consumer perspective. At the residential level, one common conclusion reached by researchers is that consumers do not understand what the Smart Grid is or the opportunities it can provide.

Consumer understanding of, and alignment with, Smart Grid concepts is necessary but not sufficient to gain their participation. A compelling value proposition is needed to motivate them to take the first steps and participate. The consumer benefits of Smart Grid must be more clearly identified and quantified including its broader societal value and that total value must be compelling, otherwise the needed consumer participation levels will not be achieved.

Consumer benefits generally fall into the following areas:

- More reliable service and reduction in consumer losses due to extended outages (spoilage, lost production, loss of product, etc.)
- Potential bill savings
- Transportation cost savings (electric vehicles vs. conventional vehicles)
- Information, control and options for managing electricity
- Option to sell consumer-owned generation, storage, and demand response into the electricity markets.

Additional benefits will likely be identified as consumer participation levels increase. For example, in some areas consumers have agreed to site utility owned distributed generation on their property in exchange for a lease payment. And much can be learned from the larger commercial and industrial consumers who have enjoyed some of the functionality of smart meters for many years. They have greatly benefited from these meters and the associated energy management systems they support. Ironically, these same customers question the incremental value of some of the Smart Grid concepts since they already have these "smart meters" in service and are enjoying their benefits now.

The societal benefits of the Smart Grid should also be communicated to consumers. Societal benefits generally fall into the following areas:

- Downward pressure on electricity prices
- Improved reliability reducing losses that impact society
- Increased grid robustness improving grid security
- Reduced emissions
- New jobs and growth in the gross domestic product
- Transformation of the transportation sector leading to a reduction in US dependency on foreign oil

All consumer benefits, both direct and societal, need to be quantified and clearly communicated to consumers and regulators. If consumers feel the value proposition is compelling, they might convert their understanding into action, work with their electric service providers and regulators, and become participants in the Smart Grid transition.

Fortunately, an increased focus is now being applied to gain understanding of consumers' perspectives. The Electric Power Research Institute (EPRI) has a new program called "Understand the Customer" and the Smart Grid Consumer Collaborative continues to do research in this area through extensive survey instruments. A number of foundational concerns are now emerging including such questions as:

- Will my energy information be kept private?
- Will "big brother" be watching me?
- Will the new technologies be hard to use or can they be as simple as "set it and forget it?"
- Why do I have to pay "up front" for all these promises? Shouldn't the power company take the risk?
- How much can I save ($ and energy)
- What risks am I taking if I go on time of use rates? Can I lose money on them?
- What else do I have to buy to make this work?
- Is cyber security risk increased?
- Can I "opt-out" of new Smart Grid programs or change my mind if I don't like it?
- Why aren't we fixing the system first?
- How will it help the environment?

Addressing these foundational questions is central to gaining trust with the consumers and further research is needed to gain an even more complete understanding of the consumer perspective.

## CP #2: The Emphasis on the Network Benefits of the Smart Grid Obscures the Potential Consumer Oriented Benefits.

The consumer is a major stakeholder in making the Smart Grid successful. In several ways, the industry has left them behind as the rest of the stakeholder groups have moved forward and gained a significant understanding of Smart Grid concepts. Now is the time to help consumers "catch up" and effective consumer education programs are essential to achieving that outcome. A documentary for mass media would be helpful as part of a national consumer education program. The industry cannot expect consumers to align with the Smart Grid vision if they don't understand it.

Many consumers today think the Smart Grid is simply about smart meters. To date, only the simplest Smart Grid concepts (smart meters) have been presented to consumers. Will consumers respond to the more complex concepts and opportunities or will the effort required for them to "self-study" be too great?

Consumer education programs should also address:

- How the Smart Grid is expected to work from the consumers' point-of-view.
- The value proposition and benefits for individual consumers (bill savings, new conveniences and applications, interaction with electricity markets to earn a revenue, etc.)
- How consumption information will be provided and how can it be used to benefit the consumer
- Time-of-use rates, how can they benefit consumers, and what the risks are
- Description of the technologies needed to give consumers full access to Smart Grid opportunities

## CP #3: Policies, Incentives and Programs do not Sufficiently Encourage Consumers to Adopt Smart Grid Technologies.

Once consumers understand, become aligned, and are incentivized around Smart Grid concepts they will take action to participate. Facilitation of their actions will require effective methods to encourage them to participate in the many new programs, technologies, applications, and other opportunities enabled by the Smart Grid. A number of ideas exist for encouraging consumer participation. Time of use rates is one of the more popular ones that give consumers the opportunity to save on their bills. Extensive research demonstrates that consumers will respond to various types of time of use programs. Figure US-CP1 suggests consumers are price-sensitive and interested in this feature of the Smart Grid:

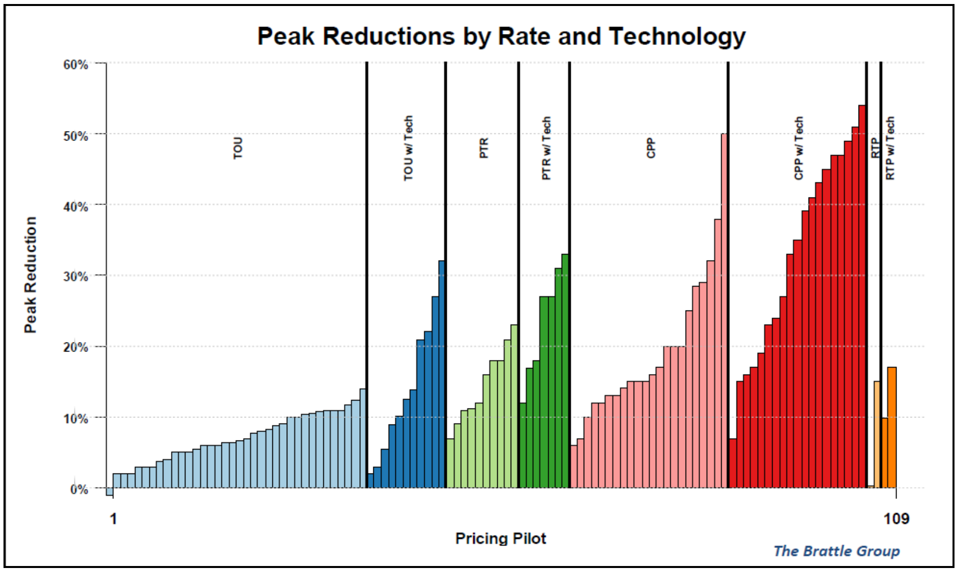



**Figure US-CP1: Consumer Response to Various Rate Designs (109 Pilots)**[xxix]

Other ideas being considered and implemented to encourage consumer participation:

- Green Button Initiative is an industry-led effort that responds to a white house call-to-action to provide consumers with easy-to-understand data about their household energy use.
- Retail Energy Suppliers are now making good progress in deregulated states and subscribing all consumer groups to shop for electricity.
- Use of text messaging to alert consumers of need to adjust their energy consumption to take advantage of varying prices of electricity to simplify their interactions.
- Working with community thought leaders (mayor, chief of police, etc.) to promote the value of Smart Grid
- Downloadable applications and home automation technologies
- Special offers to encourage specific participation—premium payments for self-generation (feed-in tariffs)
- Leadership in Energy and Environmental Design (LEED) credits to encourage widespread use of demand response programs

Enabling consumer participation is a beginning with an understanding of smart grid concepts, listening to and addressing consumer issues to gain their alignment, quantifying and clearly communicating the value proposition to them, and providing mechanisms to facilitate actual consumer participation.

