24 February 2014

Dear Member of Congress:

On behalf of IEEE-USA, I am pleased to provide you with a copy of the *2014 IEEE-USA National Energy Policy Recommendations* (NEPR). The IEEE-USA Energy Policy Committee developed this and it is based on the collective judgment of IEEE-USA members with expertise in the subject area.

The United States is facing ever increasing pressures both domestically and globally to develop a clear and concise energy policy framework. Now, more than ever, we need to take prompt action.

The NEPR outlines guiding principles and recommendations for important energy policy initiatives, such as transforming the transportation sector by diversifying its energy sources, reducing greenhouse gas emissions, improving energy efficiency, building a stronger and smarter electric energy infrastructure, expanding and accommodating new types of electric generation, and encouraging established and new technologies to enhance the performance of the electric grid. These initiatives and other recommendations contained in the NEPR are critically important to our national security, economic prosperity, and protection of the environment.

IEEE-USA advances the public good and promotes the careers and public policy interests of more than 205,000 engineering, computing, and technology professionals who are U.S. members of IEEE. IEEE-USA members stand ready to participate in briefings, legislative hearings, and other forums necessary to advance this important policy area for our nation. Please contact James Savage at james.savage@ieee.org or 202-530-8330 to arrange for future communication with the IEEE-USA Energy Policy Committee.

Sincerely,

Gary L. Blank
2014 IEEE-USA President

Encl.

IEEE-USA

IEEE-USA POLICY POSITION STATEMENT

2014 NATIONAL ENERGY POLICY RECOMMENDATIONS

Inside

About this IEEE-USA Policy Position Statement

This statement, as approved by the IEEE-USA Board of Directors in November 2013, was developed by the IEEE-USA Energy Policy Committee and represents the considered judgement of a group of U.S. IEEE members with expertise in the subject field. IEEE-USA advances the public good and promotes the careers and public policy interests of more than 205,000 engineering, computing and technology professionals who are U.S. members of IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of the IEEE or its other organizational units.

Introduction

ENERGY underlies three converging challenges facing the United States today: economic prosperity, security, and the environment. Electricity continues to be a key enabler in addressing these challenges, but it has come under substantial pressures to respond to environmental concerns, deal with uncertainties in both local and global energy supplies, and accommodate the rapid evolution of new generation sources and technology options available to its users. The major challenge is to develop solutions which take into account changing energy supply markets as well as financial resource availability.

To ensure that we can reliably and securely meet our growing energy needs, we must:

- Use energy and economic resources more efficiently
- Expand energy sources for our transportation systems
- Transition our energy systems and our economy to ones that can better manage our environment and emissions
- Prepare an engineering and skilled trades workforce that has the necessary knowledge and skills to design, plan, construct, operate and maintain modern energy delivery systems
- Build flexibility and adaptability into all elements of the physical, regulatory, and institutional aspects of our energy infrastructure

Established and new technologies must be applied at unprecedented scale, and on an accelerated schedule. Bold actions and substantial investments will be required together with the development of a clear national energy policy framework. This statement outlines the key actions and investments that IEEE-USA recommends to both public and private entities to reach these critical objectives.

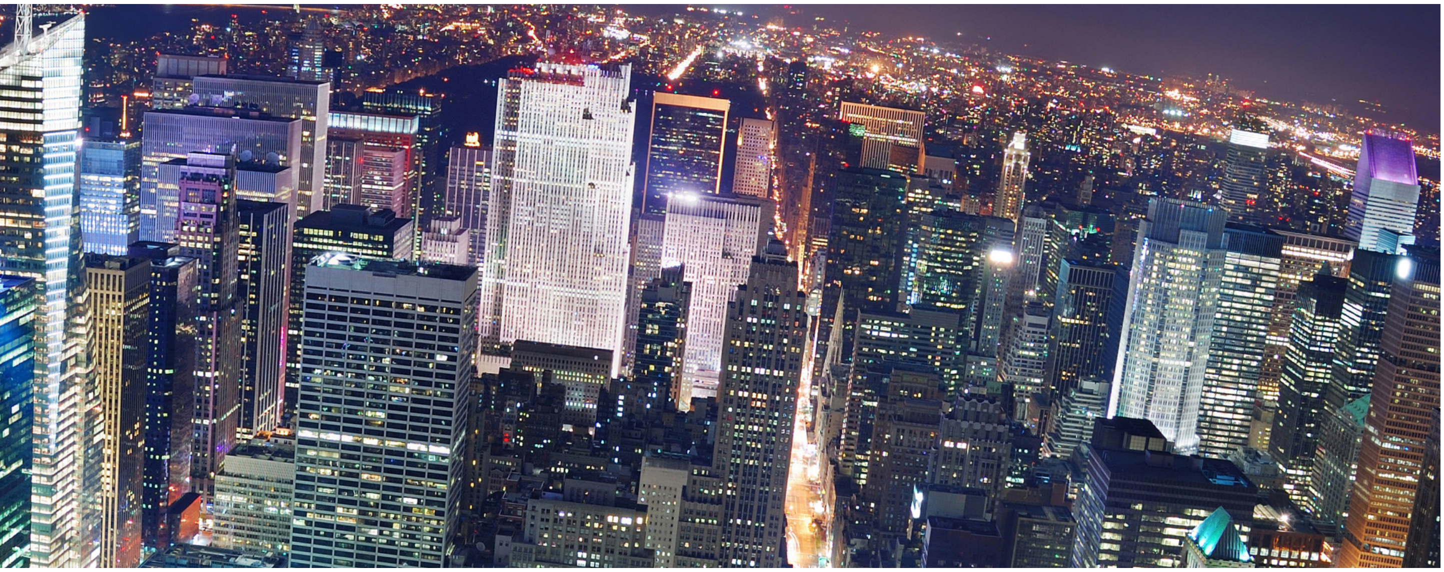
PURSUING ENERGY EFFICIENCY AND DEMAND RESPONSE

Energy efficiency[1] and demand response[2] are essential elements in any comprehensive national energy policy, because the energy that does not need to be produced is often the cleanest, safest, and the least expensive option for users. These options require more attention at all levels of the economy, because these are crucial drivers of the cost of providing energy services in a sustainable way. Further, demand response provides the customer with an additional way of reducing electric consumption and cost, and is an important complement to renewable resources, as it provides another option to compensate for some of the variability of wind and solar. While much of the demand response effort to date has concentrated on residential customers, better options are often available for industrial, commercial, and business customers having some form of building or facility energy management systems, that can be interfaced and coordinated with the operations of a modern grid. For the future, more intelligent control systems using predictive/adaptive techniques to manage not only energy use, but also costs, productivity, and product quality aspects of the entire system, will become available. Such systems will also incorporate gateways for interfacing with power system operations.

