



Electrification of the Economy – global perspective

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Key points of orientation



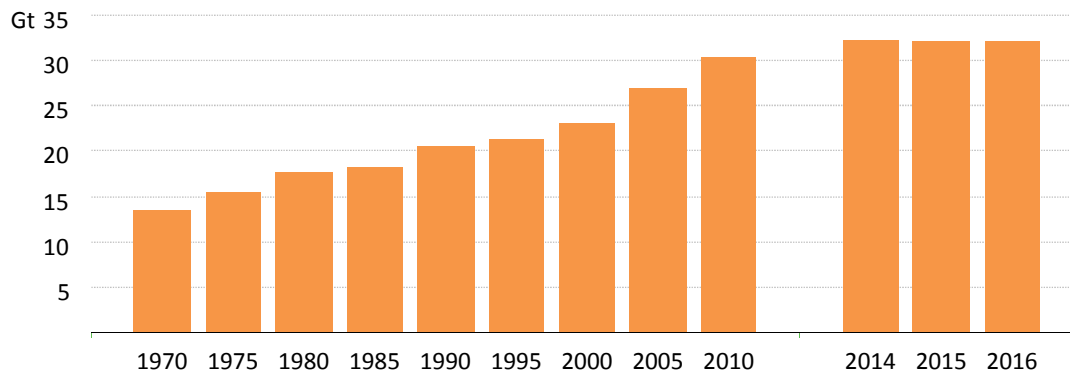
- The energy sector is key to sustainable economic growth
 - Largest source of GHG emissions today, around two-thirds of global total
 - Largest source of air pollution, linked to 6.5 million premature deaths per year
 - Billions remain without basic energy services
- The global energy transition gained momentum in 2016
 - Global energy intensity fell by 2.1% in 2016; fossil-fuel subsidy reform efforts are spreading
 - Renewables supplied half of global electricity demand growth in 2016, and nuclear net capacity reached highest level since 1993
 - Year on year record electric car sales
- There is no single story about the future of global energy
 - Fast-paced technological progress and changing energy business models

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Global CO₂ emissions flat for 3 years – an emerging trend?



Global energy-related CO₂ emissions



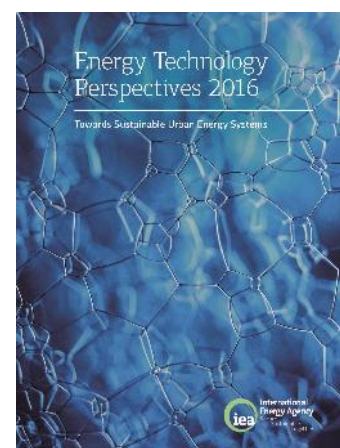
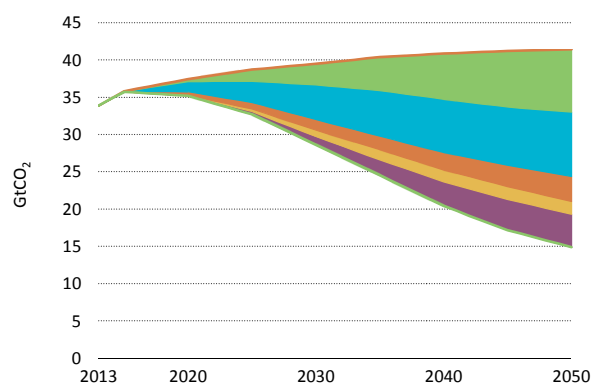
IEA analysis for 2016 shows that global CO₂ emissions did not increase for the third consecutive year in a row, even though the global economy grew.

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Energy Innovation can expand current momentum



Technology contribution to global cumulative CO₂ reductions



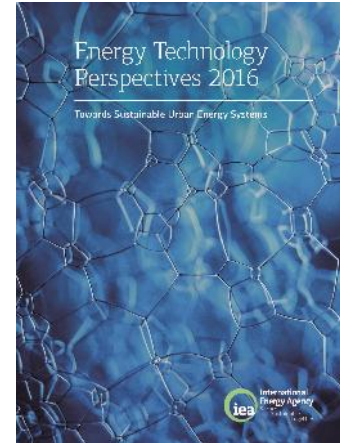
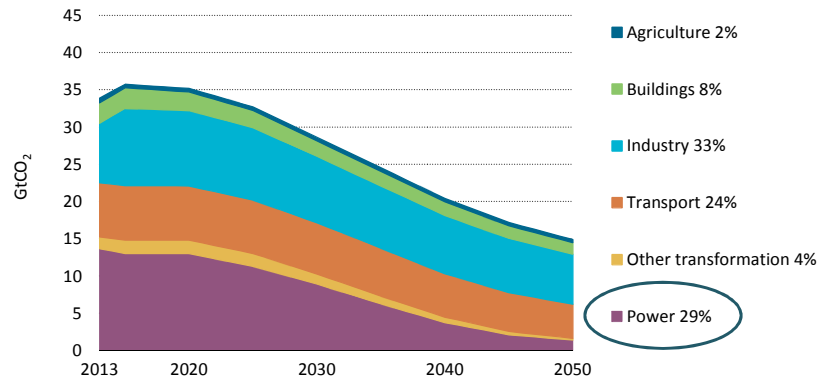
The carbon intensity of the global economy can be cut by two-thirds through a diversified energy technology mix

