Technology Roadmap

Smart Grids

International Energy Agency

Prepared for

JRC Enlarging and Integration
Energy Security Workshop

Dubrovnik, 5th-7th October 2012

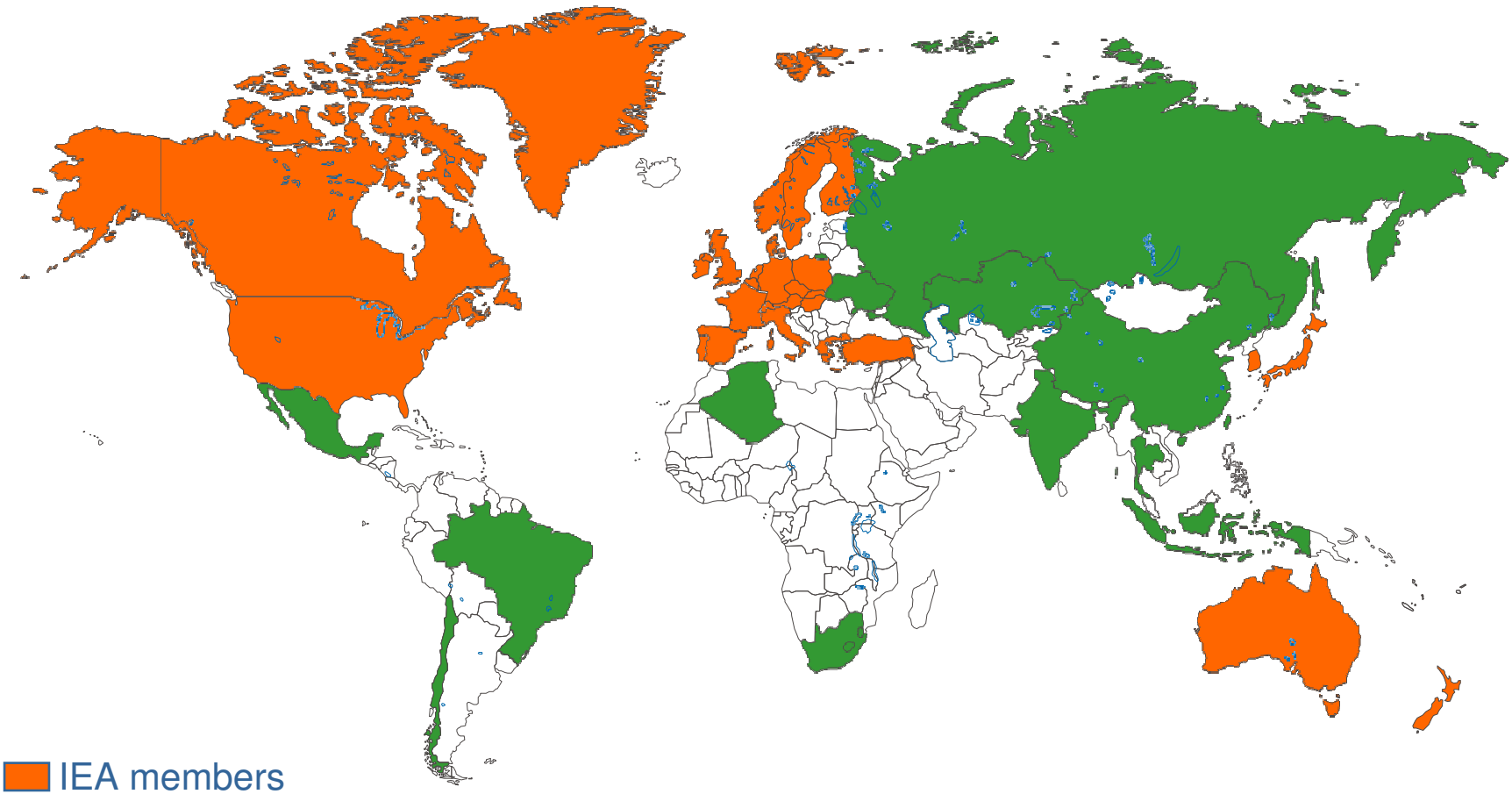
The IEA at a glance

- Formed in the wake of the 1973 oil embargo with a mission to promote member country energy security

- Autonomous organisation affiliated to the OECD
  - Governing Board – decision-making body of senior officials from member countries (IEA Energy Ministers meet every two years – next in October 2011)
  - Executive Director - reports to the Governing Board
  - Independent budget and policy making
  - Administrative support by OECD

- Staff of around 250 - primarily energy experts, economists and statisticians

IEA Members (28 countries)



IEA members

Accession country (Chile has begun the process of joining the IEA)

