

POWER ⚡ SYSTEM CHALLENGE

A Clean Energy Ministerial Campaign



Synthesis Report for the 7th Clean Energy Ministerial

June 2016

A Shared Vision for Power System Transformation

The Clean Energy Ministerial's (CEM's) Power System Challenge was established in 2015 to create a shared vision among major economies regarding the pathway to clean, reliable, resilient, and affordable power. Endorsing governments have created the following set of core principles and challenge propositions as a framework for government and industry action to support and guide power system transformation.





Core Principles of the Power System Challenge

1. Power system transformation is a strategic imperative

Power systems should provide clean, reliable, resilient, and affordable power to everyone, and power system transformation is a strategic imperative to achieve these goals. Different pathways will emerge in our different contexts, but all transformations will require innovations to increase energy efficiency and to reorient system planning and operation to take advantage of smart grid technologies and renewable resources such as wind and solar power.

The Challenge:

To show leadership by establishing national roadmaps or strategies for achieving power system transformation.

To deploy best practice planning and operational methods, and to share knowledge about effective strategies.

To identify approaches to support and measure effective power system transformation, and to work with international partners and local communities to advance diffusion of effective transformation strategies.

2. Cleaner power systems will improve public health and combat climate change

Globally, power systems are one of the largest sources of emissions that significantly degrade public health and accelerate global climate change. Working together to innovate and implement clean energy solutions across the spectrum of energy supply, delivery, and demand will yield benefits locally and globally.

The Challenge:

To work together to innovate and implement solutions that support high-quality, low emissions power systems, consistent with our national strategies.

To identify cost-effective pathways toward cleaner power systems, and to support implementation of our national strategies.



3. Markets, prices, and tariffs should be aligned to support power system transformation

Transforming power systems will require innovation in the design of energy markets, in pricing mechanisms that better represent energy costs, and in tariffs that incentivize investment in critical system assets. Alignment of these design elements will increase efficiency, flexibility, and other desired system characteristics, facilitate regional market integration, encourage system-friendly deployment of renewable and other clean energy resources, and unlock new business models.

The Challenge:

To show leadership in the design of markets, prices, and tariffs, and to share best practices through CEM initiatives.

To identify design strategies that support alignment across these elements.



4. Smart grids are a key enabler of power system transformation

Smarter power grids, enhanced with information and communication technologies, provide strategic value by increasing consumer engagement, efficiency, resilience and reliability, and by facilitating the integration of clean energy resources. They also provide opportunities for business model and technology innovation, and they support regional electricity market integration.

The Challenge:

To promote significant investment in modernized grid infrastructure as a pathway toward cleaner, more reliable, and more resilient power systems.

To support our national smart grid priorities and work with our national smart grid leadership to develop shared visions for scaling up smart grid deployment.

5. Renewable energy is a strategic power system resource

As a sustainable, domestic, and cost-effective source of supply power, renewable energy will constitute an important asset in transformed power systems. Policy and regulation should promote sustained, cost-efficient investment, and system-friendly deployment to maximize the benefits of renewable energy for the power system and society at large.

The Challenge:

To promote accelerated growth of renewable energy, consistent with our national strategies and domestic contexts.

To conduct analysis and make recommendations on best practices to achieve cost-efficient and system-friendly renewable energy deployment.

6. Innovation in finance and procurement is essential to accelerating transformation

Prices of clean energy and smart grid technologies are likely to continue to decline, yielding opportunities for accelerated investment with less reliance on subsidies. Innovation in financing and procurement will be critical in this objective. Effective policy and regulatory frameworks encourage this innovation by ensuring efficient procurement mechanisms, providing market-based price signals, and unlocking new financing business models.

The Challenge:

To develop and implement strategies to accelerate innovative financing mechanisms, and to encourage transparent, cost-effective, and market-based procurement.

To identify key principles for finance and procurement, and to facilitate greater peer learning and knowledge exchange between CEM countries.

7. Power systems should be optimized to interface with other energy systems

Power systems are part of a larger energy system. Integrating electricity and thermal systems leads to improved efficiency, reduced emissions, and improved energy security. Integrating electricity and transport systems through vehicle electrification can result in significant improvements in air quality and system flexibility. Intelligent industrial and building energy management increases efficiency and supports advanced power system operation.