# 7. BEHAVIORAL NORMS

In the context of the energy industry, there are behavioral norms for:

- The regulatory compact (treatment) and how it is negotiated
- How stakeholder advocacy is applied
- If and how accountability is applied
- If and how standards are applied
- How issues, technologies, and processes are investigated, analyzed, designed, selected, implemented, justified, communicated

*BN #1: The State-Driven Regulatory Compact Sometimes Discourages the Adoption of Smart Grid Technologies.*

*BN #2: The Current Distribution Perspective on Reliability Fails to Take in the Potential for Smart Grid Investments*

*BN #3: A Consistent Emphasis on the Network Side of the System Diminishes the Customer Driven Capabilities of the Smart Grid.*

*BN #4: Current Approaches to Consumer Education have Insufficiently Informed Customers of Smart Grid Technologies and its Benefits.*

*BN #5: Utility Behavior Regarding Vendor Selection is Based more on Trusted Relationships than on Functionality Required or Offered.*

**Impediments and Issues**

### BN #1: The State-Driven Regulatory Compact Sometimes Discourages the Adoption of Smart Grid Technologies.

Most utility and regulatory staff are comfortable with the existing traditional regulatory system and roles that are challenged by Smart Grid technologies.

### BN #2: The Current Distribution Perspective on Reliability Fails to Take in the Potential for Smart Grid Investments.

Grid reliability, an industry focus in the past, has slipped over the last several years.

### BN #3: A Consistent Emphasis on the Network Side of the System Diminishes the Customer Driven Capabilities of the Smart Grid.

There are many opportunities for energy efficiency and cost savings behind the meter. Existing rate structures to incentivize energy efficiency are insufficient to support this smart grid objective.

### BN #4: Current Approaches to Consumer Education have Insufficiently Informed Customers of Smart Grid Technologies and its Benefits.

Providing education and understanding to consumers is not a core function. Consumers are often cast as uninterested or incapable of understanding the electric system and regulatory processes that govern it.

### BN #5: Utility Behavior Regarding Vendor Selection is Based more on Trusted Relationships than on Functionality Required or Offered.

In the expanding Smart Grid technology suite, utility behavior regarding technology selection is quite predictable, being based more on the relationship with trusted vendors and less on the functionality required or offered.

**Analysis**

### BN #1: The State-Driven Regulatory Compact is a Significant Barrier to Accelerating Grid Modernization and the Adoption of Smart Grid Technologies.

Each state has unique policies, personalities, and processes rendering regulatory change needed for Smart Grid technology deployment. The regulatory staffs in utilities and state commissions are accustomed to cost-based regulation, making it difficult to justify investment in Smart Grid technology.

With little state-to-state consistency with respect to Smart Grid strategies, broader policy and framework forums are needed, e.g. SGIP (Smart Grid Interoperability Panel) and FERC/NARUC Collaboratives, to help the industry move technology, rates, and processes in a consistent direction.

### BN #2: The Current Distribution Perspective on Reliability Fails to Take in the Potential for Smart Grid Investments.

Grid reliability, an industry focus in the past, has slipped over the last several years for three reasons:

- Mid-sized commercial and industrial businesses are no longer the champions for reliability they once were. They guarantee their own reliability through on-site systems.
- Small commercial businesses are not represented well in policy and regulation and have little influence as reliability slips.
- Residential consumers typically experience little economic impact from grid outages and power quality events, so it is not a "hot button" issue.

There are few state enforcement actions directed at utilities that do not meet reliability requirements or targets. In addition, there are fewer advocates for reliability because large businesses work directly with utilities to ensure reliable electric service; mid-size businesses are turning to their own methods; and small businesses do not have the capacity to effectively participate in the regulatory dialogue.

From a federal perspective, NERC plays the reliability enforcement role at the bulk electric power system level, but does not have authority over distribution level operations at utilities. This may change if transmission reliability becomes dependent on distribution resources. However, this will become a federal versus state jurisdiction issue, and not likely to result in the single enforcement authority needed for the distribution level.

### BN #3: A Consistent Emphasis on the Network Side of the System Diminishes the Customer Driven Capabilities of the Smart Grid.

The Smart Grid is not being used to bring value-added services to consumers. For the Smart Grid to bring value-added services to consumers, economics must be added to reliability concepts. In a least cost system, only system benefits (reductions in cost of utility operations) are considered in the model. No credit is given for improved consumer services or options. If increased "value" were added to reduced "cost" when considered in the rate cases, it would also drive utilities and regulators to consider capital investments through which reliability and efficiency goals for the consumer are addressed. Based on the last decade, at the transmission level, RTO leaders and federal agencies understand that bulk power and transmission planning also needs to migrate from a reliability-based model to a value-based model.

There are many business opportunities hidden behind the meter. With cleverly developed rates and service offerings consumers and utilities could act in partnership to meet the smart grid objectives of curbing peak demand, reducing congestion, and curtailing consumption during emergencies. Many utilities do not work with consumers to buy down energy efficient technologies, improve overall efficiency in homes and businesses and take other actions on the consumer side of the meter because the regulatory incentives are opposed to doing so.

Commercial and industrial consumers (and sometimes residential consumers) are asking utilities to enable more options so that businesses can better understand, control, and reduce the electric and gas cost component of their operations. For example, CHP is a viable option for commercial and industrial consumers. However, CHP is often perceived as a competitive threat. From the stakeholder interviews, utilities do not perceive a value proposition for themselves in the CHP equation unless they are able to rate-base the CHP investment. Location specific incentives are needed to motivate the use of CHP as a solution to downstream constraints.

However, regulatory incentives for this change in behavior alone are insufficient. Smart Grid technologies need to be deployed to effectively utilize these existing consumer-owned assets. In addition, harnessing this resource will require utilities to change their asset ownership based behavior to an asset operation behavior. Such changes require more intelligent monitoring and controls offered by the Smart Grid, and a willingness to accept some risk management. This is a challenge to the behavioral norm.

### BN #4: Current Approaches to Consumer Education have Insufficiently Informed Customers of Smart Grid Technologies and its Benefits

Education and understanding related to the Smart Grid and emerging business models for utilities is not well developed for consumers, utility staff, regulatory staff, or policy makers. In addition, the regulatory compact in place for decades has allowed consumer awareness of energy fundamentals and dynamics to lapse.

This results in general consumer and advocacy group apprehension about the Smart Grid based on a lack of information being shared by authorities and utilities. The passive education approach taken by the industry on fundamentals makes it more difficult to share information about complex ideas and business models for consumers.

In comparison, large industrial consumers have been educated on the fundamentals of dynamic pricing and data privacy over the years, resulting in a consumer group that generally makes well informed energy decisions. Large consumers shop energy prices and structures more than other consumer groups, an attribute of consumer engagement prized by smart grid enthusiasts.