Countries invited to the Partnership Meeting on Energy and Sustainability

The 4 ‘E’s of the IEA mandate

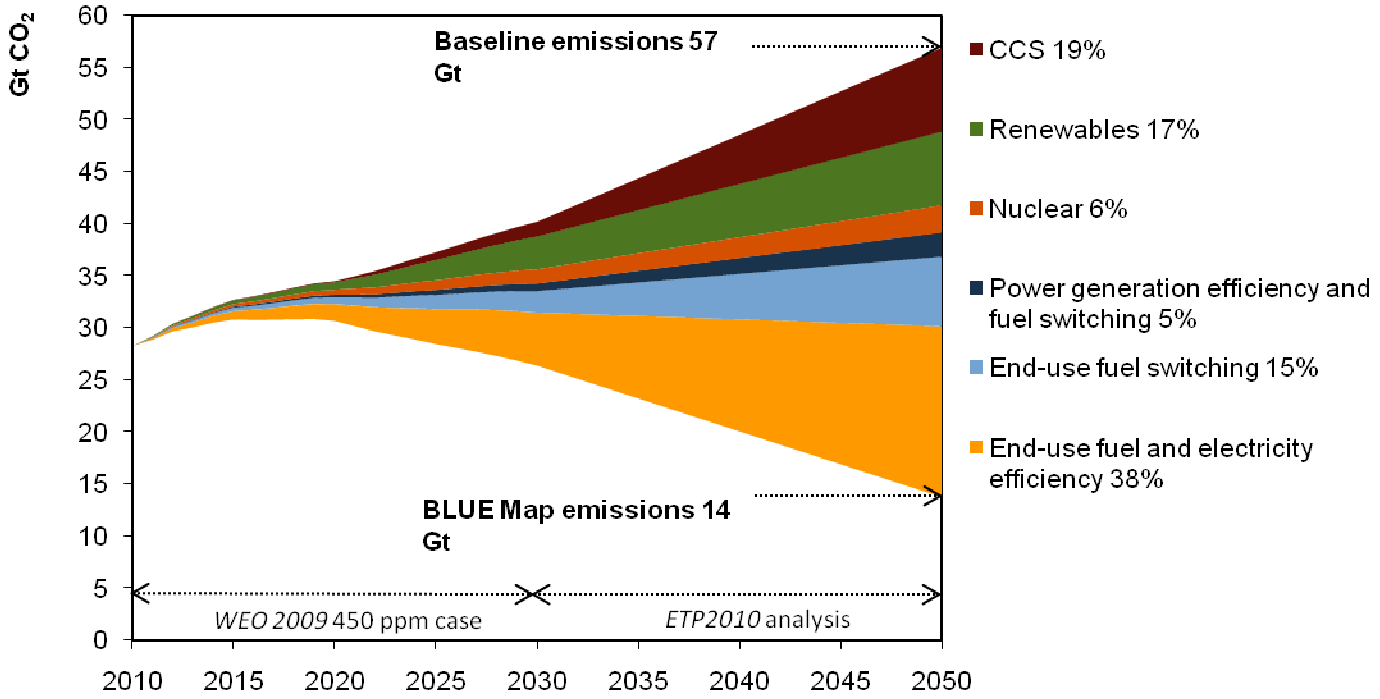
The 3 ‘E’s of sound energy policy

- Energy security
- Economic growth
- Environmental protection

And a fourth ‘E’

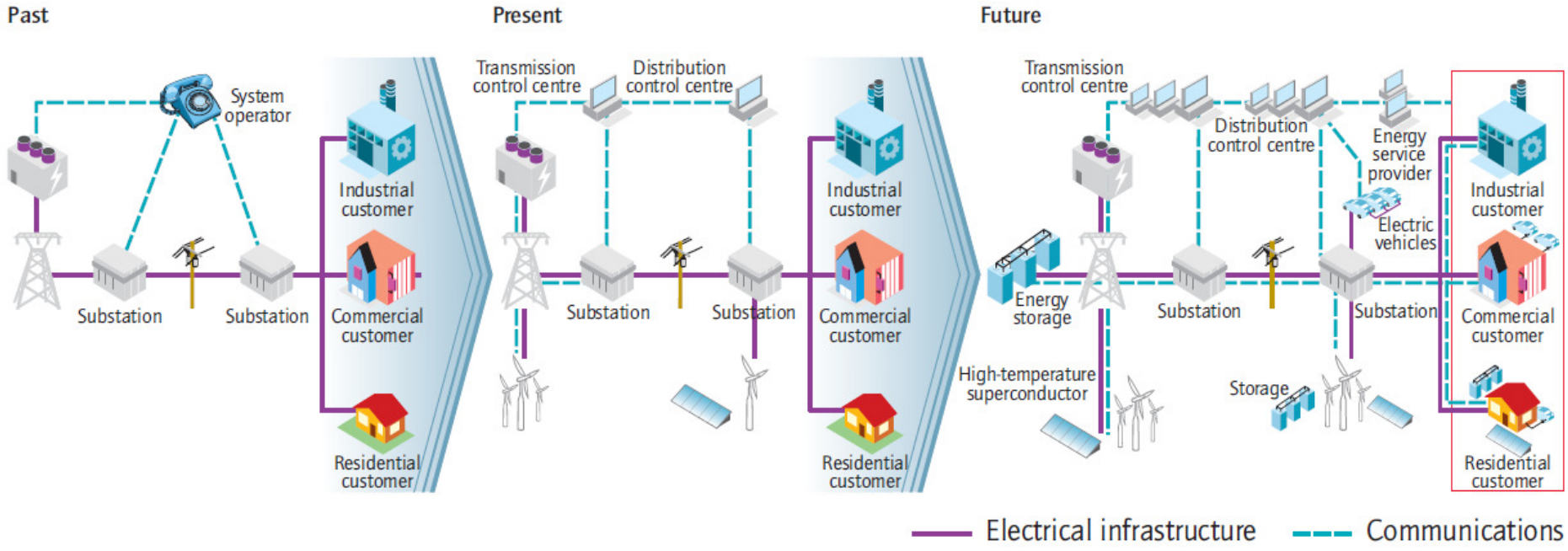
- Engagement worldwide

An energy revolution is needed to achieve our energy security and climate goals



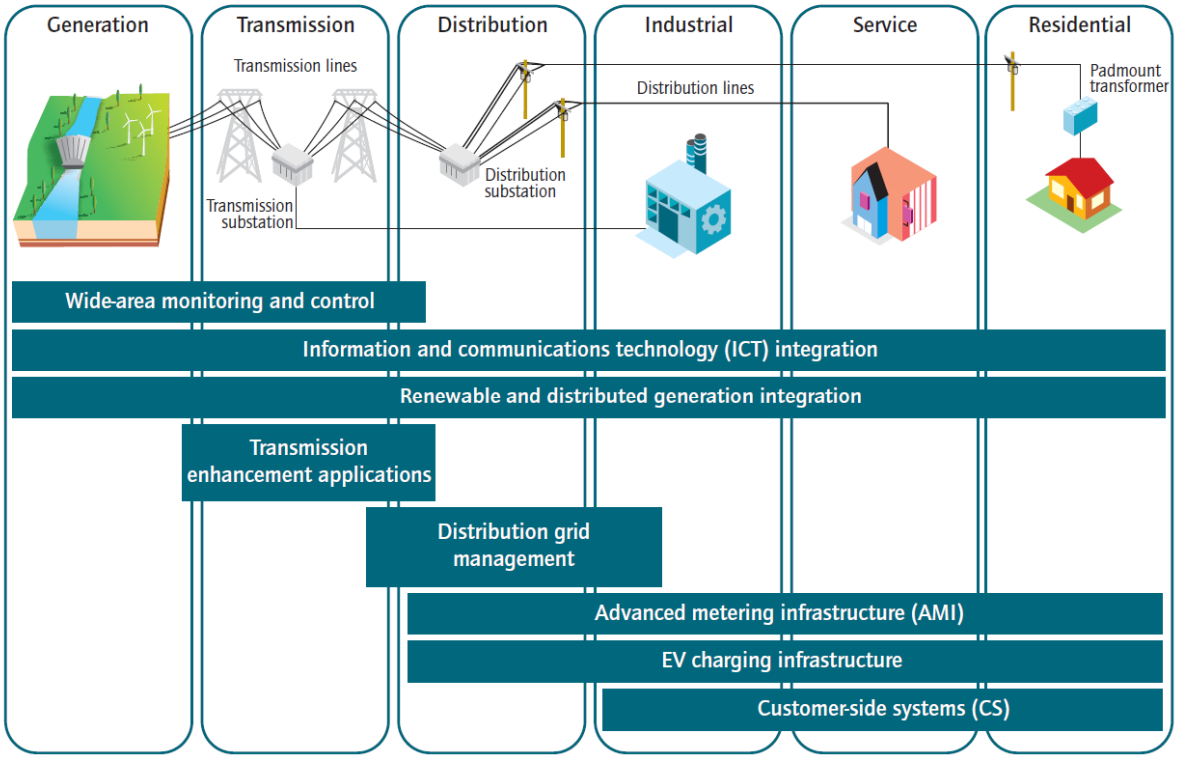
A wide range of technologies will be necessary to reduce energy-related CO2 emissions substantially.