The Challenge

To advance research and policies that promote innovation at the interface of electricity, thermal, transport, industrial, and building energy systems.

To support the diffusion and adoption of best practice approaches to energy system integration.

8. Skill and capacity development is critical to 21st century power systems

Planning and operating transformed power systems will require highly skilled workers in various fields. Proactive skill development in the areas outlined by these Principles will be crucial for realizing power system transformation.

The Challenge

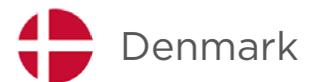
To cooperate internationally to increase the skills and capacity of power system experts, especially in emerging sectors such as smart grids, advanced power system planning and advanced power system operation.

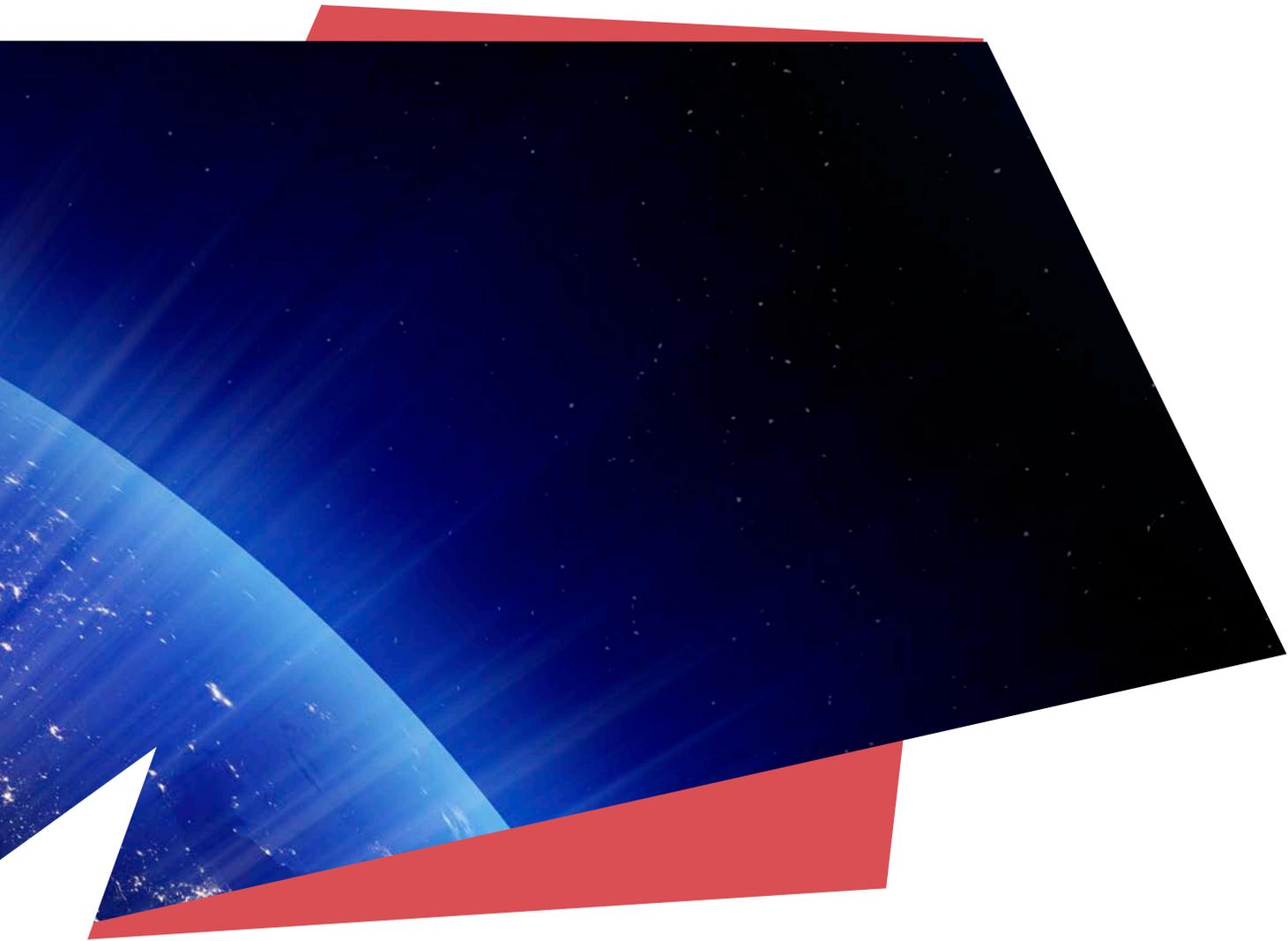
To facilitate staff exchanges and peer learning opportunities between regulators, system operators, policymakers, and utility staffs that promote skills and knowledge transfer.



