IEA Smart grids

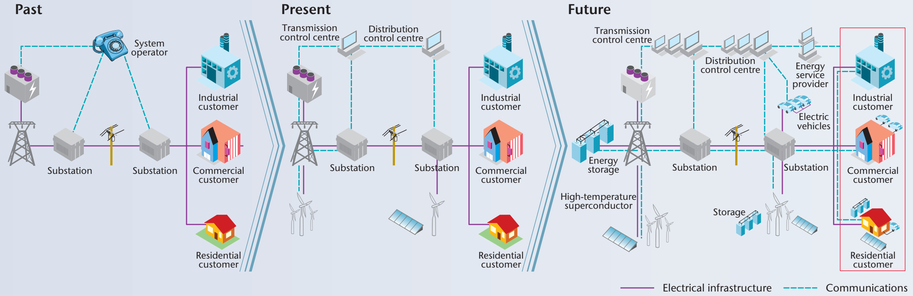
2010 2020 2030 2040 2050

International Energy Agency

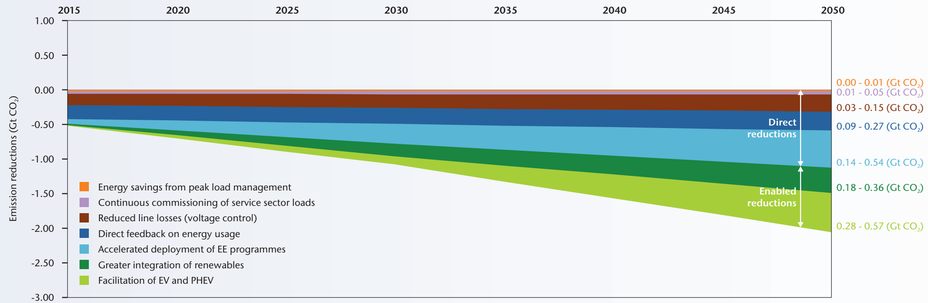
Key findings

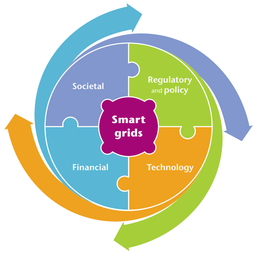
- The development of smart grids is essential if the global community is to achieve shared goals for energy security, economic development and climate change mitigation.
- No single actor can deliver smart grids; governments, the private sector and customer and environmental advocacy groups must work together to define electricity system needs and determine smart grid solutions.
- Several large-scale, system-wide demonstrations are urgently needed to determine solutions that can be deployed at scale, integrating the full set of smart grid technologies with existing electricity infrastructure.
- Developing countries and emerging economies may leapfrog directly to smart electricity infrastructure. Capacity building and targeted analysis is needed to determine specific needs and solutions in regulation and technology.
- Regulatory and market models – such as those addressing system investment, prices and customer participation – must evolve as technologies offer new options over the course of long-term, incremental smart grid deployment.
- Peak demand will increase between 2010 and 2050 in all regions. Smart grids deployment could reduce peak demand increases by 13% - 24% over this time frame in the four regions analysed in this roadmap.
- Building awareness and seeking consensus on the value of smart grids must be a priority, with energy utilities and regulators having a key role in justifying investments.
- Greater international collaboration is needed to share experiences with pilot programmes, to leverage national investments in technology development and to develop common smart grid technology standards that optimise and accelerate technology development and deployment while reducing costs for all stakeholders.

The evolutionary process of "smartening" the grid



Global smart grids emission reductions in BLUE Map, (2015-2050)





Smart grids provide an opportunity to link societal, financial, technology and regulatory and policy objectives

Building consensus for smart grid deployment
- Educate electricity system stakeholders to increase awareness of smart grids attributes
- Continue to develop and improve technological solutions in parallel with institutional structures within the electricity system to optimise overall operations, costs and performance

Technology development, demonstration and deployment
- Concentrate effort on commercial-scale, system-wide demonstrations addressing key cost, security + sustainability issues
- Continue to deploy smart grid technologies in all sectors – both in new and existing systems
- Deploy automated metering infrastructure technologies to enable demand response from all end-use sectors
- Develop and demonstrate customer-based enabling technologies
- Strategically develop international standards – proactively adjust priorities to technology and market needs