As related in one interview, behavioral norms can also negatively affect learning opportunities. For example, a large utility conducted a 3,000 smart meter experiment to examine consumer engagement with the new capabilities. The experiment failed. The post-pilot critique determined that:

- the rate design was not compelling,
- existing low rates made it less compelling to consumers,
- the utility did not engage the right consumer segments, and
- the utility did not prepare community leaders.

Such examples highlight the need to develop a social science level of understanding of the consumer and the utility programs and technologies that touch the consumer.

Another example of industry behavioral norms that could be a mismatch with a specific consumer segment relates to electric vehicles. Many utilities view deep penetration of electric vehicles (EV) in their service territory could cause significant problems with distribution transformers and circuits. The utility norm is to offer a special rate class for EV owners, believing that the EV owner will charge their EV as the special rate class dictates. However, research shows that EV owners are not very price sensitive, because “range anxiety” is an overriding driver. To be successful with its consumers who own EV, the utility will need to develop a new behavioral norm most likely based on a more socially scientific approach to these consumers.

Utilities will also need to sharpen their expectations of the behavior of various consumer groups to reduce an important impediment to smart grid technology implementation. For example, research shows that the most engaged consumers for new smart grid program offerings that save consumers even a small amount on their monthly bills are senior citizens and low-income consumers. These groups are also more likely to participate in demand response programs and pre-pay metering programs even though their benefits of doing so are relatively small. This suggests a new utility behavioral norm is needed.

### BN #5: Utility Behavior Regarding Vendor Selection is Based more on Trusted Relationships than on Functionality Required or Offered.

Lastly, utilities must adjust the method in which they select technology vendors to remove a significant impediment to smart grid technology deployment. Technology vendors understand that the predominant factor in the selection of smart grid technologies is an existing relationship between vendor and utility. Other factors included in the decision are functionality, life cycle cost, and reliability, but these factors are less dominant in the decision making process practiced by utilities in the current regulatory environment, which discourages risk. As a result, larger vendors with equipment previously installed in the utility’s system are considered the lower risk decision leading to an inwardly focused technology vision limited by what the most trusted vendor has to offer and limiting innovation from new smart grid vendors.

## 8. DATA AND ANALYTICS

The Smart Grid technologies enable much more data and analytic capabilities than in the past. This includes:

- Consumer consumption data,
- Periodic data to assess losses,
- Data and analytics to assess business impacts,
- Periodic detailed load profiles,
- Data and analytics to build detailed business cases with societal benefits included,
- Data and analytics to assess integrated resource planning (IRP) for a broader portfolio including distributed resources,
- Project (build) and performance metrics,
- Decision support tools, and
- Specific scenario simulations.

*DA #1: The Electric Utility Industry's Current Approach to Data and Analytics does not Fully Realize the Data Rich Environment Afforded by the Smart Grid.*

*DA #2: A Lack Of Industry Data And Analytic Standards Is an Impediment To The Smart Grid.*

A systematic approach to data collection, selection, analysis and informed decision making is essential to overcoming legal/regulatory, operational, market, and consumer impediments to Smart Grid technology deployment.

**Impediments and Issues**

**DA #1: The Electric Utility Industry's Current Approach to Data and Analytics does not Fully Realize the Data Rich Environment Afforded by the Smart Grid.** The industry's current data and analysis techniques provide little insight on performance trends and metrics. A Smart Grid enabled future can change this with better analytics.

**DA #2: A Lack Of Industry Data And Analytic Standards Is an Impediment To The Smart Grid.** The industry cannot reasonably be expected to collect and analyze all the raw data produced by the Smart Grid. Some intelligence needs to be applied to the approach taken by the industry to collect, select, and analyze Smart Grid data. This suggests a need for data and analytical standards to assure that the analytical methods employed provide authoritative information.

**Analysis**

### DA #1: The Electric Utility Industry's Current Approach to Data and Analytics does not Fully Realize the Data Rich Environment Afforded by the Smart Grid.

A systematic approach to data collection, selection, analysis and informed decision making is essential to overcoming legal/regulatory, operational, market, and consumer impediments to Smart Grid technology deployment. The electric utility industry's current approach to data and analytics does not fully realize the data rich environment afforded by the Smart Grid. Data analysis standards are needed to properly understand the data rich environment afforded by the Smart Grid.

New Smart Grid technologies provide more granular data than ever available to utilities, customers, regulators and policy makers. This could amount to hundreds of terabytes per year for each utility. The industry needs an intelligent approach to data and analytics memorialized in standards or policy. Smart Grid data enables these stakeholders to transition from monthly summary consumption data for each consumer to hourly consumption data that can be analyzed for trends in on-peak and off-peak usage. More granular Smart Grid data can be used to assess technical and commercial losses, business impacts of outages and power quality events, analyzing energy efficiency investments, and for developing ongoing detailed load profiles, among many other applications.

The analysis of trends and metrics are valuable on several levels in the utility system. At the local level analysis can be used to determine the results of decisions, as well as, anomalies that require action by the utility, consumer and regulator. At a higher level, the trends at multiple local levels can be combined to analyze technology, process, or policy performance, enabling a solid factual foundation for change. The accuracy of such higher-level analyses can only be assured when lower level data and analyses are repeatable and transferable. This requires standards to assure the analytical methods used provide authoritative information especially where state-wide, or industry-wide, decisions are made based on performance feedback.

The utility industry needs to develop standards that enable local utilities to collect and process data locally and send the resulting analysis to a centralized data depository, rather than attempting to transmit hundreds of terabytes of raw data to a central location. There is also the need to develop agreements with consumers and other stakeholders for sharing their data and resulting analysis.

### DA #2: Data And Analytic Standards and Tools are Insufficient to Make Informed Decisions on Smart Grid Technology Deployment.

Another example of data related impediments to Smart Grid technology deployment lies in the lack of standards for real time synchronization measurements for distribution level devices, smart meters, smart appliances, distributed energy resources, and events. In a data-rich grid environment, making sense of millions of bits of data requires time synchronization or else no one can see how the data fits together. There are two voluntary time synchronization standards used by utilities today, but no wide adoption of a standard is required by regulatory authorities. Standards used by utilities on a voluntary basis are not enforceable by a regulatory authority. Only when a regulatory authority adopts a standard into law can it be enforced.

A second standards-related impediment to Smart Grid technology deployment lies in the distribution system reliability measurement standard IEEE-1366, which it is not widely adopted within the industry. As a result, the industry lacks a definitive approach to analyzing trends and metrics in the nation’s distribution system and making informed decisions on technology deployment, market transformation and regulatory reform.

For example, more data is needed to support risk-based analyses (namely probabilistic risk assessment (PRA) for bulk power state estimation improvements. These faster and more efficient improvements, plus the use of risk contours derived from the PRA, will help operators better understand the relative level of reliability margins that exist in real-time operations.

For the challenge of renewable energy resources variability and its effect on grid stability, the industry needs more stochastic and probabilistic methods for a range of penetration of renewables.