Electricity Systems are evolving



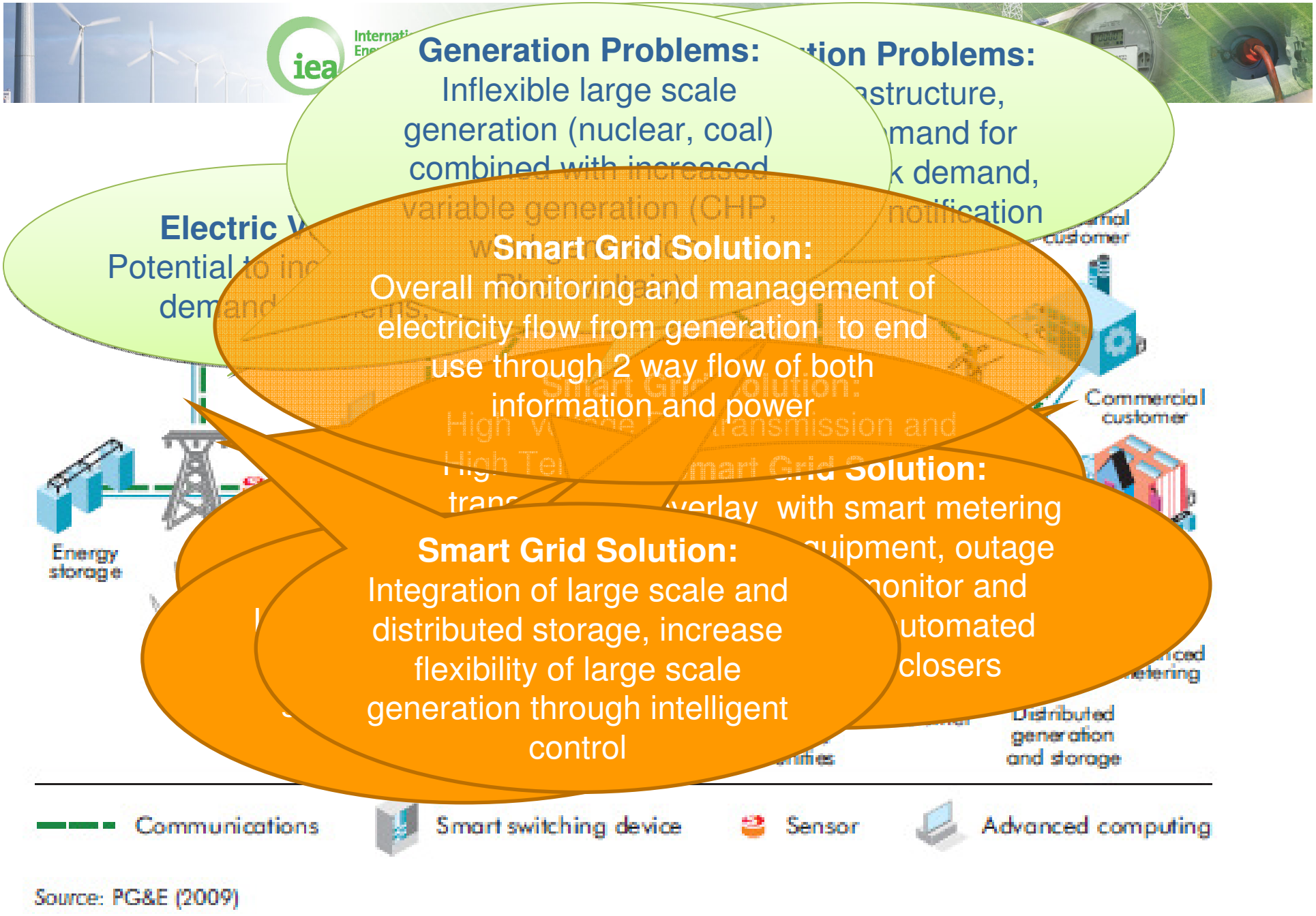
Smartening the grid is not a one time event