Utility policy and regulation
- Develop regulatory mechanisms that encourage business models and market mechanisms to support increased deployment of variable generation and consumer participation in the market
- Use an evolutionary approach to regulation to support changing generation and consumption landscape
- Determine adaptive market and regulatory policies to allow sharing of smart grid costs and benefits between generation, transmission and distribution sectors
- Address policy and regulatory barriers that hinder regional smart grids demonstration and deployment in transmission and distribution systems
- Determine regulatory mechanisms and capacity building needs for developing countries, potentially enabling them to leap-frog conventional electricity system approaches
- Tackle cyber security issues proactively through standards, regulation and best practice

Customer policy and regulation
- Codify best practice on automated demand response and energy efficiency, use findings to improve pilot projects
- Continue to evolve regulatory approaches to expand automated demand response and energy efficiency pilots and encourage widespread deployment
- Develop electricity usage tools and business models that incentivise consumers to respond to changes in electricity markets and regulation
- Address privacy, ownership and security of customer usage information by developing policies and protection mechanisms
- Address special consumer classes that may not be able to easily benefit from smart grids

International collaboration
- Expand collaboration; particularly related to standards and results of demonstration in technology, policy, regulation and business models
- Expand capacity-building efforts in developing economies with targeted roadmaps and analysis

Next ten years

- Build up commercial-scale demonstrations that operate across system boundaries of generation, transmission, distribution and end-use and that incorporate appropriate business models addressing cost, security and sustainability.
- Accelerate education and improve understanding of electricity system stakeholders – especially customers – to increase acceptance for smart grids deployment.
- Address cyber security issues proactively through both regulation and application of best practice in generation, transmission, distribution and end-user sectors.
- Demonstrate new regulations and business models to address system wide and cross-sector barriers to enable practical sharing of smart grids costs and benefits.
- Quantify smart grids costs and benefits globally and at a system level and create tools to evaluate smart grid technology options.
- Evaluate priorities and develop initial standards for equipment, data transport, interoperability and cyber security.
- Expand international collaboration; particularly related to standards and sharing demonstration results in technology, policy, regulation and business model development.

Smart grids drivers from the changing electricity system

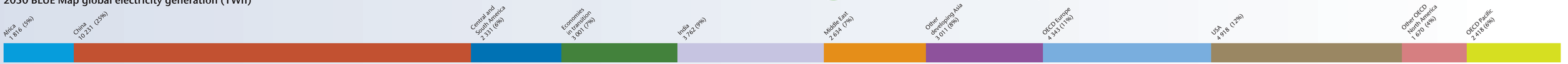
	2010	2015	2030	2050	2010	2015	2030	2050
Africa	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	674	798	1 200	1 958	676	781	1 088	1 816
% variable generation	0.2	0.7	3.6	4.2	0.3	0.9	9.5	24.9
Generation capacity (GW)	150	181	273	360	149	176	293	575
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.1
China	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	3 941	5 622	8 847	12 470	3 944	5 436	7 022	10 231
% variable generation	0.9	1.8	3.0	4.2	0.8	2.9	10.3	15.6
Generation capacity (GW)	869	1 215	1 936	2 276	868	1 132	1 806	2 424
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.4	11.7	26.3
Central and South America	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	1 071	1 247	1 745	2 243	1 075	1 234	1 568	2 331
% variable generation	0.2	0.6	2.7	3.7	0.2	0.7	6.4	17.5
Generation capacity (GW)	240	276	391	483	240	273	386	784
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8.7
Economies in transition	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	1 635	1 868	2 375	3 107	1 638	1 850	2 101	3 001
% variable generation	0.1	0.4	2.0	2.9	0.1	0.4	5.5	11.0
Generation capacity (GW)	416	443	523	861	416	425	505	919
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	1.1	3.9
India	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	934	1 271	2 737	4 067	904	1 055	1 786	3 762
% variable generation	2.6	3.6	3.0	2.7	2.5	3.9	7.5	10.1
Generation capacity (GW)	200	263	571	695	201	252	540	947
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	3.2	22.6
Middle East	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	792	967	1 656	2 726	795	946	1 477	2 634
% variable generation	0.0	0.4	1.8	4.1	0.0	0.4	7.5	26.9
Generation capacity (GW)	228	269	389	510	229	268	381	830
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	0.9	6.7