All sectors of the economy are substantial consumers of energy and most of these sectors have some flexible energy uses suitable for demand response. State and local governments must improve energy efficiency, create demand response options in the public sector, and become leaders in promoting these measures in the private sector among households, businesses, and industries. Much of this effort is already taking place. While the electric utility industry has significant market incentives to continuously improve energy efficiency of the power system, efforts to increase efficiency and demand response capabilities across all components of the economy need to continue. Such efforts must include improvements to the transportation sector, discussed under a separate section of this document.

1 Energy efficiency is the ability to provide the same or better, product or service, using less energy.

2 Demand response is a capability to modify customers' energy use over time, so as to provide a resource for power system operations.



IEEE-USA urges federal, state and local governments, along with quasi-governmental and private sector organizations, to work toward improving energy efficiency, and to pursue demand response opportunities and **RECOMMENDS:**

- **Education:** Energy providers and governments (federal, state and local) should provide all types of energy users (including homeowners, builders, businesses, government, etc.) with educational resources, as well as increase their awareness of energy efficiency and energy management opportunities and incentives.

- **Standards:** Federal, state and local governments and standards organizations should continue developing and implementing methods, standards, and codes for sustainable products and buildings, consistent with lifecycle analysis, as well as customer comfort and productivity needs.

- **Best Practices:** Federal and state governments should compile the necessary resources to equip customers and energy stakeholders with information on existing programs, studies, methods, and data used for energy management.

- **Transportation:** Automobile, bus, ship, train, airplane, truck, and utility vehicle manufacturers should continue to develop, commercialize, and use more efficient electric drive train technologies.

- **Industrial Process R&D:** Industry and governments should cooperate in conducting R&D on new industrial processes that can improve productivity, product quality, and energy use.

- **Electric Grid Efficiency:** Strengthen federal R&D on efficient system designs, technologies, and processes to further reduce energy losses and improve performance of electric power generation, transmission, and distribution.

TRANSFORMING TRANSPORTATION BY DIVERSIFYING ENERGY SOURCES

Today, more than 90 percent of the energy used in transportation comes from oil. The transportation sector consumes about 70 percent of all petroleum used in the United States. Oil will continue to be a major fuel for decades, but our ability to substantially reduce its use for transportation will be essential to reducing the national security risks inherent in dependence on a single energy source.

We need a radical transformation of the transportation sector, not only to reduce our dependency on oil, but also to increase the security of our transportation system and to reduce emissions in the transportation sector, particularly in large cities. Because transportation emissions are widely dispersed, it is unlikely that these emissions could ever be captured and stored. Hence, the principal option is substitution of alternate energy sources for oil.

IEEE-USA recommends a three-pronged effort: (1) to electrify transportation, focusing on plug-in electric and hybrid technologies; (2) to pursue replacing conventional fuels with alternative liquid fuels; and (3) to expand the use of natural gas for heavy-duty vehicles. Domestically produced electricity and alternative liquid fuels would give the United States the ability to maintain its economy and transportation system, regardless of what happens in the rest of the world.

Conventional hybrid vehicles have already demonstrated the capability to substantially increase fuel economy. The plug-in feature adds an option to substitute electricity for some or all of the gasoline used in the vehicles.

1. Electrifying Transportation: Plug-In and Hybrid Electric Vehicles

The electric infrastructure already in place is sufficient to permit on the order of 75 percent reduction in the dependence on liquid fuels, through greater penetration of plug-in electric vehicles (PEV), including all electric and plug-in hybrid electric vehicles. In addition, very little oil is used to produce electricity in the United States, and the fuels used (nuclear, coal, gas and renewables) are primarily domestic. Therefore, electrification of vehicles would produce a direct and immediate substitute for oil along with commensurate benefits for national security and the environment. Electric motors are inherently more efficient than internal combustion engines. Motors do not consume energy while vehicles are stopped in traffic, and when paired with batteries, provide the opportunity to recover energy from braking. Current hybrid electric vehicle (HEV) technology, e.g., Ford Focus, Toyota Prius, Honda Insight, and others, demonstrates the potential of this approach. Some of the improvements developed for electric and hybrid cars have migrated into and are now improving conventional vehicle fleet efficiency.

Electrifying the transportation sector will increase transportation energy efficiency and reduce greenhouse gas and other emissions, even with the current generation fuel mix. Increased use of natural gas for generation is making the environmental advantage even more prominent. In addition, electrification opens up a clear pathway to near-zero “well-to-wheels” emissions in the transportation sector.

While the technical feasibility of PEVs is evidenced by the growing number of manufacturers, the market is still in its infancy. The current sales volume and maturity of plug-in vehicles are comparable to those of Prius in 2000, when it entered the U.S. market. Stable, predictable incentives, similar to those provided to help introduce conventional hybrids, are needed to expand this market and enhance economies of scale. These market development measures should be combined with further technology advances, particularly in battery systems, to improve cost competitiveness with conventional internal combustion technology.

IEEE-USA RECOMMENDS that federal, state and local governments, along with quasi-governmental and private sector organizations, develop and pursue a strategy to electrify transportation; including mass transit, passenger and commercial vehicles, buses and short- and long-distance rail by:

- **Efficiency and Deployment:** Increasing transportation efficiency and promoting the rapid deployment of PEVs and HEVs through measures such as:

  (1) assuring that federal Corporate Average Fuel Economy (CAFE) standards are as demanding as those of other developed economies

  (2) offering federal and state tax credits, rebates and other incentives for electric vehicle purchase

  (3) offering state and city incentives, such as commuter lane driving opportunities, and special parking privileges for consumers who drive PEVs and HEVs

  (4) accelerating U.S. Department of Defense development of HEV and PEV technology for military applications

(5) offering city-, county-, or state region-sponsored incentives for PEV sharing

(6) offering city and state license incentives for use of PEVs and HEVs as taxis

(7) purchasing PEVs and HEVs by companies for employees use

- **Battery Charging Infrastructure:** Promoting the development of battery charging infrastructure, and its deployment by cities, states, and businesses, and along the interstate highway system with the support of the federal government. California, New York, and other states may serve as templates for measures that can be implemented.