Smart Grid Technologies



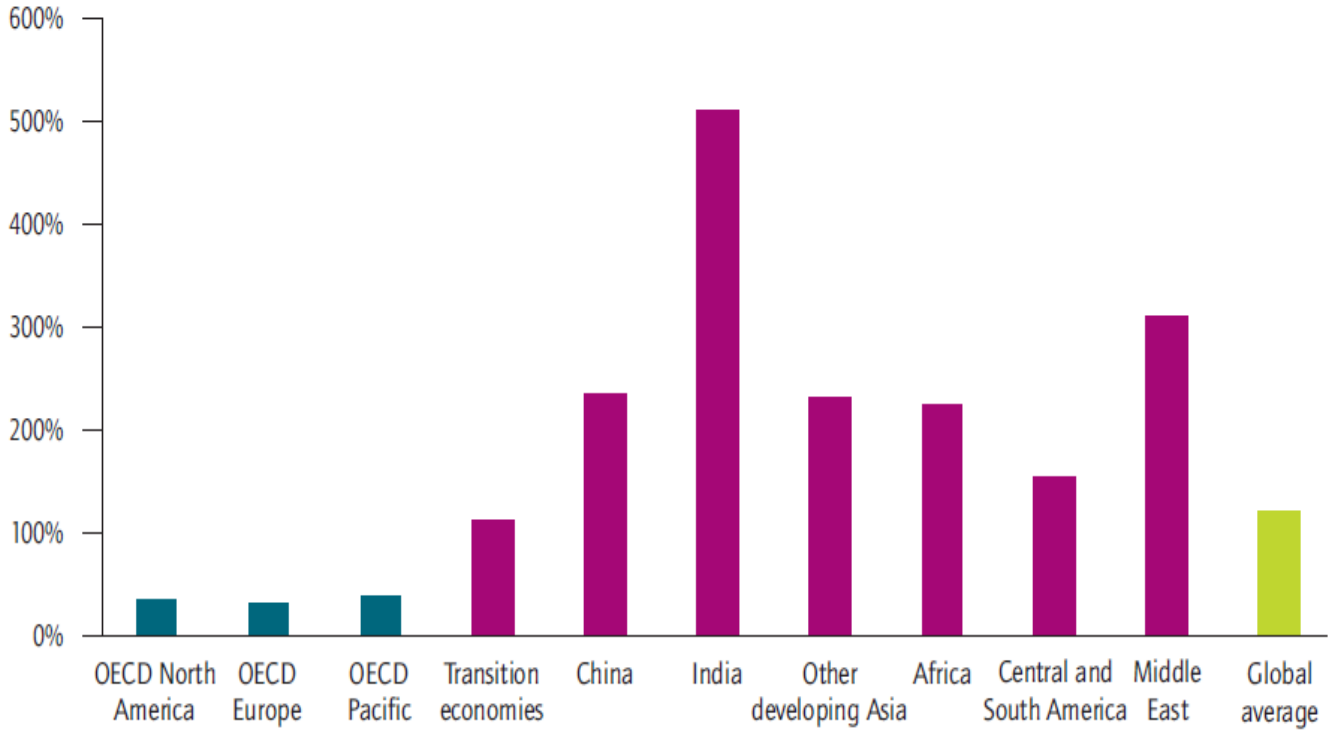
Source: Technology categories and descriptions adapted from NETL, 2010 and NIST, 2010.

Smart grid technologies are applied across the entire electricity system



Source: PG&E (2009)

Electricity Demand Growth from 2007 - 2050

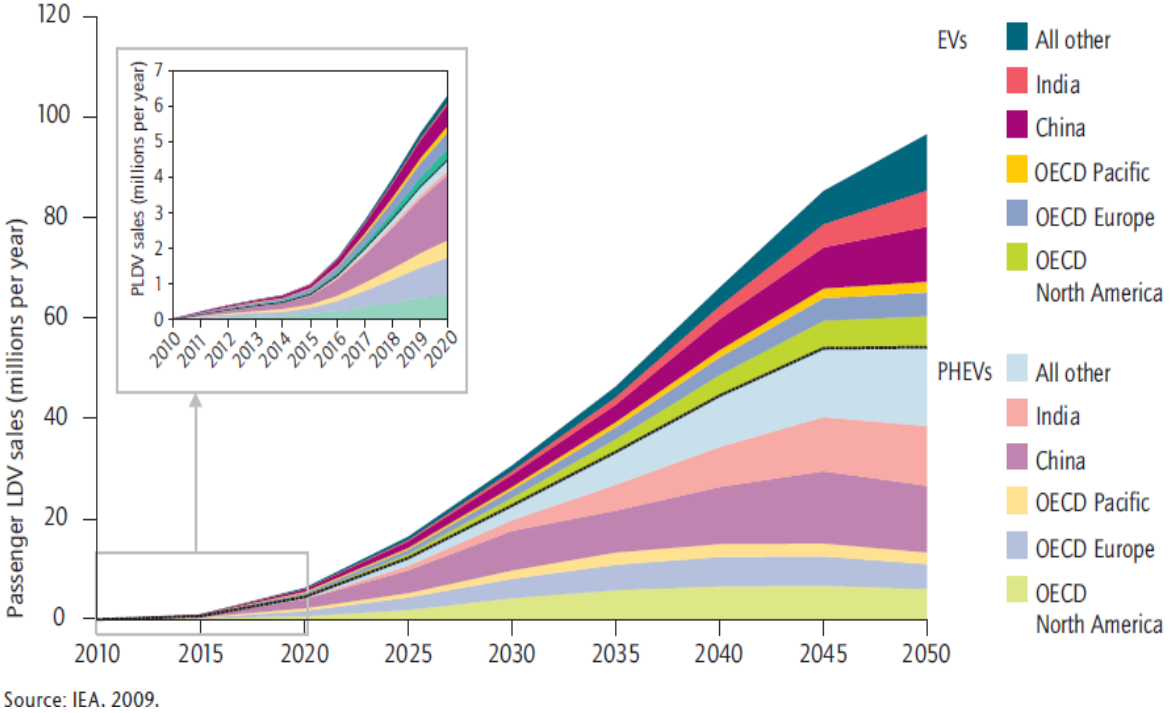


Smart grids can provide grid efficiency improvements, better asset utilisation, and foster growth and significantly reduce electricity system losses in emerging economies through construction of smart infrastructure.

Regional Electricity System Use and Losses, 2008

	Own use in plants	pumped storage	T&D losses	Total losses
OECD	4%	1%	6%	11%
Brazil	4%	0%	16%	20%
Russia	7%	0%	10%	18%
India	7%	0%	23%	30%
China	8%	0%	6%	14%
South Africa	6%	0%	8%	15%
Other Africa	4%	0%	13%	16%
Other Asia	4%	0%	8%	12%
Other former USSR	9%	0%	12%	21%
Other Latin America	3%	0%	16%	18%
Middle East	5%	0%	12%	17%
WORLD	**5%**	**0%**	**6%**	**11%**