Participating Governments

Participating governments are committed to pursuing domestic and international activities that support the Core Principles of the Power System Challenge. Visit PowerSystemChallenge.org to learn about what each country is doing and how Clean Energy Ministerial initiatives are supporting these efforts.





European Union



Finland



France



India



Indonesia



Japan



Mexico



Norway



South Africa



United Arab
Emirates



United States



Highlights of Government Action

Denmark

Denmark has achieved notable power system transformation over the past 40 years through a combination of research, development, and deployment efforts, incentives, taxation, and regulations and standards, along with structural and market changes. Wind power currently supplies 40% of Denmark's electricity demand and the goal is to expand that to 50% by 2020, as outlined in The *Danish Energy Agreement*. To facilitate even higher levels of variable renewable power sources like wind and solar, a further transformation of the Danish power system is underway that includes expanding technical- and market-based flexibility for the conventional power plants, establishing even more power interconnection capacity with neighboring countries, and improving further forecasting of timing and quantities of renewable energy sources like wind power.

Finland

Finland is an active member of the Nordic electricity market and published its *Energy and Climate Roadmap 2050* in November 2014. The roadmap, which outlines Finland's energy and climate policy goals for 2050, serves as a strategic guide for achieving the long-run objective of a carbon-neutral society. Over the medium term, Finland's climate and energy objectives are outlined in the 2013 updated *National Climate and Energy Strategy*, which outlines concrete measures to reach the 2020 targets and includes an outlook for post-2020. Finland's goal is to increase the share of renewable energy of the end consumption of energy to 38% by 2020, where biomass sources play a central role.

France

The development of clean, reliable, resilient, and affordable power systems is in line with the main goals of the French energy policy, as outlined in the *Energy Transition towards Green Growth Act* passed on August 17, 2015. The Act sets out medium- and long-term objectives in order to provide a joint framework for action by citizens, businesses, regions, and the government by: reducing greenhouse gas emissions by 40% between 1990 and 2030 and by 75% between 1990 and 2050; reducing final energy consumption by 50% by 2050 in relation to the 2012 benchmark, while aiming to achieve an intermediate target of 20% in 2030; reducing final energy consumption of fossil fuels by 30% by 2030 in relation to the 2012 benchmark; bringing the proportion of renewable energy up to 23% of gross final energy consumption by 2020 and to 32% of gross final energy consumption by 2030, with individual targets of 40% of electricity generation, 38% of final heat consumption, 15% of final fuel consumption and 10% of final gas consumption; and bringing the proportion of nuclear energy in electricity generation down to 50% by 2025.

Germany

The overall strategy for power systems transformation in Germany, the German “Energiewende,” aims to ensure a secure, environmentally friendly, and economically successful future. The energy transition strategy is set out in a 10 Point Energy Agenda defining the key steps forward. Key policies put in place to support the 10 Point Energy Agenda include: mitigating climate change by rigorously implementing the national emission reduction target of 40% by 2020 through various measures; setting up the “electricity market 2.0” to guarantee security of supply at the lowest possible cost; having some lignite-fired power plants serve as capacity reserve for additional security before they are closed down; supporting the conversion from coal-fired to gas-fired combined heat and power (CHP) plants by making them profitable; expanding the grid quickly and in a citizen-oriented way by prioritizing underground cables over overhead powerlines for new direct current routes; and establishing financial reserves for nuclear power plants that will be phased out.