- **Battery R&D:** Accelerating and diversifying federal and private sector R&D aimed at improving battery technology including:

  (1) increasing energy storage density

  (2) decreasing cost

  (3) increasing life

  (4) assuring safety

  (5) implementing rapid battery recharge or change-out strategies

  (6) identifying secondary markets for used batteries

  (7) recycling strategies

- **Grid Integration R&D:** Continuing federal and utility-sponsored research on the integration of PEVs on the electric grid, developing and implementing industry consensus standards to realize full potential benefits.

- **Full Cost Assessment:** Identifying through federal research the true costs and benefits, particularly the public health benefits, of electricity, and other alternatives to oil for transportation.

- **Power Electronics and Electric Machine R&D:** Accelerating and diversifying federal and company sponsored R&D aimed at substantially reducing weight, volume, and cost of power electronics (PE), and electric machines for PEVs including:

  (1) highly efficient PE interfaces, including integration with electric machines

  (2) wide band-gap semiconductor materials research

  (3) advanced, high-temperature PE packaging

  (4) enhanced PE reliability

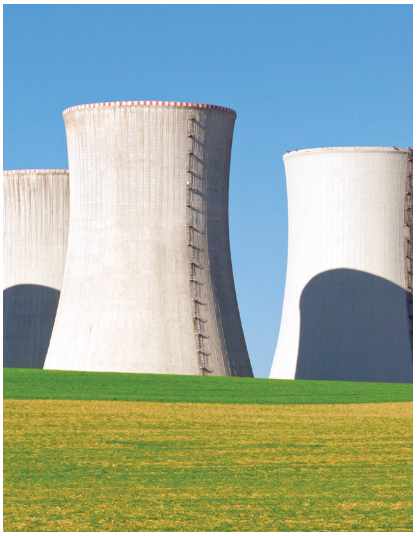
  (5) alternatives to rare earth permanent magnet electric machines

2. Developing and Using Alternative Transportation Fuels

The fastest and most efficient way to reduce dependence on petroleum is to combine a strategy of rapid electrification, together with rapid development of alternative liquid fuels, to satisfy the continuing requirement for liquid fuels. Some alternative liquid fuels generate CO_2 emissions as great as conventional petroleum, but others may offer an opportunity to substantially reduce net CO_2 emissions. Some of the most significant issues with biofuels are water consumption and competition with food crops. It is, therefore, essential that these issues be fully understood as part of developing a broader perspective on this topic.

To help meet our transportation fuel demand from secure, domestic sources as soon as possible and at reasonable cost, **IEEE-USA RECOMMENDS**:

- **Fuel Flexibility:** Passing federal legislation to mandate fuel flexibility in vehicles.
- **Biomass R&D:** Pursuing federal R&D to convert sustainable biomass to transportation fuels, which can be blended and distributed with gasoline.
- **Fuel Distribution and Control:** Promoting fuel flexibility in the fuel distribution system; and advanced control technologies to maximize efficiency, and minimize emissions across the spectrum of fuels.
- **Government Vehicles:** In all government procurement of light-duty vehicles, give preference to vehicles that offer three-way fuel flexibility, to use at least gasoline, ethanol, and M60 methanol blends.
- **High EROI Fuels:** Promoting the use of biofuels that offer a higher energy return on energy invested (EROI).
- **Natural Gas:** Supporting comprehensive congressional legislation to promote greater use of natural gas in heavy-duty vehicles, so long as such legislation provides equal, or greater, stimulus to electrification and alternative vehicles.


GREENING THE ELECTRIC POWER SUPPLY

In 2012, EIA reports about 67 percent of U.S. electricity was generated from fossil fuels, with most of the rest provided by nuclear (19%), hydroelectric (7%), renewables (5%), and other (2%). Historically, the shift from burning fuels at the point of use to producing electricity at central power plants increased the efficiency of electricity production, greatly reduced the emissions at the point where energy is used, enabled less costly control of emissions, and reduced the total environmental impact of energy use.

The United States needs to further reduce the environmental footprint of the electric power supply to continue its longstanding effort to reduce criteria pollutants and toxic emissions, and to contribute to global reduction in release of greenhouse gases. Achieving such reductions requires a portfolio of cleaner energy resources and generation technologies.

Technologies that can green the power supply include nuclear and renewables (hydroelectric, geothermal, wind, solar thermal and solar photovoltaic, direct combustion of biomass, and biofuels). Wind, hydroelectric, geothermal, solar PV and biomass combustion are now commercially available, and with the right policy support, can continue to grow, mature, and become more affordable. To a large extent, the pace of progress toward electricity produced from renewable resources will be influenced by public policy, because most of these technologies are still more expensive than conventional fossil generation. Nevertheless, national policy should support renewable development. Society benefits even with subsidies to renewable generation, because renewables and other clean technologies avoid some of the unpriced externalities of combustion technologies. However, any policies designed to influence the market price of renewables, such as a production tax credit for wind generation, must be stable and predictable to inform investments in these green generation options. The congressional practice of authorizing incentives for short periods of years, with the threat they might be discontinued, has created disruptive "boom and bust" cycles of renewable development.

For project developers and the investment community, the best case scenario would be a stable and predictable price offer for all renewable energy resources stimulating private investment and jobs.