The utility industry, policy makers and regulators also lack data collection and analysis standards for consumer and societal benefits. This means an industry standard, adopted approach for populating the business cases with justifiable, repeatable data for consumer and societal benefits. This expansion of the benefits within a business case is necessary to move from a cost-based regulatory compact to a value-based regulatory compact.

As outlined in the US DOE Smart Grid Vision, one of the key technology areas for the Smart Grid is Decision Support. While some parts of the electric power system have made significant improvements, there is still a need for more research and development in data-informed decisions with advanced decision support tools. This is necessary to understand how Smart Grid technologies and new data can help the industry and consumers make better decisions regarding asset aging and grid modernization.

For example, the American Recovery and Reinvestment Act of 2009 (ARRA) stimulus projects are being evaluated by DOE on a project level basis. Analytical tools are needed to evaluate this large collection of projects at a higher level to extrapolate some industry-wide results. Such results could give the industry a better value proposition framework for Smart Grid technology selection, pilot project structures, and/or deployment strategies. Likewise, one interviewee related that a database of all Smart Grid projects and researchers around the world could further inform the industry on better value propositions related to technologies, pilot structures, and deployments.

Another example of improved data analysis and decision support relates to developing new pricing structures in a Smart Grid enabled future. Consider a utility real-time pricing pilot where a five-minute distribution locational marginal pricing (DLMP) market is explored. In general, such a pilot would demonstrate that the industry needs better understanding of how dynamic pricing works for different consumer groups:

- How should the utility provide a price signal?
- What is the price aversion “curve” by consumer or consumer group?
- What transparency choices are required to be successful?

A third example relates to FERC Order 1000, which includes a more diverse set of resources for the planning environment. Whereas, in the past, only bulk power system resources (central-station generators and transmission lines) and consumer loads would be considered, now aggregated distribution resources such as ancillary services, capacity resources, or energy resources are included. However, the data and analytical basis for bringing distribution resources into the planning environment is not well developed. The benefit of including such resources based on justifiable, repeatable analyses properly managed in a Smart Grid environment could result in less new construction of central-station generators or transmission lines.

Finally, specific scenario simulation of the penetration of PV, distribution automation devices, EV, community energy storage, etc., could be extremely valuable to the industry on a local, regional, and national level. Such simulation requires much data and analysis developed in a structured framework to make the simulations justifiable and repeatable.

# 9. SMART GRID INVESTMENT ENVIRONMENT

Smart Grid technology deployment will require substantial investment that requires policy changes, legal initiatives, regulatory analysis and change, and stimulus such as feed-in tariffs and tax credits.

*SGIE #1: Inconsistent Federal and State Regulatory Incentives Impede Investment in Smart Grid Technologies.*

*SGIE #2: The Smart Grid is an Additional Capital Expense Over and Above Utility Capital Budgets.*

*SGIE #3: Technology and Process Cost Uncertainties Impede Smart Grid Deployment.*

**Impediments and Issues**

**SGIE #1: Inconsistent Federal and State Regulatory Incentives Impede Investment in Smart Grid Technologies.** The Smart Grid investment environment has structure, but it is not consistent across the nation. At the federal level, Smart Grid investment has been encouraged by funding pilot research and demonstration programs and with tax credits. Only a few states have incentives for utilities and consumers to invest in the Smart Grid.

**SGIE #2: The Smart Grid is Viewed as an Additional Capital Expense Over and Above Utility Capital Budgets.** A general consensus within the utility industry is that the Smart Grid is an additional capital expense over and above its existing capital budgets. As a result, expenditures on Smart Grid technologies are seen as competition for capital at the utility and state level regulatory authority. Moreover, in today's environment, fossil plant environmental upgrades compete with Smart Grid projects for limited capital budgets.

**SGIE #3: Technology and Process Cost Uncertainties Impede Smart Grid Deployment.** Since placing significant intelligence in the grid has never been contemplated before, utilities perceive great uncertainty in Smart Grid costs. The inability to capture benefits outside the utility also impedes the implementation of Smart Grid technology. There is no experience in the industry for building a business case that includes benefits outside the utility system.

**Analysis**

### SGIE #1: Inconsistent Federal and State Regulatory Incentives Impede Investment in Smart Grid Technologies.

The Energy Independence Security Act of 2007 and the American Recovery and Reinvestment Act of 2009 federal acts essentially jump-started the Smart Grid investment environment. EISA 2007 created the policy driving force for investment in Smart Grid demonstrations and deployments. ARRA 2009 created the funding stream for the EISA 2007 investment programs. However, these significant Smart Grid investment stimuli are now past, and the industry's investment structure has not changed in a way to sustain the investment.

Within the state regulatory process for assessing capital investments, the natural comparison is always made to the historical least-cost case. This preserves the status quo, and does not promote value-added benefits to the consumer or society. Regulators must shift their paradigm to make the default case the optimal consumer/societal benefit case. This would encourage

Smart Grid investment, since Smart Grid technologies and processes will generate the greatest benefits for consumers.

State regulators and utilities also lack experience evaluating business cases for Smart Grid investment. As utilities continue to press for Smart Grid investment, the level of experience will improve and regulatory staff will begin to consider value-based regulation.

One way for states to sustain the Smart Grid investment environment could be to enact CO2 pricing. Some of the business cases for the Smart Grid enable utilities to defer building new power plants, which results in lowering the average emissions. Enacting $CO_2$ pricing would monetize this emissions reduction in the business case. Another is to establish feed-in tariffs (FIT) for variable renewables, where deeper penetration can only be enabled by the Smart Grid. One stakeholder interviewed for this report indicated that a few state programs are increasing the terms (years) for feed-in tariffs, and targeting a broader constituency in the FIT power purchase agreements.

### SGIE #2: The Smart Grid is Viewed as an Additional Capital Expense Over and Above Utility Capital Budgets.

In general, the utilities view Smart Grid investment as an added capital expense on top of the existing budgets for generation, transmission, and distribution additions. In nearly all Smart Grid strategies, the deployment of Smart Grid technologies is designed to curb some traditional capital expenditures on generation, transmission, and distribution. In these cases, the Smart Grid investment can simply come from a re-purposing of the planned capital budget with minimal to no additional capital expense.

Significant competition exists at utilities for capital budget, especially those that have a large coal-based generation component of their generation fleet. Competition for capital comes from the emissions issues that the coal-based generation must address under increasingly stringent environmental rules.

And, as natural gas prices have declined, utilities have embarked on strategies to replace older, less efficient coal-based generation with new natural gas combined cycle power plants. This certainly does not ease the competition for capital budget within these utilities. Little consideration is given to a Smart Grid investment that will obviate the need to replace the older, less efficient power plant. In essence, some Smart Grid investments will have to compete with the potentially short-lived low price of natural gas. In this environment, Smart Grid investments are considered optional and often do not pass the competitive capital budget hurdle regardless of the business case or benefits to consumers.

### SGIE #3: Technology and Process Cost Uncertainties Impede Smart Grid Deployment.

While much of it seems appealing, the certainty in project costs that utilities and regulators typically experience with “iron and wires” does not exist yet with Smart Grid technology roadmaps. Deploying “iron and wires” is less complex compared to the technical and policy environment needed for successful Smart Grid deployment programs.