India

India is in the process of dramatically expanding its electricity sector and has ambitious targets for renewable energy deployment. Under *Deen Dayal Upadhyaya Gram Jyoti Yojna* (DDUGJY), electricity access will be expanded to 18,450 villages by May 2018. This program to provide 24x7 power across India is accompanied by a comprehensive set of reform measures that seek to diversify India’s electricity generation, strengthen transmission and distribution infrastructures, reduce network losses and electricity prices, and improve the operational efficiency of distribution companies. India has set an ambitious target of achieving 175 gigawatts (GW) of renewable generation capacity by 2022, including 100 GW of solar power, 60 GW of wind energy, 10 GW of biomass-based energy, and 5 GW of small hydropower. To achieve these goals, central and state government stakeholders are working together to implement policies that provide for flexibility in conventional generation, frequency control, generation reserves, ancillary services, and improved forecasting among others.



Indonesia

Indonesia's power sector is growing rapidly, and will play a key role in helping the country meet economic development goals as outlined in *The Masterplan for the Acceleration and Expansion of Indonesia's Economic Development 2011 – 2025*. Indonesia relies heavily on geothermal power and is taking steps to further expand its usage. The country has a medium-term renewable energy target of 25% by 2025 and plans to invest around \$38 billion USD in renewable energy sector in next five years, as well as to provide full electricity access by 2020.

Japan

Japan's *Long-term Energy Supply and Demand Outlook* serves as a forecast and vision of the country's desired energy future. In the recovery of the unprecedented Fukushima nuclear accident of 2011, imports of oil and natural gas as alternatives to nuclear energy have increased. The basic principle for the power supply-demand structure is to lower dependency on nuclear power generation to the extent possible through energy efficiency and conservation and introducing renewable energy as well as improving the efficiency of thermal power generation, among other things. Japan liberalized its electricity retail market in April 2016 and targets unbundling of the transmission/distribution sector in April 2020. By 2030, Japan aims to introduce 44% clean energy of power source composition and reduce greenhouse gas emissions by 26% compared to 2013 levels.



Korea

In 2014, Korea announced a planned reduction in greenhouse gas emissions of 30% by 2020 compared to a business as usual future in its *Roadmap to Achieve National Greenhouse Gas Reduction Goals*. Its *Intended Nationally Determined Contribution* in 2015 furthered the target to a 37% reduction by 2030. Korea's electricity sector is partially reformed, and uses a power exchange and grid operator to manage wholesale electricity competition. Two-thirds of Korea's electricity is generated from fossil fuels, with nuclear making up most of the remainder. Nuclear, energy efficiency, and renewables are expected to help the country meet its emission mitigation targets.

Mexico

Mexico has initiated an aggressive set of electricity sector reforms, including the introduction of a wholesale electricity market run by an independent operator, open access to the transmission and distribution networks, the establishment of a clean energy certificates mechanism, opening of investment in new generation and geothermal energy to private investors and enhanced social participation. The first long-term auction successfully awarded 2,200 MW of solar and 562 MW of wind with an average price below 50 USD/MWh. The Energy Transition Law establishes that 25% of total generation will come from renewable and other clean energy technologies by 2018, while the goals for 2021 and 2024 have been set to 30% and 35%, respectively. The General Law on Climate Change also establishes that generation from renewable and other clean energy technologies will reach 50% by 2050. At COP21, Mexico expressed its commitment to reduce greenhouse gas emissions 22% by 2030.



Norway

Norway is an active member of the Nordic electricity market and has a power supply system dominated by hydropower. Norway is committed to strengthened security of supply, profitable renewable production, more efficient and environmentally friendly use of energy, and economic development through effective utilization of renewable resources. In April 2016, Norway released a *white paper* finding that security of supply, consequences for climate, and economic growth must be considered together to secure an efficient and climate-friendly energy supply. The Norwegian action plan lays out how Norway can achieve an overall renewable share of 67.5% and a renewable share of 10% in the transport sector, by 2020. Norway and Sweden have a common goal of increasing electricity production based on renewable energy sources by 28.4 terawatt-hours by 2020 using the joint electricity certificate market.