Nuclear is well established, but no new plants have been placed into service in the United States in many years. Life extensions to sixty years and increases in power capacity have been granted for existing nuclear power plants. Some suspended projects have been restarted, and, as shown by commitments in Georgia and South Carolina, some of the industry is commercially ready to proceed with federal leadership, as well as public and private support. Nevertheless, the high initial cost of nuclear presents a serious barrier to new plant construction. In the past year, several existing nuclear plants have closed, or have announced near-term retirement dates. For nuclear power plants, the cost of major repairs or life extensions can be extremely expensive. When confronted with expensive repairs, and when less expensive options exist, some owners can be expected to retire the facility. Additionally, disposal of spent nuclear fuel and high-level radioactive waste remains a controversial topic requiring prompt attention by all stakeholders.

A shift from coal to gas generation is expected to continue, with more than 60 GW of coal capacity already scheduled for retirement over the next few years. Compared to coal technologies, efficient gas generation reduces GHG emissions by more than 50 percent. Nevertheless, coal is still one of the most abundant domestic resources, and its continued use would be greatly bolstered by retrofitable carbon capture options, along with technologies for reuse and sequestration of CO_2. Unfortunately, carbon capture is yet to be demonstrated for a commercial scale electric generating plant, and it is not expected to make a significant contribution to GHG reduction in the next decade.

1. Expanding the Use of Renewable Electric Generation

Renewable electric generating technologies can be deployed to the extent that they are technologically and economically practical, and have an acceptable impact on the environment and aesthetics. Such technologies include electricity generated from wind, sunlight, conventional hydroelectric, geothermal, waves, and tidal flows. Although renewables are not free from environmental impacts, they generally operate without the greenhouse gas emissions, and the criteria pollutants from combustion of fossil fuels.

Recent studies from DOE's national labs suggest that high levels of renewable generation can be integrated into bulk power systems. The analysis also finds that this transformation would face significant institutional and technical challenges, including the need for increased electric system flexibility from other resources, to enable electricity supply-demand balance. This flexibility can come from a portfolio of supply- and demand-side options, such as flexible conventional generation, grid storage, new transmission, more responsive loads, and changes in power system operations. These studies find that the most cost effective renewable energy future will require a substantial expansion of the transmission network to deliver the best renewables from the Great Plains, Midwest and desert Southwest to distant load centers, as well as continued improvements in renewable generation technologies.

Many states are pursuing actions to "green" their power systems, including adopting renewable portfolio standards and are well down the path to achieve their goals. Some states, such as California, have already achieved high penetration of renewable electric generation using portfolio standards and are considering whether to increase their long-term goals. Technological progress and higher manufacturing levels of renewable generating equipment have caused costs to drop, therefore, decreasing the premium over conventional fossil fuel generation.

IEEE-USA RECOMMENDS:

- **R&D:** Congress should focus more aggressively on funding R&D aimed at reducing the cost of energy delivered by a broad range of renewable electric generation.

- **Market Transformation:** Congress and the states should promote the use of renewable energy because of its security of supply, distributed and modular nature, and reduced greenhouse gas emissions. Portfolio standards and other mechanisms should be considered by all states and Congress.

- **Stable Incentives:** Financial incentives for renewables should assure that these technologies don't get displaced in the long-run by the short-term availability of inexpensive natural gas. Incentives should be stable and sufficiently predictable to allow long-term planning by renewable power purchasers, project developers and equipment manufacturers.

- **Regional Planning:** The U.S. DOE and FERC should continue supporting regional and interconnection-wide transmission planning practices and system operating procedures, to support integration of variable renewable generation for public benefit.

- **Market Design:** FERC and system operators should revise market designs to accommodate high penetration of renewable resources.

2. Revitalizing Nuclear Power Generation

Nuclear power plants are among the power generation sources that emit negligible greenhouse gases. They have the ability to provide continuous base-load generation, regardless of the time of day, or weather conditions. The operators of more than 100 existing nuclear plants in the United States believe these facilities are cost competitive with both conventional fossil fuels and renewable sources, and through license renewal, could operate for many decades. Although progress is being made toward smaller, more modular designs, the near-term emphasis should be on getting proven nuclear plant designs built and operating. Nuclear power is, and must remain, an important part of a balanced portfolio of energy sources.

IEEE-USA RECOMMENDS:

- **Spent Fuel Management:** The U.S. DOE should propose, and Congress should enact, a comprehensive spent nuclear fuel management program that would close the fuel cycle, and develop a disposal facility as mandated by the *Nuclear Waste Policy Act of 1982*.

- **Nuclear Fuel Reprocessing:** Congress should enact incentives to encourage deployment of advanced nuclear fuel reprocessing technologies to reduce proliferation concerns, and to diminish the volume and lifetime of wastes.

- **R&D:** Congress should appropriate funds to support fundamental R&D in industry, academia and government, to continue exercising world leadership in nuclear fission and fusion science.

- **Licensing and Construction:** DOE and NRC should actively support provisions of the Energy Policy Act of 2005 pertaining to the construction of new power plants, and the Next Generation Nuclear Plant (NGNP); and support development and licensing of small modular reactors, including their potential to re-power some existing fossil-fueled generating plants.

- **Process Heat Applications:** DOE should allocate funds to demonstrate applications of nuclear process heat/cogeneration in chemical and petroleum industries, such as enhanced oil recovery, coal-to-liquid and production of hydrogen, and NRC should devise safety regulations for the commercial deployment of these nuclear process heat technologies.

- **Safety:** NRC should continue to promote vigilant observance of safety practices and environmental protection. When required, NRC should mandate upgrade of facilities as lessons are learned from operating experience — such as the accidents at Fukushima and San Onofre — and from ongoing evaluations.

3. Reducing Carbon Emissions from Fossil Power Plants

Coal is our nation's most plentiful, one of its lowest-cost, domestic fossil fuel resources, and is important to the economic vitality of some areas of the United States. It provides more than 20 percent of U.S. primary energy supplies and about 40 percent of total electrical energy. Coal, however, is also one of the major sources of carbon dioxide (CO_2), and emissions such as sulfur oxides (SOx) and mercury. Only the use of petroleum in transportation is a comparable source of CO_2 within the United States. As a result of regulations requiring mitigation of the environmental impacts of coal combustion, the construction of new coal power plants has greatly diminished in recent years. Many older, less efficient plants are expected to be shut down. Most of them are being replaced by gas-fired power plants that also emit CO_2, albeit at lower levels.