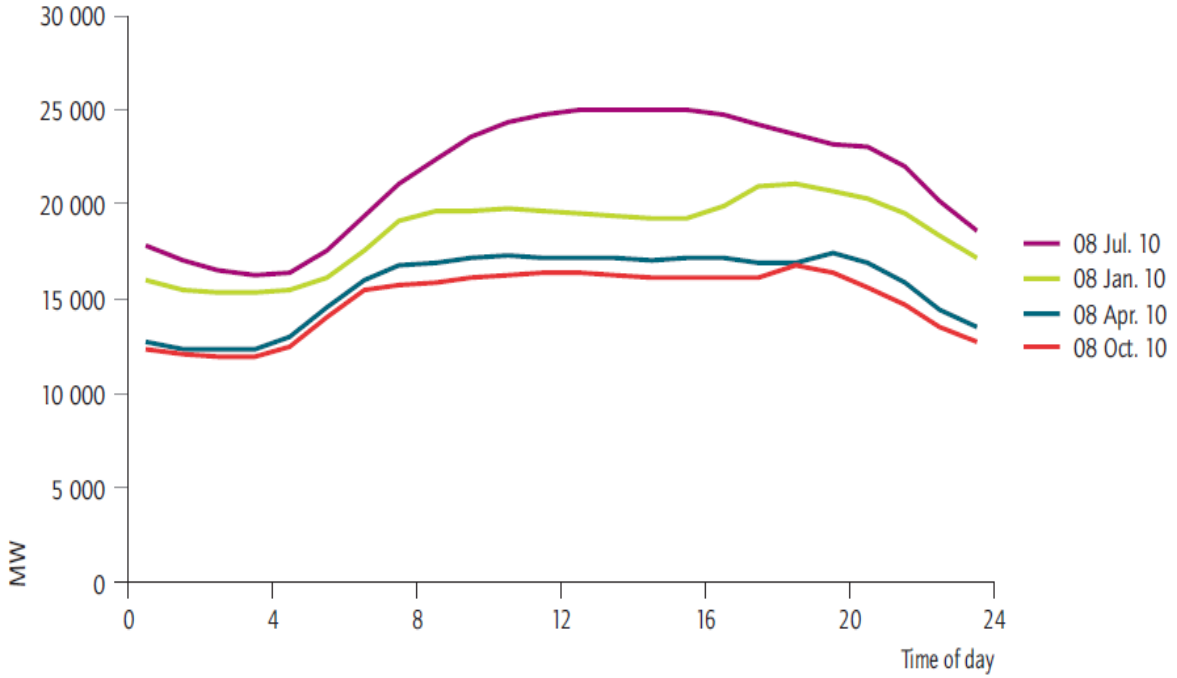
EV/PHEV Deployment



Source: IEA, 2009.

Smart grids will facilitate effective management of EV/PHEV and avoid negative impacts on electricity system performance.

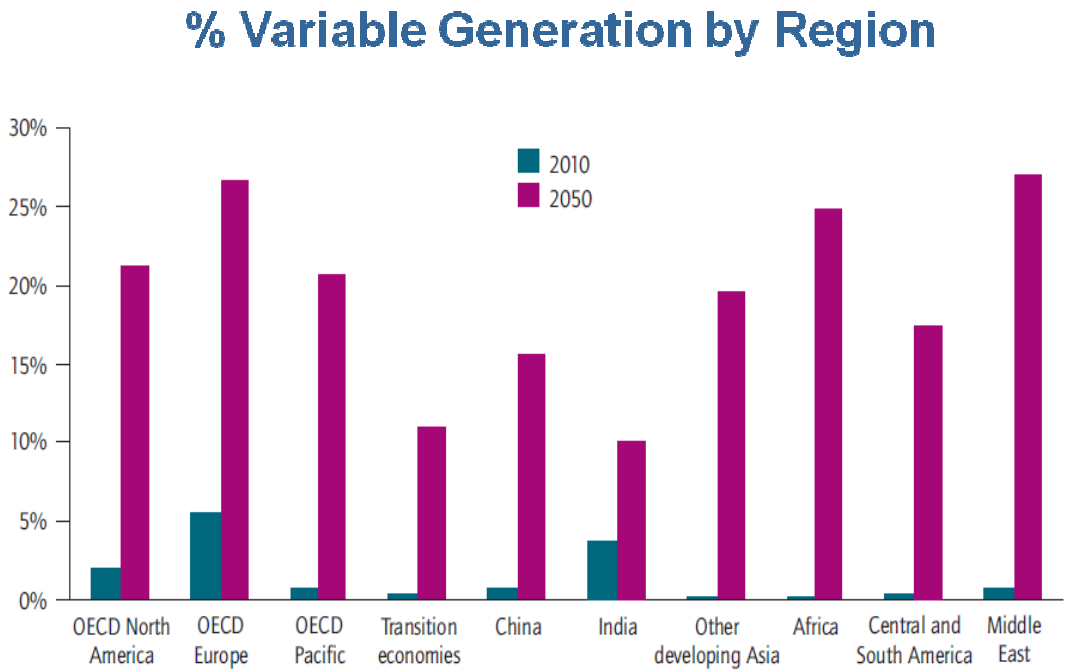
Peak Demand



Source: Data from Independent Electricity System Operator, Ontario, Canada.[7]

Smart grids can reduce peak demand by deployment of advanced system operation and customer programmes

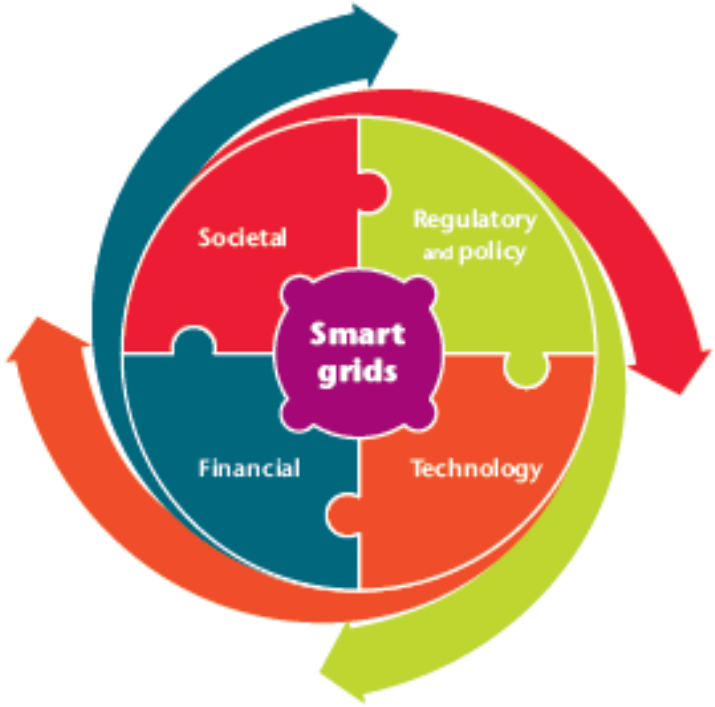
Deployment of Variable Generation



Smart grids will enable high penetration of variable generation while maintaining system reliability and stability

The integrating nature of smart grids

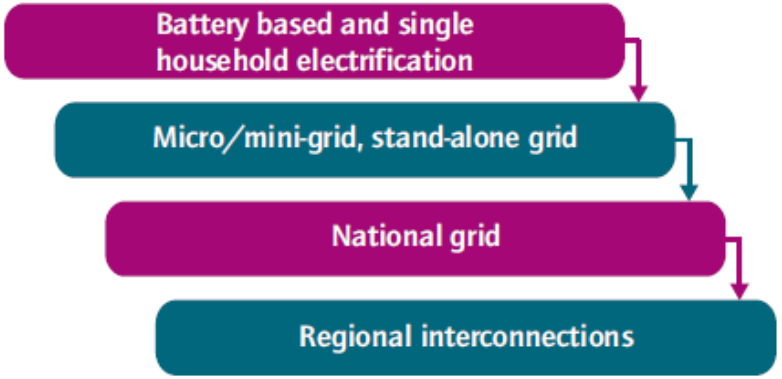
Smart grids will increase electricity system information and transparency, improving the ability to make system investment decisions – sharing costs and benefits with all stakeholders.