South Africa

The Republic of South Africa (RSA) is embarking on a vast clean energy transformation. The South African grid is heavily reliant on coal, but through its centrally administrated Integrated Resource Plan, the country has ambition to diversify into nuclear and renewable sources—specifically, to have over 50% of its generation from nuclear and renewables by 2050. The country is a leader in renewable energy in the Southern African region, having already successfully procured over 6,000 MW of renewable energy over the last several years with sharply decreasing prices for wind and solar resources. The RSA government is also beginning the procurement process for 9,600 MW of new nuclear energy capacity, and embarking on a Gas-to-Power Procurement Programme that plans to utilize liquefied natural gas fuel to provide mid-merit and peaking capacity to the grid.



Sweden

Sweden is an active member of the Nordic electricity market and has a power supply system dominated by hydroelectric and nuclear plants. Over the past ten to fifteen years there has also been strong growth in renewables such as bio-CHP, wind power, and solar power. In 2015, the Swedish government established a cross-parliamentary Energy Policy Commission, tasked to draft a proposal on the future Swedish energy policy before the end of 2016, with emphasis on the electricity system from 2025 and beyond. In 2016, Sweden also established the Swedish Smart Grid Forum, a public-private consortium with connections to the Clean Energy Ministerial's International Smart Grid Action Network (ISGAN).

United Arab Emirates

The UAE is currently transitioning from an electricity sector heavily dominated by natural gas generation to one that relies substantially on renewable energy and other low-carbon options. Each of the seven emirates controls its own electricity policy rather than being run at the central level, but all grids are in the process of being interconnected, and eventually linked to the larger Gulf Cooperation Council grid. The UAE is a leader in renewable energy and carbon mitigation among fossil fuel exporting nations. The country plans to have 20% of its generation from nuclear and renewables by 2020 and has tendered some of the lowest-cost solar projects in the world since 2014.



United States

The U.S. electricity system is currently undergoing rapid transformation due to a shift from coal to natural gas generation, rapid growth of wind and solar, steady progress on energy efficiency programs, and expansion of advanced grid technologies. In addition to a goal to reduce greenhouse gas emissions by 26%–28% by 2025 from 2005 levels, the U.S. Department of Energy, through a variety of research, development and deployment programs, aims to cut solar PV costs to 1 USD per watt, double the output of renewable generation, and deploy an additional 10,000 MW of renewable energy on public lands. More detailed blueprints for the power sector have been generated by the *Quadrennial Energy Review (QER)* effort, an administration-wide, ongoing analysis of opportunities to achieve reliable, safe, secure, affordable, and sustainable energy. In addition, the Department of Energy's *Grid Modernization Initiative* is a broad-based effort to rejuvenate the electricity grid, ensuring greater efficiency, resilience, and reliability.

European Union

In June 2014, the European Union Heads of State and Government defined a secure energy and climate future as one of the *five overarching priorities* for the EU over the next five years. To help meet this challenge, the Commission launched a *Strategy for a Resilient Energy Union with a Forward Looking Climate Change Policy* in February 2015. A key objective of this strategy is to develop a sustainable, low-carbon, and climate-friendly economy. It should help the EU move away from an economy driven by fossil fuels where energy is based on a centralized, supply-side approach and that relies on old technologies and outdated business models. The key targets the EU countries have agreed to for 2030 include: at least a 40% cut in greenhouse gas emissions compared to 1990 levels; at least a 27% share of renewable energy consumption; and at least 27% energy savings compared with the business-as-usual scenario. The Commission will be proposing a legislative package to EU Member States and the European Parliament on a new electricity market design towards the end of 2016, as well as a proposal to revise the existing Directive on Renewable Energy.



Clean Energy Ministerial Initiatives

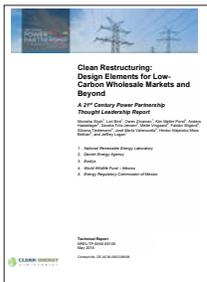
Clean Energy Ministerial (CEM) initiatives are the primary mechanism for implementing activities that support the Power System Challenge. CEM initiatives supporting the Challenge and highlights of their contributing activities are summarized below. For a more comprehensive summary of initiative reports and activities, visit powersystemchallenge.org.

21st Century Power Partnership

The 21st Century Power Partnership (Power Partnership) serves as a platform for public-private collaboration to advance integrated solutions for the large-scale deployment of renewable energy in combination with energy efficiency and grid modernization. It supports a broad range of research, knowledge sharing, and capacity building activities to accelerate the diffusion of high-impact policy and regulatory strategies.