The capture, transport and storage (or sequestration) of carbon, or its combustion products, is a daunting challenge — because of the enormity of the necessary infrastructure, the loss in efficiency and plant output, and the cost. Yet, because coal is our nation's most extensive energy resource, the effort is essential, if we are to address the long-term challenge of mitigating greenhouse gas emissions. Two power plant proposals — one in Mississippi now under construction, and one in California in the permitting process — could offer an opportunity to demonstrate commercial scale capture and use of CO_2 for enhanced oil recovery.

IEEE-USA RECOMMENDS:

- **CCUS R&D:** Congress and the U.S. DOE should maintain long-term R&D efforts to develop and test retrofitable pre- or post-combustion carbon capture and storage or reuse technologies that would make coal a viable energy resource in a future, carbon-emission constrained world.

- **Clean Generation R&D:** Congress and the U.S. DOE should continue public R&D, in conjunction with private R&D, to develop and demonstrate other clean fuel generation technologies, including biomass fuel production and utilization, and projects for carbon capture and storage from other fossil-fuels.

BUILDING A STRONGER, MORE INTELLIGENT ELECTRIC ENERGY INFRASTRUCTURE

The National Academy of Engineering classified electrification as the number one engineering achievement of the 20th century. A panel of national experts judged electricity to be the second most important innovation in the history of mankind. (The printing press ranked first.) Today, the U.S. electric grid is a network of approximately 10,000 power plants, 170,000 miles of high-voltage (>230 kV) transmission lines, and more than six million miles of lower-voltage distribution lines, and more than 15,000 substations. The transmission system is an interstate grid whose primary purpose is to connect generating plants with electrical load centers, like cities, with high-demand commercial and industrial facilities. In turn, the local distribution system provides for service to residential, commercial and small business customers.

Most of the systems currently in place were built by and for the regulated monopoly utility industry and are not fully prepared to handle the increasingly larger and faster changes in markets and technologies on both the supply and consumer-side. In particular, the system is largely unidirectional; and its planning, design, operation and control assume that all flow is from generation to a readily predictable load. The change in customers' ability to generate power and proactively manage energy consumption requires that the infrastructure become more flexible and adaptable. The system must be reconfigured into one capable of transmitting power and data in multiple directions.

Much of the current federal effort is focused on transmission. Yet, it is essential that market design and grid expansion programs for both the transmission and distribution systems work together to maintain adequate levels of grid reliability, security of the power supply, and provide customers with the services and choices they demand. At the minimum, the system must support the addition of both conventional and renewable generators along with demand response; and enable implementation of technologies like electric vehicles and solar on the distribution system. In addition to technology aspects, this will require a radical change in regulatory structure and market design; to enable better choices and trade-offs between generation, transmission and distribution.

IEEE-USA's long-term vision is to tie generation, transmission, distribution, and use into a common network with each stakeholder having access to data, information, and knowledge to enable faster, predictable and more accurate decision-making. The recommendations below represent some of the critical near-term steps towards this vision.

1. Making the Network More Intelligent

Adding more intelligence — sensors, communications, monitors, optimal controls and computers — to our electric grid can lead to substantially improved efficiency and reliability through increased data availability, situational awareness, reduced outage propagation, and improved response to disturbances and disruptions. This so-called "Smart Grid" could also facilitate transparent pricing of electricity and better customization and differentiation of service options available to customers. It will also allow consumers to manage their energy costs and facilitate distributed generation, opening the door to wider use of variable renewable generation sources and supporting expanded use of electric vehicles.

The federal government recognized this potential by implementing the Energy Independence and Security Act (EISA) of 2007. Title XIII of the Act mandates a Smart Grid that is focused on modernizing and improving the information and control infrastructure of the electric power system. Among the areas being addressed in the Smart Grid program are: transmission, distribution, home-to-grid, industry-to-grid, building-to-grid, vehicle-to-grid, integration of renewable and distributed energy resources (such as wind and solar), and demand response.

IEEE-USA RECOMMENDS:

- **Smart Grid Interoperability Panel:** Continuing federal government support for the Smart Grid Interoperability Panel (SGIP) as the principal coordinator of Smart Grid standards under EISA 2007, to the extent needed to ensure the viability and continued operation of this evolving private-public partnership.

- **Standards:** Working with IEEE's Standards Association, other Standards Developing Organizations (SDOs), and the stakeholder community to improve the timely development of Smart Grid standards, and promote their widespread deployment.

- **Testing and Product Certification:** Developing an institutional infrastructure for testing and certification of products claimed to be compliant with Smart Grid standards; and means for rapidly resolving technical issues and ambiguities, either prior to or immediately following, adoption by SDOs.

- **Cooperation between Organizations:** Working with state regulators, the Federal Energy Regulatory Commission, the National Association of Regulatory Utility Commissioners, and their joint Smart Grid Collaborative to resolve issues of customer involvement — especially for standards having benefits focused on national security, energy independence, or difficult-to-quantify issues.

- **Situational Awareness:** Expanding situational awareness through use of new measurement technology, such as the North American SynchroPhasor Initiative (NASPI).

- **Broadband Communications:** Supporting the advancement and the deployment of broadband and other communication technologies that help maximize Smart Grid benefits.

- **Enhancing Customer Relationships:** Electricity providers should develop and maintain customer-centric programs to enhance customer relationships and help customers to understand that a modernized grid will, among other things: provide an interactive source of information that they can consult and manage on a daily basis; support efficiency and demand response programs; facilitate the use of distributed generation; and enhance their economic and personal well-being.

2. Expanding the Transmission System

Much of the renewable energy and natural gas potential in the United States is located in areas that are remote from population centers, lack high demand for energy, and are not well connected to our national infrastructure for transmission of bulk electrical power. The recent expansion of natural gas production in the United States has affected grid development. To achieve public policy objectives, sufficient transmission capacity must link new natural gas generating plants, on-shore or off-shore wind farms, solar plants, and other renewables to customers, if those resources are to serve the energy needs of homes and businesses, and have the potential to replace significant portions of the oil used today in transportation.