Smart grid deployments must reflect regional needs and conditions. A "one-size-fits-all" does not apply to the deployment of smart grids.

Developing Countries and Smart Grids

- Under the right conditions – emerging economies could leap-frog directly to smart grid infrastructure
- Targeted analysis and roadmaps – created collaboratively with developed and developing countries – are required to determine specific needs and solutions in technology and regulation.



Developing and emerging economies can use smart grids to build from household electrification to community and regional systems

Key Efforts Needed

Technology

- Build up commercial-scale demonstrations that operate across system sectors, incorporating business models addressing cost, security and sustainability.
- Develop global technology standards to optimise and accelerate development and deployment while reducing costs
- Integrate with existing electricity infrastructure in addition to new build and new technology

Policy and Regulation

- Evolve electricity system regulation to address changing system needs and take advantage of new technology through leadership from governments and private sector
- Determine approaches to address system-wide and cross-sector barriers to enable practical sharing of smart grids costs and benefits.
- Address cyber security issues proactively through both regulation and application of best practice.
- Develop “smart customers” through codifying best practice, demonstrate and deploy engaging pricing policies and usage tools, protection systems and approaches for data treatment and implement social safety nets

Key Efforts Needed continued

Building Consensus

- Accelerate education and improve understanding of electricity system customers and stakeholders (including energy utilities, regulators and consumer advocates)

International Collaboration

- Expand smart grid collaboration; particularly related to standards and sharing demonstration findings in technology, policy, regulation and business model development.
- Link with electricity system technology areas that are not exclusively focused on smart grids.
- Expand capacity-building efforts in rapidly developing countries tailored to contexts such as rural electrification, island systems and alternative billing approaches.

Other relevant projects at the IEA

- Smart customers – further study and policy recommendations
  - www. Iea.org/papers/2011/sg_cust_pol.pdf
- Impact of Smart Grid technologies on Peak Load until 2050
  - www.iea.org/papers/2011/smart_grid_peak_load.pdf
- Harnessing Variable Renewables - *A Guide to the Balancing Challenge*
  - http://www.iea.org/w/bookshop/add.aspx?id=405
- Benefit / Cost analysis for smart grid deployment
  - System modeling – high level regional basis
  - Monetize the benefits and costs
- Energy Technology Perspectives 2012 – Flexible Energy Systems (June 2012)
  - Technical Potential of Demand Response
  - Electricity systems in emerging economies and developing countries
  - Smart Grid deployment cost

International Smart Grid Action Network (ISGAN)

A mechanism for bringing high-level government attention and action to accelerate the development and deployment of smarter electricity grids around the world.

Current Participants:

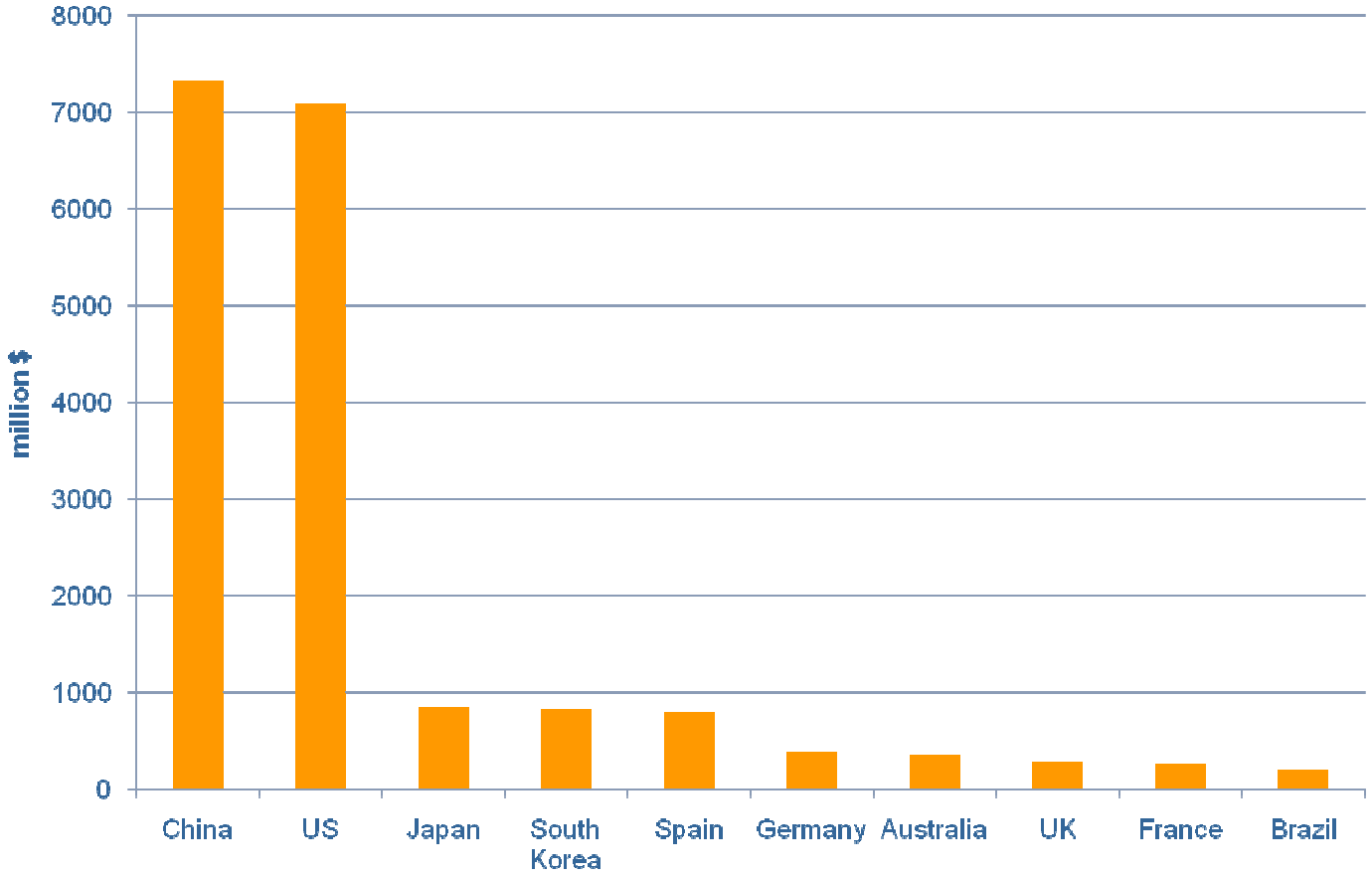
Australia	Belgium	Canada
China	France	Germany
India	Italy	Japan
Republic of Korea	Mexico	Norway
Russia	Sweden	United Kingdom
United States	European Commission	