Thought Leadership

The Power Partnership regularly publishes and disseminates multi-institutional reports that address emerging topics in power system transformation. In 2015, the initiative published two reports that contributed to the creation of the Power System Challenge: Power Systems of the Future and Status Report on Power System Transformation.



2016 Report : Clean Restructuring: Design Elements for Low-Carbon Wholesale Markets and Beyond

The latest Power Partnership report discusses market design and infrastructure issues for restructuring a vertically integrated market in a way that is friendly toward clean energy integration.

Electricity Sector Planning Studies

The Power Partnership and its operating agent—the U.S. Department of Energy’s National Renewable Energy Laboratory—facilitate in-depth technical cooperation among partner countries. Through a new partnership with the World Bank and U.S. Agency for International Development, the Power Partnership has launched a national evaluation of the impacts to grid operations of India’s 175 GW renewable energy target.

Fellowships

To speed up the transfer of tools and methods in power system planning and operations, the Power Partnership has launched a fellowship program to support mid-career staff exchanges. By fall 2016, four fellowship exchanges will have occurred and the partnership is actively working to identify more opportunities for exchanges among energy ministries, system operators, utilities, and regulatory agencies in CEM countries.

For more information on activities of the Power Partnership, visit 21stcenturypower.org.

Clean Energy Solutions Center

The Clean Energy Solutions Center (Solutions Center) provides no-cost, on-demand resources for governments, advisors, and analysts in CEM and non-CEM developing countries.

Ask an Expert Service

The Solutions Center connects governments with policy experts who can provide reliable and unbiased advice and information. Over 50 world-class experts are now on call to provide timely consultative support in issues such as clean energy policy and finance instruments, regulations and standards, and deployment programs. The Solutions Center has responded to the Challenge by increasing the number of Ask an Expert responses by 50%—completing over 75 consultations in the last year alone.