New transmission will play a critical role in the transformation of the electric grid to enable public policy objectives, accommodate the retirement of older generation resources, increase transfer capability to obtain greater market efficiency for the benefit of consumers, and continue to meet evolving national, regional and local reliability standards. These considerations are often evaluated using operations research modeling techniques — similar to those long-used by such companies as Federal Express to cost-effectively route its trucks.

To optimize the use of the natural gas sites and renewable energy resources, the necessary electrical infrastructure must be installed, requiring both significant financial investments and cooperation at all levels on politically challenging items, such as siting facilities and routing new transmission lines.

IEEE-USA RECOMMENDS:

- **State Approval Process:** Reforming the state-by-state approval process for routing and siting, to ensure that delays in transmission construction do not also delay progress in expanding the use of renewable energy, and achieving national clean air goals.

- **Regional Planning:** DOE should continue support for the development of regional plans that include both federal and state public policy goals, such as the Eastern Interconnection Planning Collaborative, and MISO's Multi-Value Projects.

- **Transmission Integration:** ISOs/RTOs and industry should support goals for integrated interregional, regional and local transmission system planning (FERC Order 1000) — to increase system efficiency, achieve public policy objectives, and continue to meet evolving reliability standards.

3. Accommodating New Types of Generation and New Uses of Electricity

New types of generation and new uses of electricity are creating both challenges and opportunities. Examples of new generation types include wind and solar, both of which vary in output and predictability. While most wind installations are grid-scale generation sources, many solar and a few wind sources are also in place in distribution grids, presenting the additional challenges, discussed below. An example of a technology that serves both as an electricity use (load) and as an electricity source is energy storage, affording the opportunity to compensate for varying grid conditions by providing or absorbing energy to help correct system voltage or frequency. Placing an energy storage device in the distribution grid to serve as both a load and as a distributed energy resource (DER) also offers new integration challenges and opportunities for increased reliability: The electric vehicle, for example, presents challenges in minimizing the grid impact of its charging, and also in the opportunity for its use as a DER.

Another technology that has received renewed interest is direct current (DC), especially in localized grids called "microgrids." For example, solar photovoltaic produces DC, batteries store DC, and loads such as computer equipment and variable speed motors operate on DC. The grid operates mainly on alternating current (AC), and conversions need to take place between AC and DC to interconnect DC generation or loads to the AC grid. Efficiency considerations suggest minimizing the number of such individual conversions, leading to exploration of new concepts for managing electricity at locations involving these generation sources, storage methods, and loads.

As mentioned, the new loads, and many of the new generation sources, such as solar, will often be connected to the distribution grid that has been traditionally designed to unidirectionally distribute the output of the bulk electric system. Accommodating these new loads and generation sources will require both bridging the gap between the transmission and distribution grids, and crossing the chasm between federal regulation of the transmission grid and individual state regulation of electric distribution. The importance of meeting these challenges is heightened because the economic feasibility of many of the new technologies is dependent on serving both the transmission and distribution grids simultaneously.

Over recent decades, the transmission grid has been stressed by an increase in electric demand, and changes in the location and characteristics of generating plants, such as the recent shift to natural gas generation. The introduction of new sources of renewable wind and solar power must also be managed, because of the inherent variability in output. Further, the increasingly complex and competitive regional power markets can add stress to the grid. These conditions can create grid congestion, reliability risks and higher transmission losses, all of which can result in higher rates for electricity. Reinforcing the grid and deploying advanced technologies will help address some of these concerns, and increase physical and cyber security of the grid. A strong transmission grid provides the flexibility and robustness required to maintain reliability for future conditions that may be difficult to predict. For example, introduction of Flexible AC Transmission Systems (FACTS) allow for dynamic voltage regulation that helps to smoothly incorporate variable generation resources, control loop flows, and optimize the throughput of transmission lines. The North American SynchroPhasor Initiative (NASPI) supports next generation monitoring equipment to increase reliability and reduce cost for consumers through development of secure, high-speed, time-synchronized data about bulk power system conditions.

Increasing reliance on natural gas — even for baseload supply — exposes much of the electricity supply to potential interruptions in gas supply. Adequate natural gas storage, and other measures, will be needed to help guard against these potential risks. Further, the markets for wholesale electricity are very different from those for natural gas. These differ both geographically, and in scheduling approaches. It will be important to provide for a better coordination of these markets to eliminate potential challenges, as electricity generation competes with other consumers for natural gas, and the potential for exporting natural gas to other regions of the world. Additionally, some experts have reported that production in existing fractured shale rock formations has already fallen below peak production levels; and that projections for future shale gas production volumes are highly uncertain.

The importance of the distribution system to achieve national energy policy objectives must not be overlooked. Distribution systems are operated by local utilities under state regulation (or for some municipals and cooperatives, state authority to self-regulate); but as new types of technologies are employed, their operation becomes more closely linked with that of the inter-regional transmission grid, and wholesale electric trading markets. Operation of technologies such as demand response (DR) and distributed energy resources (DER) as well as electric vehicles are inextricably linked to operation of both the local distribution system, and the regional transmission grid. Distribution system design, operation and regulation must accommodate the evolution of technology.

Unlike many energy resources, electric power is generated and consumed instantly, unless it is stored by converting electricity to other forms of energy that can be converted back to electricity when needed. Many believe that large-scale, grid-level energy storage must be developed and deployed if intermittent sources of electric power, such as wind and solar, are to reach full potential. Until less expensive storage becomes available, other cost effective solutions for addressing the variable nature of renewable energy sources, such as improved forecasting and spinning reserve, must be explored. When it becomes available, energy storage could complement variable generation and reduce fossil plant usage.

IEEE-USA RECOMMENDS:

- **Technical and Jurisdictional Issues:** Resolving technical and jurisdictional issues associated with devices, such as battery storage and rooftop solar, that simultaneously serve both the distribution and transmission grids; and operate across institutional, regulatory, and information architectural boundaries.

- **Forecasting:** Collaborating among government, industry and users to improve weather forecasts, and other factors relevant to load management and renewable generation.

- **Transparent Collaboration:** More transparent, participatory and collaborative discussions among federal and state agencies, transmission and distribution asset owners, and RTOs/ISOs and their members and supporting research, to improve understanding of mutual impacts, interactions and benefits that may be gained from these efforts.