For example, Smart Grid technologies introduce cyberspace into the utility's operation. This adds a high cost of complying with NERC cyber standards (particularly asset hardening), and could render new applications like synchro-phasor projects and demand response programs not cost-effective.

The uncertainty of the treatment of cost recovery for utilities is a significant barrier to utility investment in Smart Grid technologies, processes, and large deployment plans. The basic economics have to make sense, but the regulatory method of cost recovery for utilities must make sense to the utility.

These issues begin to form a picture of what a utility Smart Grid investment must capture:

- The basic economics must make sense
- The regulatory method of cost recovery must be no risk or low risk
- The regulatory method of cost recovery must make sense to the utility
- The regulatory method must recognize benefits beyond the traditional system benefits, i.e. consumer and societal benefits
- The Smart Grid investment must make productive use of competitive capital budget
- The technology cost must be certain

# 10. EDUCATION

The Smart Grid is a "system of systems" that consists of the integration of new processes, technologies, and applications. A diverse set of skilled human resources is required to support the planning, design, procurement, implementation, operations, and maintenance of such a complex vision.

The industry must also find additional skilled resources to replace those lost as the "baby-boomers" begin to retire in large numbers. Defining the new skills demanded by the Smart Grid, creating the new training programs and curricula to support manning those positions, and ensuring that an adequate pipeline of skilled resources exist today and in the future to support both the Smart Grid demand and retirements is a challenging endeavor.

## Impediments and Issues

*ED #1: The U.S. Workforce does not have Enough Skilled Workers to Fully Implement the Smart Grid.*

*ED #2: The Necessary Skills to Successfully Support the Smart Grid Still Need to be Fully Identified.*

*ED #3: Universities do not have the academic curricula developed to provide the new skills required by the smart grid.*

### ED #1: The U.S. Workforce does not have Enough Skilled Workers to Fully Implement the Smart Grid.

Adequate numbers of skilled resources will be vital in supporting the build out of the Smart Grid and to support its new processes, technologies, applications and their integration. A great deal remains to be done to establish this much needed human resource pipeline and to create the incentives needed to attract students to the Smart Grid field of study.

**ED #2: The Necessary Skills to Successfully Support the Smart Grid Still Need to be Fully Identified.** Additionally, how to package those skills to best equip the new smart grid worker is needed.

**ED #3: Universities do not have the academic curricula developed to provide the new skills required by the smart grid.** Academia and industry need to define the best approach for curriculum, course work, and training.

Collaboration is needed to create and sustain the pipeline and availability of skilled human resources. A driving force is needed to keep the pipeline full and to efficiently impart the needed education and training throughout the careers of Smart Grid workers.

## Analysis

### ED #1: The U.S. Workforce does not have Enough Skilled Workers to Fully Implement the Smart Grid.

Historically, electric service providers recruited electrical engineers with an emphasis in power engineering for most of their technical positions. This talent pool served them well over the years as these skills were well matched for the system planning, engineering and operational support positions needed to support the nature of the traditional grid. Later as information technology became an important aspect of their business—at least within the non-operational processes—an emphasis in computer science was added. Degrees in Electrical Engineering and Computer Science became popular and made a good fit with the electric service providers' technical positions.

The advent of the Smart Grid with its integration of information and communication technologies (ICT) deep into the operations processes—often referred to as operations technologies (OT), the incorporation of the consumers' resources into grid operations, and the expected availability of essentially unlimited data regarding the state of the grid, now requires an even deeper and broader scope of skills—from consumer psychology to modeling and simulation and from deterministic to probabilistic perspectives.

### ED #2: The Necessary Skills to Successfully Support the Smart Grid Still Need to be Fully Identified.

The Smart Grid will create the need for new skills in various areas and among the various stakeholder groups. Besides the electric service providers, consumers, state regulators, legislators, system integrators, vendors, university professors, analysts, and others will need to develop new skills. Some of these new skills will necessarily be technical in nature to give these other stakeholder groups the understanding they need to conduct business in a Smart Grid world.

On the technical side, skills are needed in:

- Power system engineering, monitoring, and analysis
- Advanced instrumentation, protection, and control
- Communications
- Power electronics
- Advanced smart grid components
- Reliability centered maintenance and condition monitoring
- Computer analytics
- Power system modeling, simulation, and visualization
- Environmental engineering
- Cyber security
- System architecture and integration (e.g. systems view analysis)
- Scenario analysis

Other skills needed will be less technical in nature:

- Marketing
- Economics
- Change management
- Decision-making
- Consumer psychology
- Creativity

The capability to consider technical concepts from a probabilistic perspective (risk-based analysis) in addition to the traditional deterministic perspective will also be needed.

A number of universities and industry groups in the US are beginning to catalog the complete set of Smart Grid skills needed. Figure US-1E below illustrates some categorization done by the Illinois Institute of Technology. It is important to note that while a new set of skills is required, skills in a silo will limit the value of these new skill sets. The value is greater when a portion of the technical skills are matched with ICT skills and matched with economic skills. As the Smart Grid crosses technical operational silos, so do the skills required to support the Smart Grid.

## ED #3: Universities do not have the academic curricula developed to provide the new skills required by the smart grid.

A number of universities are working on the development of a Smart Grid curriculum and some are offering "Smart Grid" courses. For example, the Power Systems Energy Research Center (PSERC) is building a Smart Grid curriculum using input from its thirteen university members.


**Figure US-E1: Illinois Institute of Technology Smart Grid Skills**

**http://www.iit.edu/galvin_center/job_training_needs.shtml**

Development of a complete Smart Grid education program requires a systems view analyses to ensure the right skills are identified, the specific Smart Grid positions are mapped to these skills, delivery methods are identified, and at what level (high school, trade school, junior college, university, OJT, etc.) the materials should be introduced.

The Smart Grid transition is in progress and some immediate training and education is needed while more complete programs are being developed. Some examples include:

- Condition Based Maintenance and Reliability Centered Maintenance are being taught in graduate level Transmission and Distribution hardware courses at some universities.
- Several utilities are working with universities to help educate their work force and are working with middle and high schools on electrical engineering concepts. Some are also using coop programs to expose students to IT and Smart Grid.
- RTOs are training their own staff after hiring. One is using a university to provide course work for their existing employees on key topics.

- The Energy Providers Coalition for Education (EPCE) is developing SG courses and will be offering them to universities.
- Electric service providers and consumer industry groups such as the Smart Grid Consumers Council are now making progress on this critical educational program. Very little is being done in the area of operator training for the new Smart Grid environment. An increased emphasis in science, technology, engineering, and mathematics (STEM) as an integrated curriculum would also be helpful at the middle school level. In fact, more emphasis on the "science and technology of integration" is needed throughout the educational program. And the need to educate the state regulators who currently lack the resources and availability to become Smart Grid experts should not be forgotten.

Collaboration among industry, academia, government, and all Smart Grid stakeholders are needed to create and sustain the pipeline and availability of skilled human resources. As noted above much is being done, but more is needed to ensure the best Smart Grid program is identified, created, and delivered. A driving force is needed and incentives in place to attract new students to the Smart Grid field. All stakeholders stand to benefit through improved education of Smart Grid concepts and systems.