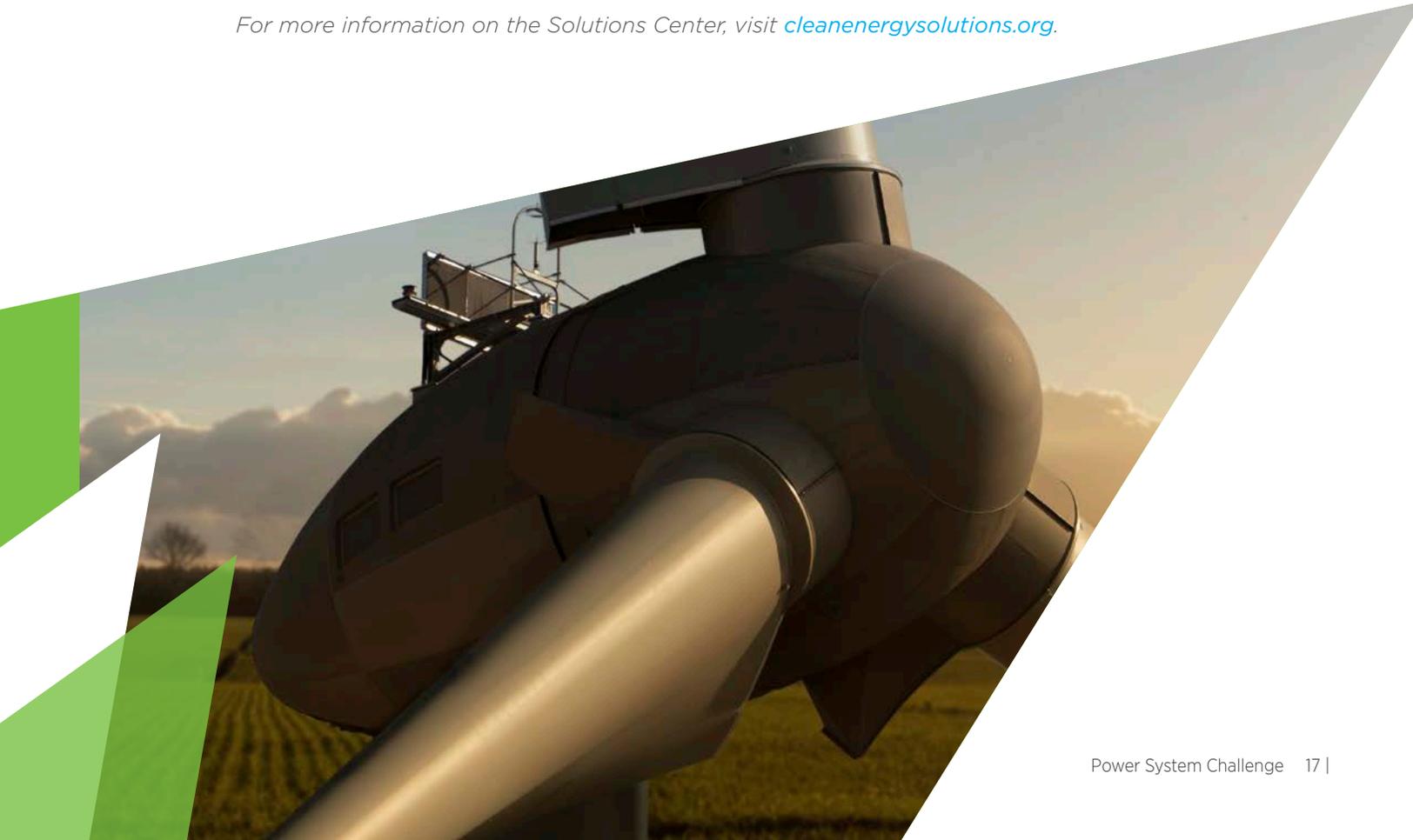
Webinar Trainings and Policy Briefs

Since CEM6, the Solutions Center has published 2 reports, 5 policy briefs, and offered 36 webinar trainings on clean energy policy and finance topics. Additionally it has worked Leonardo Energy to develop e-learning trainings and the Inter-American Development Bank and the Economic Community of West African States (ECOWAS) to deliver an on-site energy efficiency assessment and audit training.

Increased Resources

Governments such as Australia, Canada, Mexico, and Sweden have responded to the call for additional financial and in-kind resources to support the Solutions Center. This has enabled the Solutions Center to launch a new Clean Energy Finance Web Portal and increase its outreach to subnational governments.

For more information on the Solutions Center, visit cleanenergysolutions.org.



Electric Vehicles Initiative

The Electric Vehicles Initiative (EVI) is a policy dialogue dedicated to accelerating the worldwide introduction and adoption of electric vehicles (EVs), including plug-in hybrid electric vehicles and fuel cell vehicles.

Political Leadership

With representation that spans the world's largest economies, the biggest cities, and a majority of the world's automotive manufacturing capability, EVI countries are implementing a leading global vision for EV deployment. At COP21, EVI drafted and endorsed the [Paris Declaration on Electro-Mobility](#) to affirm its role in leading by example and providing best-in-class research, tools, and policy support. EVI is also in the process of re-tooling the initiative, forming new research partnerships, and committing more financial resources to execute an expanded program of work.

Data Collection

The 2016 Global EV Outlook, released at CEM7 and developed by the International Energy Agency and EVI member countries, provides an authoritative source of information on the electric vehicle market and support policies in major economies.

Policy Assistance

EVI researchers are developing and applying sophisticated analytical techniques to evaluate the impact of electric vehicles on the power grid and to quantitatively assess the effectiveness of EV consumer incentives in leading markets. This year, EVI has launched a partnership with the Government of India to support pilot projects and infrastructure planning in key urban areas.

For more information on EVI, visit cleanenergyministerial.org/our-work/initiatives/electric-vehicles.



International Smart Grid Action Network

The International Smart Grid Action Network (ISGAN) brings together experts from more than two dozen countries to advance the development of smarter, cleaner electricity grids around the world. Through sharing information, best practices, and competence specifically on electricity networks, ISGAN helps to highlight emerging policy and technology solutions, enable replication of proven ideas, and support greater national ambition for modernizing power systems.