- **Grid R&D:** Increasing federal research and development for emerging technologies that may impact the transmission and distribution grids, including NASPI, new types of generation, new uses of electricity, and energy storage; with an additional focus on deploying and integrating such technologies to improve reliability, efficiency, and grid management.

- **Market and Infrastructure Coordination:** U.S. DOE, FERC, NERC, RTOs/ISOs and utilities should continue working on better coordination of electricity and gas markets and infrastructure, to mitigate potential new reliability and cost issues, due to increasing reliance on gas generation.

- **Natural Gas as a Bridge:** Federal and state governments, utilities, and other stakeholders should take those actions necessary to facilitate, encourage and scale development of next-generation energy technologies — to fully transition the United States to a cleaner, smarter, more efficient and secure energy future.

- **Market Economics Education:** NSF and/or other government agencies should aggressively support development of new curricula that add market economics to electrical engineering degrees.

CYBER AND CRITICAL POWER, AND ENERGY INFRASTRUCTURE SECURITY

The existing end-to-end energy and power-delivery system is vulnerable to natural disasters and intentional cyber-attacks. Virtually every crucial economic and social function depends on the secure, reliable operation of power and energy infrastructures. Energy, electric power, telecommunications, transportation, and financial infrastructures are becoming interconnected — posing new challenges for secure, reliable, and efficient operation. All of these interdependent infrastructures are complex networks, geographically dispersed, non-linear; interacting both among themselves, and with their human owners, operators, and users.

Challenges to the security of the electric infrastructure include:

Physical security – The size and complexity of the North American electric power grid and its supply chain makes it impossible both financially and logistically to physically protect the entire end-to-end and interdependent infrastructure. Currently, more than 450,000 miles of 100kV, or higher, transmission lines exist, and many more thousands of miles of lower-voltage lines, exist. As an increasing amount of electricity is generated from distributed renewable sources, this problem will be exacerbated.

Cyber security – Threats from cyberspace to our electrical grid are rapidly increasing and evolving. While there have been no publicly known major power disruptions due to cyber-attacks, public disclosures of vulnerabilities are making these systems more attractive as targets.

Due to the increasingly sophisticated nature and speed of some malicious code, intrusions, and denial-of-service attacks, human response may be inadequate. Furthermore, currently more than 90 percent of successful intrusions and cyber-attacks take advantage of known vulnerabilities and misconfigured operating systems, servers, and network devices. Technological advances targeting system awareness, cryptography, trust management and access controls are underway and continued attention is needed on these key technological solutions.

Cyber threats are dynamic, evolve quickly, and are often combined with the lack of training and awareness. Cyber connectivity has increased the complexity of the control system and facilities it is intended to safely and reliably control. To defend electric infrastructure against the impacts of cyber-physical attacks, significant challenges must be overcome before extensive deployment and implementation of smart grid technologies can begin. Cyber security and interoperability are two of the key challenges of smart grid transformation. Security must be built-in as part of its design and not glued on as an afterthought.

One important constraint on regulatory oversight of security protection is the split jurisdiction over the grid. The bulk electric system is under federal regulation; but the distribution grid, metering, and other aspects of the grid are regulated by individual states. As a result, the oversight of cyber security is split along with other regulatory functions.

IEEE-USA RECOMMENDS

- **Infrastructure Design:** Federal and state governments and utilities should take those actions necessary to facilitate, encourage, or mandate that secure sensing, "defense in depth," fast reconfiguration and self-healing be built into the infrastructure.

- **Protective Measures:** Mandating security for Advanced Metering Infrastructure (AMI); providing protection against personal profiling; guaranteeing consumer data privacy; conducting real-time remote surveillance; protecting against identity theft, home invasions and activity censorship; and avoiding making decisions based on inaccurate data, are all protective measures that must be assured by federal and state agencies.

- **Wireless and Internet Access:** Wireless and the public Internet increase vulnerability to cyber attack, and should be avoided by utilities.

- **Jurisdiction:** Congress should address bridging the jurisdictional gap between Federal/ NERC, and the state commissions on cyber security.

- **Grid Owners:** Electric generation, transmission, distribution, and consumption needs to be safe, reliable, and economical each in their own right. FERC should require asset owners to practice due diligence in securing their infrastructure as a cost of doing business.

- **Threat Coordination:** The DOE should develop hierarchical threat coordination centers — at local, regional, and national levels — that proactively assess precursors and counter cyber attacks.

- **Accelerate Standards:** FERC should: (1) speed the development and enforcement of cyber security standards, compliance requirements and their adoption, and (2) facilitate and encourage design of security, from the start, and include it in standards.

- **Grid Investment and R&D:** The DOE should increase investment in the grid and in R&D areas that assure the security of the cyber infrastructure (algorithms, protocols, and chip-level and application-level security).

- **Grid Segmentation:** The DOE should develop methods, such as self-organizing micro-grids, to facilitate grid segmentation that limits the effects of cyber and physical attacks.

ENERGY SECTOR JOBS, WORKFORCE REQUIREMENTS AND THE ECONOMY

The energy sector is the backbone of the U.S. economy. Energy underlies nearly all of the goods and services produced in the United States; and the direct, indirect and induced jobs created by this sector are a key driver of economic and employment growth.

It has been estimated that 2.7 million jobs were created in the United States between 2002 and 2012. These jobs are located in economic ecosystems that are centers of knowledge and ideas; and energy production clusters. Approximately one million of these jobs were related to shale oil and gas drilling.

The energy sector is in the midst of significant transformational change, influenced by a range of factors, including changes in energy supplies and costs, environmental awareness and concerns, escalating physical and cyber-security concerns, political factors, societal demands, and emerging technologies.

The workforce that currently serves this sector is shrinking and continues to mature and retire. The U.S. electric and natural gas utility workforce dropped from 535,000 in 2009, to 525,000 in 2011 — primarily as a result of reductions and delays in hiring due to economic recession. In addition, the average age of this same workforce has increased from 45.7 in 2006 to 46.1 in 2010. Comparison by age grouping shows that the number of employees between the ages of 18 to 27 has decreased while the number of employees age 53 and above has increased. Based on 2011 data and projections, almost 62 percent of this sector has the potential to retire or leave for other reasons over the next decade. Furthermore, 36 percent of skilled utility technicians and engineers (excluding positions in nuclear), may need to be replaced due to retirements and other attrition by 2015, with an additional 16 percent estimated to be replaced by 2020. Based on this circumstance, the United States may not have a domestic skill set in place in time to meet the needs of the evolving energy sector.