An effective Smart Grid education and training program is a fundamental need in making the Smart Grid vision real and will enable its implementation and operation to be most efficient.

## 11. GRID MODERNIZATION

Modernization of the U.S. electric power grid is essential to address future growth in demand (GW) and consumption (GWh), and to replace aging systems whose material condition is rapidly declining. The cost to modernize has been estimated to be hundreds of billions of dollars if traditional means are used.

Using Smart Grid technologies to complement traditional means could result in reducing the total cost of modernization. Additionally, Smart Grid systems and programs would transform the one-way, analog power system into a two-way, interactive, digital power system that will give consumers new options and control over their electricity consumption. The modernized grid will look similar to the existing system, but will have functionality and capability far beyond what it has today.

**Impediments and Issues**

Using the Smart Grid principal characteristics as a template for change will greatly modify how the modernized grid meets its future demands. The adoption of proven change management techniques are essential to providing the foundation needed to make progress towards this vision.

A number of technical and policy barriers exist that must be resolved soon to prevent implementation efforts from stalling. And methods to share Smart Grid experiences—both best practices and lessons learned—are needed to prevent "re-inventing the wheel".

***GM #1: Ineffective Change Management Principles Prevent Implementation of the Smart Grid Vision.***

***GM #2: The Lack of a National Policy for Grid Modernization Results in Inconsistent Approaches to Smart Grid Deployment.***

***GM #3: There Are Numerous Fundamental Barriers to the Smart Grid that still need to Identified, Acknowledged, and Addressed.***

***GM #4: Smart Grid Deployment Best Practices and Lessons Learned are not Effectively Shared Among all Stakeholders.***

***GM #5: The Development Of The Smart Grid Is Not Necessarily Seen As Complementary To Other Grid Modernization Strategies.***

### GM #1: Ineffective Change Management Principles Prevent Implementation of the Smart Grid Vision.

Proven change management principles are needed to ensure that grid modernization continues and gains the momentum and interest of stakeholders to achieve it vision as effectively and efficiently as possible. These principles include the need for effective sponsorship, a clear vision, communications to gain understanding and alignment, establishment of methods to identify barriers to progress, and incentives to move stakeholders forward. Large change programs frequently fail if these fundamentals are not followed.

**GM #2: The Lack of a National Policy for Grid Modernization Results in Inconsistent Approaches to Smart Grid Deployment.** The lack of a national energy policy that addresses grid modernization and negatively impacts a unified (and therefore less than optimal) approach for modernizing the grid.

**GM #3: There Are Numerous Fundamental Barriers to the Smart Grid that still need to Identified, Acknowledged, and Addressed.** A great deal of work has been done to address some of the change management principles discussed above including the identification of a number of fundamental barriers. Some of these barriers could be "game stoppers" if they are not effectively addressed in the near future.

**GM #4: Smart Grid Deployment Best Practices and Lessons Learned are not Effectively Shared Among all Stakeholders.** An effective experience-sharing process will reduce rework and leverage the positive experiences of others.

**GM #5: The Development Of The Smart Grid Is Not Necessarily Seen As Complementary To Other Grid Modernization Strategies.** The Smart Grid will not be a total solution to the grid modernization challenge.

**Analysis**

### GM #1: Ineffective Change Management Principles Prevent Implementation of the Smart Grid Vision.

Proven change management principles provide the structure and foundation needed to generate the interest and motivation needed to create a desire in stakeholders to make the change happen. This begins with sponsorship—an entity must act as sponsor to articulate the vision and provide the priority and resources needed to accomplish it. Additionally, the sponsor ensures the team develops communication plans to reach out to all stakeholders to engage them, develops implementation plans, identifies and addresses barriers to progress, and creates incentives to motivate all to action. But grid modernization is such a large endeavor affecting so many independent entities, therefore sponsorships, all aligned around a common vision, may have to reside at various levels and within different stakeholder groups.

### GM #2: The Lack of a National Policy for Grid Modernization Results in Inconsistent Approaches to Smart Grid Deployment.

Today, the US lacks national sponsorship for grid modernization. The lack of a national energy policy that addresses grid modernization and establishes fundamental national goals that all stakeholders can accept, negatively impacts a unified (and therefore less than optimal) approach for modernizing the grid.

The DOE's Modern Grid Initiative (MGI) was a good first step in that it identified key value areas as reasons for moving forward with the Smart Grid. Specific metrics and goals are needed in each of these value areas to make them more concrete—goals at the transmission level might best be national goals while goals at the distribution level might be best served at the state level. Focusing on goals associated with each of these key value areas (reliability, economics, efficiency, environmental, safety) will help create the optimal solution set for Smart Grid investments. Goals such as renewable portfolio standards and peak load reduction and energy efficiency standards are some examples. Some of these goals have been established by progressive states that are motivated to making Smart Grid part of the grid modernization solution.

The Smart Grid Principal Characteristics developed by the MGI serve as a high level national vision to be used as a template by electric service providers as they customize it to meet their local and regional needs. A number of other organizations have developed Smart Grid visions—most seem to be consistent with the MGI work. Clearly, unique Smart Grid visions are needed at regional, state, and even local levels, but all should be linked to the higher level national vision. It's important that only one national level vision is adopted to reduce misunderstandings and create consistency. One of the issues created by multiple visions is the lack of clarity on what specific research is needed to support the transition. EPRI is currently evaluating all the visions to look for gaps where research is needed. The national sponsor should work to ensure we have one national view on the Smart Grid vision.

### GM #3: There Are Fundamental Barriers to the Smart Grid that still need to Identified, Acknowledged, and Addressed.

Many specific issues will come up during grid modernization and they will be resolved as they do. But a number of fundamental barriers exist now that could prevent the Smart Grid from successfully complementing the larger grid modernization effort. While progress is being made on some of them, we must keep them visible until they are completely resolved. Some examples of these fundamental barriers include:

- **Interoperability and cyber security of Smart Grid components and systems**—the Smart Grid is a "system of systems" and that architecture requires complete interoperability and security of its components and systems. Standards are a minimum requirement for achieving both. Extensive work is underway by the National Institute of Standards and Technology (NIST) and the Smart Grid Interoperability Panel (SGIP). The FERC plans to adopt NIST accepted standards in the future and their plans to do so are keeping stakeholders accountable and engaged. Progress is being made, but given the scope of the Smart Grid, much remains to be done.

- **State regulations**—every regulation is a potential barrier to grid modernization in some form or another. But the regulatory environment, particularly at the state level, is particularly onerous. First, regulations among the fifty states are different and often inconsistent. Additionally, regulations within each state were developed to support traditional ratemaking for traditional investments, not smart grid systems. Current PUC processes present challenges when deciding on new Smart Grid investments. Regulatory reform is needed at the state level to better align the regulatory process with the needs of the Smart Grid including such topics as rate recovery, used and useful, least cost, net metering, interconnection standards, decoupling revenue from kWh sales, and others.

  Regulatory reform will be a significant challenge. State regulators are not positioned to be advocates for the Smart Grid or to push for regulatory reform. Their priority is to address matters and issues with service providers and customers (i.e. the regulatory compact). PUCs generally do not have the resources or time to understand what needs to be done and take action to accomplish it. Some states such as California, Texas, Illinois, and Ohio are working hard to address this. Perhaps the lessons learned and best practices from their experiences might be used to guide other states.