ISGAN initial projects

1. **Global Smart Grid Inventory**
   of smart grid-enabling programs and policies
2. **Smart Grid Case Studies**
   using a common framework and metrics
3. **Benefit-Cost Analyses and Toolkits**
   to inform smart grid regulatory and investment decisions from both top-down and bottom-up perspectives
4. **Synthesis of Insights for Decision Makers**
   making projects results accessible and useful for advancing effective smart-grid enabling policies and programs

- **ISGAN is not the only entity developing an "inventory"**
- **Several such efforts underway regionally**
  - **ASGI**
  - **JRC**
  - **EU SET Plan**
  - **Etc.**
- **Although different drivers for each, there are opportunities for cooperation**

Smart Grid federal stimulus investment, 2010



Source: Zpryme

Some leading countries

- **China**
  - The Chinese government has developed a large, long-term stimulus plan to invest in infrastructure including smart grids.
  - Smart grid projects are considered an energy efficient way to connect load and demand centers.
  - A smart grid deployment programme, developed by the State Grid Corporation, maps out the deployment to 2030.
- **USA**
  - USD 4.5 billion was allocated to grid modernisation under the American Recovery Reinvestment Act of 2009
    - USD 3.48 billion for the quick integration of proven technologies into existing electric grids
    - USD 435 million for regional smart grid demonstrations, and
    - USD 185 million for energy storage and demonstrations.
- **Republic of Korea**
  - Korea has announced in a roadmap to implement smart grid nationwide by 2030.
  - The Korean government has launched a USD 65 million pilot programme on Jeju Island in partnership with industry. The pilot consists of a fully integrated smart grid system for 6 000 households, wind farms and four distribution lines.

- **Japan**
  - Focusing on distribution systems and integration of all energy systems (smart communities/smart cities concept)
- **Italy**
  - Telestore project, launched in 2001, invested over €2.1 billion, implementing more than 33 million smart meters, completed the automation of more than 100,000 MV/LV distribution substations, and radical change in the management of the operating of the system – generating €500 million in savings per year
  - In 2011 the Italian regulator has awarded eight tariff-based funded projects on active medium voltage distribution systems, to demonstrate at-scale advanced network management and automation solutions necessary to integrate distributed generation.
- **Ireland**
  - Ambitious wind Integration levels (40% of generation), renewable transportation and electric vehicles (10% transport to be renewable and 10% electric vehicles) and increased energy efficiency (20% improvement) by 2020. National smart meter roll-out and significant network investments (over €10 B).

Smart grids:

Accelerating electricity system evolution to achieve shared goals for energy security, economic development and climate change mitigation.

For more information:

www.iea.org/roadmaps

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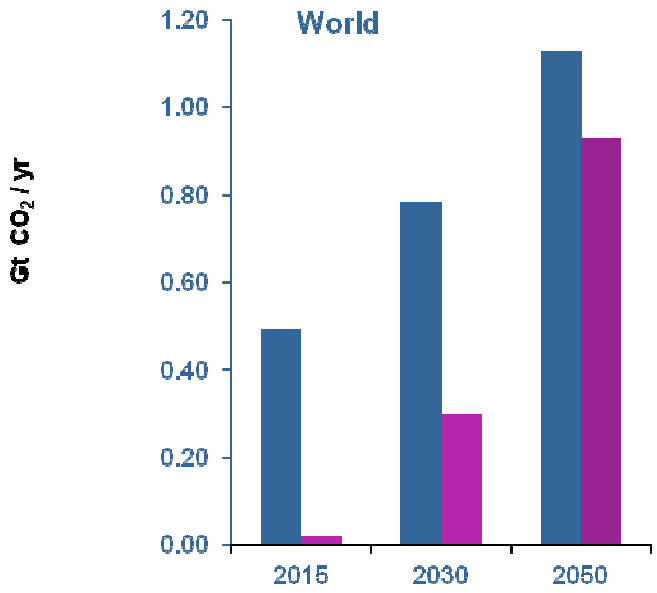
Thank You

Annex

What can smart grids do?

- Enables informed participation by customers
- Accommodates all generation and storage options (inc. varRE)
- Enables new products, services and markets (inc. DR, EV's)
- Provides the power quality for the range of needs
- Optimises asset utilisation and operating efficiency
- Provides resiliency to disturbances, attacks and natural disasters

Direct and enabled emission reductions



Smart Grids have the potential reduce global CO_2 emissions by over
2 gigatonnes per year by 2050

Direct reductions: energy savings from peak load management, continuous commissioning of service sector loads, accelerated deployment of energy efficiency programs, reduced line losses, and direct feedback on energy usage