	2010	2015	2030	2050	2010	2015	2030	2050
Other developing Asia	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	1 052	1 340	2 517	3 902	1 054	1 299	2 114	3 011
% variable generation	0.1	0.3	2.9	3.2	0.0	0.5	7.7	19.5
Generation capacity (GW)	258	314	564	921	259	307	546	881
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	8.7
OECD Europe	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	3 423	3 716	4 398	5 085	3 434	3 665	4 182	4 343
% variable generation	5.2	9.0	15.8	18.4	5.2	9.4	23.0	26.7
Generation capacity (GW)	912	1 005	1 162	1 531	915	989	1 266	1 400
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.2	5.4	9.6
United States	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	4 219	4 526	5 277	5 901	4 229	4 390	4 826	4 918
% variable generation	2.0	4.1	7.2	8.6	2.0	4.3	12.2	21.0
Generation capacity (GW)	1 074	1 096	1 239	1 656	1 074	1 075	1 131	1 497
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.2	5.2	10.6
Other OECD North America	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	892	989	1 244	1 743	895	953	1 110	1 670
% variable generation	0.2	0.5	3.4	4.3	2.7	5.0	17.0	21.9
Generation capacity (GW)	194	211	263	354	193	198	261	538
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.8
OECD Pacific	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	1 807	2 007	2 296	2 767	1 810	1 959	2 055	2 418
% variable generation	0.7	1.2	4.0	5.3	0.7	1.4	8.6	20.7
Generation capacity (GW)	429	496	511	650	424	489	542	750
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	0.2	2.3	4.4
World	*Baseline*				*BLUE Map*			
Electricity generation (TWh)	20 440	24 352	34 292	45 970	20 486	23 759	29 939	40 135
% variable generation	2.1	3.1	6.2	6.1	1.7	3.5	11.1	18.7
Generation capacity (GW)	4 970	5 728	7 821	10 298	4 956	5 493	7 574	11 545
EV/PHEV sales (milions)	0.0	0.0	0.0	0.0	0.0	1.0	33.3	106.4

** Electricity generation: total generation from power plants, which is a sum of total electricity consumption and transmission and distribution losses.*

*** 2010 values are estimated from latest available actual data.*

2050 BLUE Map global electricity generation (TWh)



ROADMAP INSIGHTS

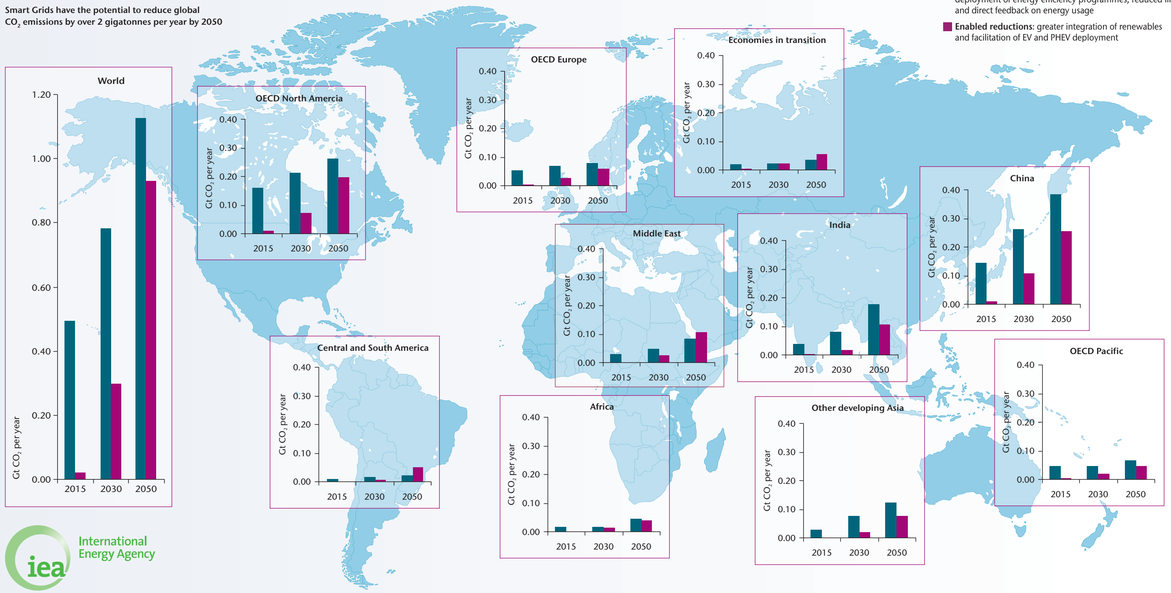
Smart Grids

Regional smart grids CO_2 emission reduction potential

Smart Grids have the potential to 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 programmes, reduced line losses and direct feedback on energy usage

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



International Energy Agency