- **Retail Energy Providers (REP) can only operate in deregulated states**— REP companies have been quite successful in deregulated states in advancing consumer engagement. They are working with state commissions and consumers and are offering exciting new programs that regulated utilities have not yet been able to do. In essence, the REP companies are acting as catalysts in moving some of the Smart Grid investments forward. Unfortunately, REP operation is limited to states that have undergone deregulation. This creates a barrier or at least a delay in engaging consumer participation in regulated states and limits the amount of demand response available to the wholesale markets.

- **Research and commercialization of new technologies and applications**—collaboration among the various research bodies would clarify roles, responsibilities, scopes and priorities. For example, some believe the federal government should be involved in longer term, higher risk, basic and strategic research and to assist in the demonstration of integrated technologies and the evaluation of concepts (pre-commercial)—areas that private R&D organizations will avoid.

  The last decade of R&D created the tools and technologies for today's Smart Grid deployments. Today's research will create the tools needed for the next decade of Smart Grid investment. Other research organizations such as EPRI and universities can leverage the successes of governmental research and drive them to commercialization consistent with the needs of grid modernization.

Other barriers to grid modernization should be added to this list as they emerge. This list needs to be visible to all stakeholders, modified as new issues arise, relative priorities established for each, and progress acknowledged when each is resolved. Working together to address them is the best way to solve them in time to prevent any from becoming a "game stopper" for grid modernization.

### GM #4: Smart Grid Deployment Best Practices and Lessons Learned are not Effectively Shared Among all Stakeholders.

Sharing of smart grid experiences is necessary to prevent repeating mistakes, minimize rework, and leveraging the good work of first adopters for those that follow. Some work is underway to create the venue and processes for sharing Smart Grid experiences, but more is needed to make it "broader and deeper" to ensure all may benefit.

At the international level, the US State Department is supporting the International Smart Grid Action Network (ISGAN) to create a mechanism for multilateral government-to-government collaboration to advance the development and deployment of smarter electric grid technologies, practices, and systems. It aims to improve the understanding of smart grid technologies, practices, and systems and to promote adoption of related enabling government policies.

In the US, a number of organizations are conducting on-line webinars to share the latest experiences of various stakeholder groups. Case studies are also being prepared to document and communicate experiences. These efforts are excellent tools for sharing these best practices and lessons learned. The challenge, though, is not the delivery of the information but its collection—to ensure all of the key experiences are identified and then processed through webinars, Smart Grid conferences, and case studies.

This same concept is beneficial at the electric service provider level. By keeping all internal stakeholders informed of the latest issues and their resolutions can improve performance, build teamwork, and lead to a lower cost and more effective smart grid implementation experience.

Another possible experience-sharing opportunity is to work with regional transmission organizations. Development and implementation of the RTO concept experienced some of the same barriers that the Smart Grid transition faces. RTOs have successfully navigated those waters and, therefore, may be a rich source of best practices and lessons learned for the Smart Grid.

The DOE, through the National Energy Technology Laboratory (NETL) has developed a white paper on, "Sharing Smart Grid Experiences through Performance Feedback" which identifies a complete process for the collection and delivery of best practices and lessons learned. It also addresses the benefits and challenges for its implementation.

### GM #5: The Development of the Smart Grid is Not Necessarily Seen as Complementary to other Grid Modernization Strategies.

The Smart Grid should be complementary to other grid modernization strategies to ensure that the best of both approaches are applied. A number of new concepts warrant increased attention as they have promise for advancing grid modernization if adopted. Some examples include:

- A national **transmission grid overlay** would provide a robust backbone to further optimize (and modernize) the grid. It would be complementary to the Smart Grid. This concept is costly but highly beneficial. A number of regulatory issues exist around such a large investment crossing many state jurisdictions—in particular cost recovery, i.e. who pays and how much? The Tres Amigas project is an example of this notion where the three US interconnected networks will be joined.
- **Utility and community microgrids** that can operate in parallel with the grid to optimize around specific reliability, economic, and environmental criteria can be helpful to the grid modernization effort. Microgrids can leverage the dispatch of local generation, storage, and variable load thereby moving the distribution system closer to a network system (rather than radial), thereby creating solutions for many of the modernization issues of today. Unfortunately, electric service provider interest in microgrids is generally low, although a few are being deployed to address local reliability issues.
- **Regional Distribution Organizations (RDO)** may be needed as the deployments of distributed resources increase and the need for their real time dispatch increases. If the vision of the Smart Grid is achieved—deep penetrations of dispatchable distributed resources—then RDOs could simplify distribution operations. Operation of RDOs at the distribution level would be analogous to that of RTOs at the transmission levels. RDOs could dispatch in real time to reduce local demand, reduce energy "take" from the transmission system, and mitigate voltage and overload issues following contingencies, as a an option to reinforcing the transmission grid at a higher cost. They would be complementary with RTOs and would receive input from RTOs for distribution dispatch. This would increase compatibility between distribution and RTO market systems.

Grid modernization is a tremendous undertaking but one that is urgently needed to sustain growth and prosperity in the US. The Smart Grid is expected to make a significant contribution to grid modernization, but traditional upgrades are also needed. Hopefully, the total cost of grid modernization will be less through the application of Smart Grid technologies than it would otherwise be if done using only traditional solutions.

# SUMMARY

In summary, the impediments and issues provide insights for each of the domains; essentially a list of actions necessary to move Smart Grid strategies forward in the nation.

### *Regulatory*

- Regulators have limited resources to address new Smart Grid concepts.
- Consistent state policy is needed to advance retail markets.
- The patchwork of state regulations present a significant barrier to grid modernization, and most state regulations are silent on Smart Grid investments.
- National and state policy fails to drive economic efficiency. Regulations need to drive a new norm of accountability for reliability and efficiency. Regulators do not use trends and metrics to track utility performance.
- Little attention is given to cross-subsidies.
- The regulations continue to support investments in an already under-utilized generation fleet.
- Commissions should stress the value of consumer education and share consumer concerns with the industry. Yet, state commissions' staffs have limited resources to devote to Smart Grid education.

### *Market*

- The integration of wholesale and retail markets should be part of the solution for grid modernization. The Smart Grid will create new opportunities to integrate the wholesale and retail markets.
- The Smart Grid offers better linkage of Distribution and Transmission to increase efficiency of markets.
- Capacity markets subsidize energy markets.
- Markets are generally non-supportive of distributed generation.
- Lessons learned from RTOs can help retail consumer engagement.
- Norms need to transition from a cost-based structure to a value-based structure.
- Organized markets are perfect examples of decisions informed by data and analytics.
- Organized markets provide a basis for some Smart Grid investment.
- How markets might work in a Smart Grid environment is not widely understood.

### *Consumer*

- Education is needed to help customers understand and support Smart Grid concepts and opportunities. Need a new consumer education norm of distributed, broadly informed many.
- Consumer education is improving, but a broader national educational effort is needed.
- Success of the Smart Grid depends on the level of consumer participation and market participation by consumers depends on time of use rates.
- Policies need to give economic efficiency and reliability objectives "teeth" with performance standards.