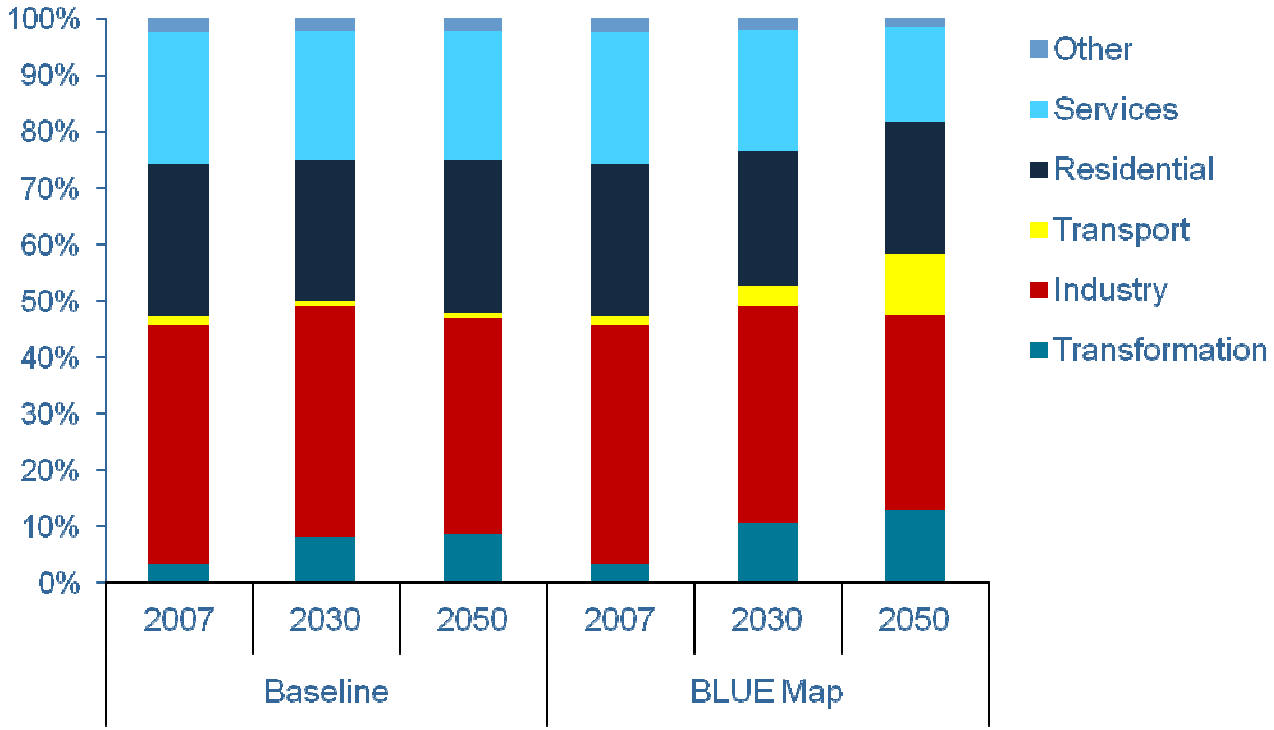
Enabled reductions: greater integration of renewable and facilitation of EV and PHEV deployment

Regional Electricity Demand

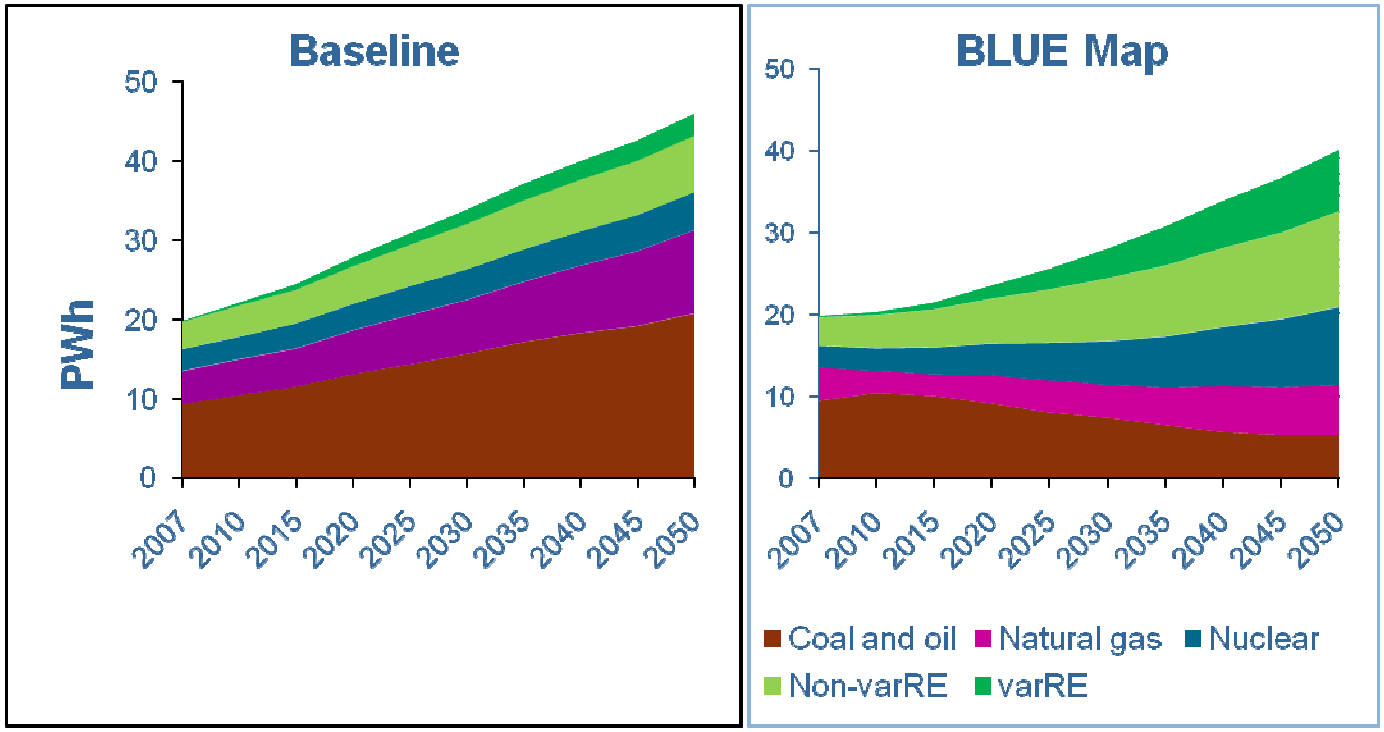
	2007 Electricity demand [TWh]	2050 BLUE Map Electricity demand [TWh]	BLUE Map Percent growth 2007 to 2050
World	**16 999**	**36 948**	**117%**
OECD North America	**4 664**	**6 252**	**34%**
OECD Europe	**3 136**	**4 071**	**30%**
OECD Pacific	**1 681**	**2 311**	**37%**
Economies in Transition	**1 149**	**2 348**	**104%**
China	**2 856**	**9 500**	**233%**
India	**567**	**3 453**	**509%**
Other Developing Asia	**853**	**2 822**	**231%**
Africa	**521**	**1 691**	**225%**
Latin America	**808**	**2 062**	**155%**
Middle East	**594**	**2 437**	**310%**

Note: Electricity demand equals generation minus losses.

Sectoral Electricity Demand



Electricity Generation Mix



Variable renewables are becoming a significantly larger proportion of overall electricity generation