Sharing Global Insights

Through workshops, webinars, case books, technical papers, policy briefs, and other publications, ISGAN captures and shares practitioner experience to advance uptake of good emerging practices on smart grids. Over its 2015–2016 program of work, ISGAN has produced and distributed more than a dozen knowledge products and led or co-led at least a half-dozen significant knowledge-sharing events.

Advancing Smart Grid Testing

ISGAN coordinates a network of testing and research facilities that undertake joint technical activities to advance testing methods, enhance laboratory and test bed performance, and promote state-of-the-art approaches. Efforts include joint evaluation of test protocols for advanced photovoltaic and energy storage system inverter functions.



Smart Grid International Research Facility Network (SIRFN) Draft Test Protocols for Advanced Battery Energy Storage System Interoperability Functions

In June 2016, ISGAN will publish a new technical report that captures the experience of four world-class facilities in Europe, Asia, and North America in developing a harmonized evaluation and certification protocol for advanced energy storage functions.

Recognizing Excellence

ISGAN showcases global leadership and innovation through its annual Award of Excellence. In 2016, ISGAN recognizes projects that exemplify excellence in use of Smart Grids for Reliable Electricity Service.

For more information on ISGAN, visit iea-isgan.org.



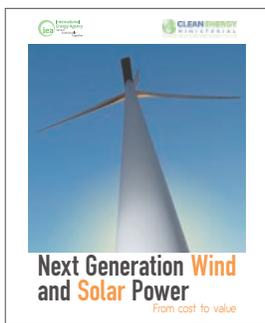
Multilateral Solar and Wind Working Group

The Multilateral Solar and Wind Working Group promotes the accelerated global deployment of solar and wind energy technologies and, through its research, seeks to allay the incremental costs of providing wind and solar energy to all regions of the world.

2015 Report: Renewable Energy Auctions: A Guide to Design

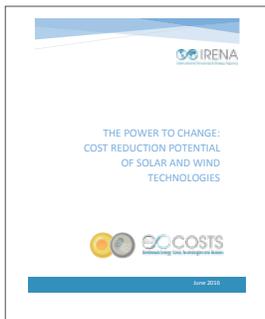
The number of countries relying on auctions has increased from just six in 2005 to more than 60 by early 2015. This report, led by the International Renewable Energy Agency, presents lessons learned and best practices on how governments can design and implement auctions cost-efficiently while ensuring that projects awarded come online in a timely manner. The guide presents the main trade-offs involved in auction design decisions and suggests ways to find the right balance for each jurisdiction.

2016 Report: Next Generation Wind and Solar Power – From Cost to Value



The study, carried out by the International Energy Agency's Renewable Energy Division, highlights the opportunity that cost-reductions and advanced technology—a next generation of wind and solar power—bring for meeting energy policy objectives, in particular in emerging countries. The report presents options how to deploy wind and solar power in a way that maximizes their system value, i.e., their overall benefit to the power system as a whole. It also features specific recommendations on how to craft policies to unlock the contribution of wind and solar power for successful system and market integration. The study includes detailed case studies of key emerging economies (Brazil, China, Indonesia, Mexico, South Africa), that contribute to capacity building of local policy makers and power system stakeholders.

2016 Report: The Power to Change: Cost Reduction Potential of Solar and Wind Technologies



This analysis by the International Renewable Energy Agency provides data on costs and performance for solar photovoltaics, concentrating solar power, and onshore and offshore wind power generation technologies as well as forecasts to 2025 on the drivers of future cost reduction potential. It provides stakeholders in government and the energy industry with an evidence base regarding the future competitiveness of these technologies and a resource to use when considering policies to support them..

For more information on the Multilateral Solar and Wind Working Group, visit cleanenergyministerial.org/our-work/initiatives/solar-and-wind.



Web Portal of the Power System Challenge

Launched at CEM7, the Power System Challenge web portal will serve as a repository for implementation strategies of endorsing countries. In addition, the portal will track progress in power system innovation and provide a centralized source for information on relevant CEM initiatives and their activities.

Visit us at powersystemschallenge.org





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CLEAN ENERGY
MINISTERIAL

Accelerating the Global Clean Energy Transition

The views expressed in this document do not necessarily reflect the views of Clean Energy Ministerial member governments. Any errors or omissions are the responsibility of the authors.

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