- Commercial consumers have little influence in regulation.
- Consumers have much generation capacity not connected to the grid. The integration of their resources can partially address growth and reliability issues.
- Large majority of consumers have only their monthly bill as an analysis basis.
- The consumer expects the state regulator to take the lead in selecting Smart Grid investments.

### *Technical*

- Smart Grid success depends on the integration of processes and technologies to achieve optimization goals.
- In-premise technologies are needed for customer participation. Plus, consumer-facing technologies should be simple, i.e. “set it and forget it”.
- Energy storage promises to improve system and capital efficiency, but this technology has not proven itself broadly.
- Smart meters without smart rates mean large unrealized Smart Grid benefits.
- The growth of PV challenges local grid stability.
- Industry needs the Smart Grid, to change the technology norm from limiting options to increasing options.
- The Smart Grid enables a new level of granular data and analysis capabilities.
- Smart Grid complexity adds risk to utility cost estimates.
- Smart Grid related technical education is needed at all levels from middle school through university levels and OJT.
- Both Smart Grid and traditional solutions are needed to meet grid modernization needs.

### *Social / Society*

- The Smart Grid vision provides much societal benefits by optimizing around the key values.
- Retail customer participation can create substantial societal value, which is large in the Smart Grid business case.
- Federal laws have made power plant siting uncertain, making grid planning very difficult.
- While a cross-subsidy may not be negative, it should have a reason.
- Distributed energy resource use has environmental challenges.
- Society needs a new norm to engage consumer side.
- The industry behavioral norm of not researching trends and metrics harms society.
- Smart Grid education needs to be more interesting and fun to gain the interests of society.
- Grid modernization is needed to sustain growth and prosperity in the US.

### *Operations*

- The decentralized Smart Grid operating concept enables better optimization.
- Economic dispatch of many distribution resources is a new operating model and requires new advanced operations tools.
- Improved supply and demand dispatch efficiency reduces congestion and peak load.
- Consumer resources in operation on the grid will create new operational challenges

- Need a new behavioral norm of sharing control, risk, and information.
- From planning to real-time operations few trends and metrics are used.
- Operator training on Smart Grid technologies is lagging. Training programs are needed when these technologies are commercialized.

### *Education*

- New skills are needed to support the new Smart Grid concepts—additional education will be required at the university as well as on-the-job (OJT) levels.
- Gaining consumer participation depends on effective consumer education. Consumer education is essential to stimulate the markets they touch.
- The broad stakeholder lack of understanding of how costly the 45% electric asset utilization is to society must be corrected immediately. If the consumer had more knowledge of the generation capacity factors, they would be asking harder questions.
- The industry lacks knowledge on cross-subsidy issues.
- The new norm is that consumer education is a core function.
- The Smart Grid can move the industry to learning lessons based in fact, trends, and metrics.
- The industry needs to learn how to monetize Smart Grid benefits.
- Smart Grid education is needed for all Smart Grid stakeholders, not just electric service providers, to promote grid modernization.

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[i] I.Volkova, V.Okorokov Intellectual Electric Power Systems: Technical Possibilities and Efficiency // Energy Academy, 2010 -№№3-4

[ii] Russian Federation, 2009, Energy Strategy of Russia for the Period up to 2030, Ministry of Energy of the Russian Federation. Moscow
http://energosber.74.ru/Vestnik/2009/09_07.htm

[iii] Federal law «On Energy Saving and Energy Efficiency».
http://graph.document.kremlin.ru/doc.asp?ID=55577

[iv] Russian Power Industry 2030: Target Vision / under the general editorship B. Vaynzikher – Alpina Business Books, 2008 – p.46

[v] Russian Power Industry 2030: Target Vision / under the general editorship B. Vaynzikher – Alpina Business Books, 2008 – p.47

[vi] Russian document is: Concept of UE – JSC FGC UES, 2012.

[vii] The Russian Federation, 2009, Energy Strategy of Russia for the Period up to 2030, Ministry of Energy of the Russian Federation. Moscow

[viii] With the exception of residential and equivalent categories of consumers who still purchase and supply electricity and power in the wholesale market at regulated prices.
[ix] Projects of these documents are palced on the web-site of the Ministry of Energy for public discussions. See: http://minenergo.gov.ru/documents/razrabotka/13828.html; http://minenergo.gov.ru/documents/razrabotka/13829.html
[x] The state sets prices for network companies, NPP and HPP, as well as tariffs for TPP whose expensive capacity cannot otherwise complete the CCS admission procedure successfully. For the rest of generators a ceiling prices for capacity are established (price cap).
[xi] Consumer who also produces energy.
[xii] http://minenergo.gov.ru/
[xiii] [xiii] Federal Program on Energy efficiency for the Period until 2020, Russian Federation collection of Legislation, 2010, No. 2446-p
[xiv] Presidential Decree of June 4, 2008 № 889 defined a task of reducing energy intensity of GDP by 40% by 2020.
[xv] The state program was approved by Order of the Government of the Russian Federation of December 27, 2010 № 2446-r.
[xvi] Energy Efficiency in Russia: Untapped Resources. Report. The World Bank. International Finance Corporation. 2008. P.81. URL: http://www1.ifc.org/wps/wcm/connect/400e24004b5f69148d21bd6eac26e1c2/Final_EE_report_engl.pdf?MOD=AJPERES

[xvii] This stays in partial contradiction with the Second law of thermodynamics.
[xviii] According to the Master Plan, in the next 10 years annual growth in energy consumption is expected to reach ca 2-3%.
[xix]
http://www.google.ru/url?sa=t&rct=j&q=уровень%20потерь%20электроэнергии%20в%20россии%20&source=web&cd=6&ved=0CEQQFjAF&url=http%3A%2F%2Fwww.ntc-power.ru%2Fupload%2Fpresentation%2FPrezentation_Vorotnitskiy_Turkina.pdf&ei=ioBlUK-wM6XP4QT424CQDw&usg=AFQjCNHEjFa0znJXtxPZA2-2JhXxQF65_w&sig2=XnAAGHeJr1Gxt2hnQq397w&cad=rjt –
[xx] Theft of power has quite a clear upward trend, especially in regions with weak heat supply for consumers in colder times of the year, as well as in virtually all regions in the fall and spring periods when temperatures are already severely diminished, but heating is not yet turned on.
[xxi] http://smartmetering.ru/news/smart_met/index.php?id_4=210#.UGUrCX6f_8I
[xxii] Objective difficulty in collecting industry statistics is explained by a complicated hierarchical character of power industry structure that produces great variety of data collected, the large number and variety of reporting entities and respondents differing in territorial, functional, production principle, type of property, etc.
[xxiii] See Main Provisions of Concept for Intellectual Energy System based on **Active and Adaptive Grid: URL:** www.fsk-ees.ru/upload/docs/ies_**aas**.pdf

[xxiv] An analogue of EU Public-Private partnership instrument with the same name.

[xxvi] http://www.fa-kit.ru/main_dsp.php?top_id=8044
[xxvii] http://minenergo.gov.ru/documents/
[xxviii] http://minenerg o.gov.ru/documents/