Technological advances, for example, in oil and gas extraction have led to recent increases in workforce demands and needed job skills. Competency requirements for the energy sector workforce are evolving; and the abilities needed to meet future demands will be more sophisticated, complex, diverse and interdependent. Energy sector workforce development and maintenance must become a top priority to successfully innovate, plan, design, operate and maintain reliable, secure, and safe systems into the future; and to ensure long-term U.S. economic growth and prosperity.

IEEE-USA urges federal, state and local governments, along with quasi-governmental organizations, and stakeholders in industry and academia, develop and pursue strategies to prepare for future workforce needs in the U.S. energy sector and **RECOMMENDS:**

- ***America COMPETES Act*****:** Congress should reauthorize the *America COMPETES Act*, which provides critical support for investments in physical sciences; and engineering research and science, technology, engineering and mathematics (STEM) education.

- **Education Partnerships:** Governments and other stakeholders should support the development of partnerships within the education, labor, industry and government sectors, to develop new curricula and enhance secondary and post-secondary energy sector workforce training programs, apprenticeships and best practices.

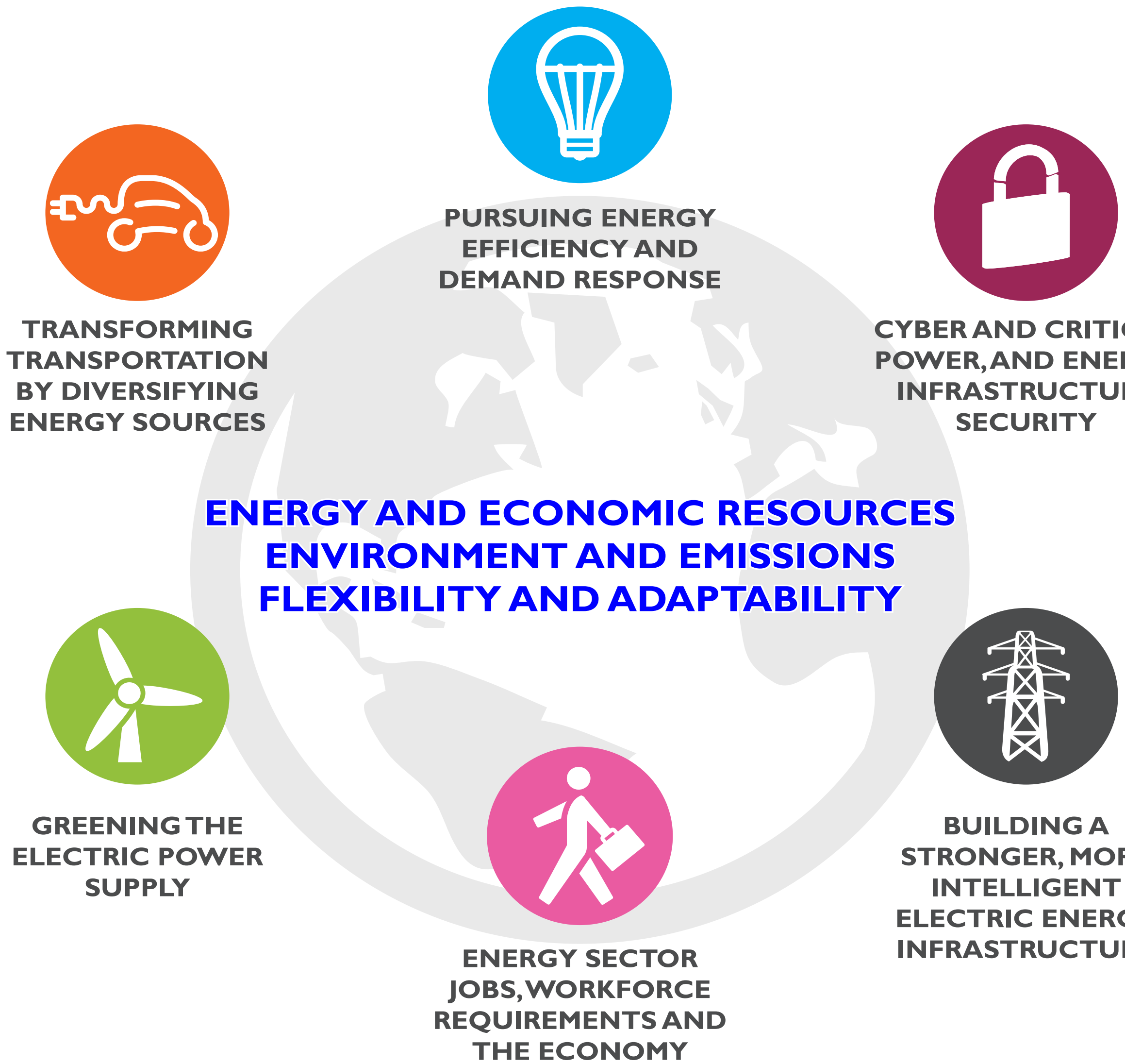
- **Certification Programs:** Universities and professional organizations should create industry recognized credentials or certifications that can be awarded after the completion of education or training, to demonstrate an individual's achieved skill level.

- **Assess Workforce Issues:** Congress should direct the Department of Energy and the Department of Labor to take necessary actions to better understand the implications of a maturing workforce, technology advancements, and policy changes on future workforce requirements.

The Need to Take Action Now

Urgent action is needed now because, with each passing year, U.S. options to respond to large local and global uncertainties will diminish. We cannot allow low prices to again lull our country into complacency. The need for a sustained energy vision, strategy, policy, and regulatory structures is real — no longer just important, but urgent.

Now is the time to invest in new and established technologies to help our nation become better energy stewards, reduce environmental impacts, and secure energy supplies for the future. Electricity has a major role to play in reaching these objectives.



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