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But the challenge increases to get from 2 degrees to “well below”



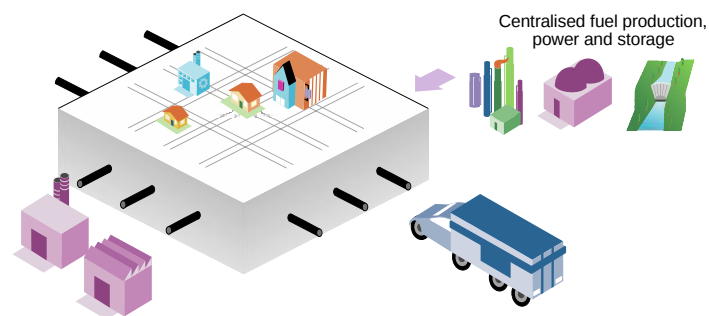
Energy- and process-related CO₂ emissions by sector in the 2DS



Industry and transport account for 57% of the remaining emissions in the 2DS in 2050.

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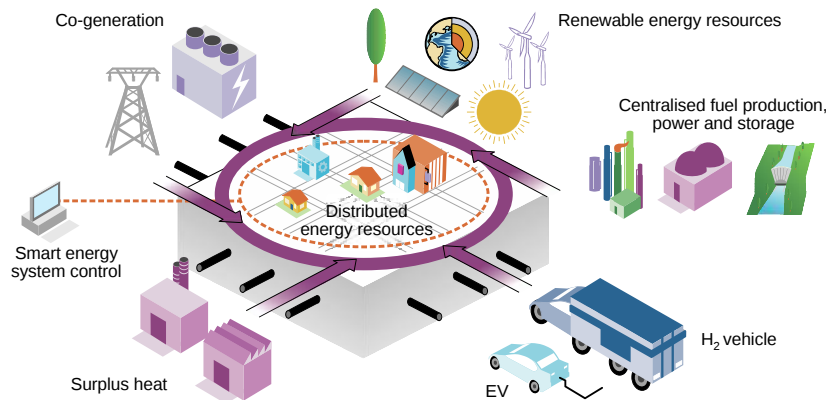
Systems thinking and integration



Today's energy system paradigm is based on a unidirectional energy delivery philosophy

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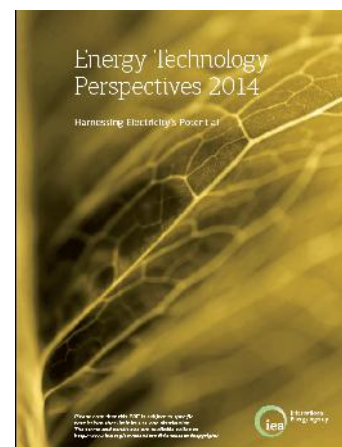
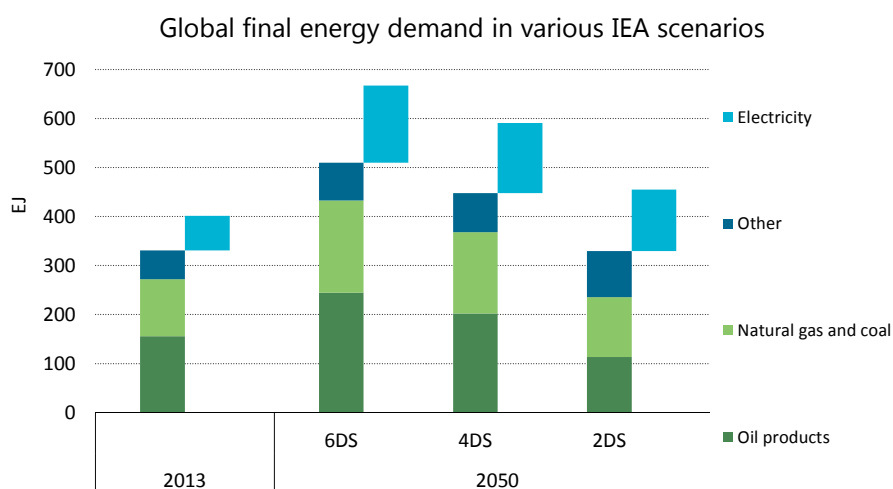
Systems thinking and integration



A sustainable energy system is a smarter, multidirectional and integrated system that requires long-term planning for services delivery

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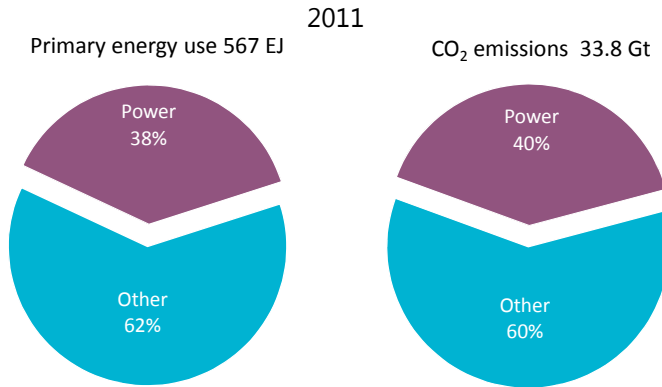
Understanding Electricity's potential



Increasing electricity consumption and share of overall energy usage for ALL IEA forward looking scenarios

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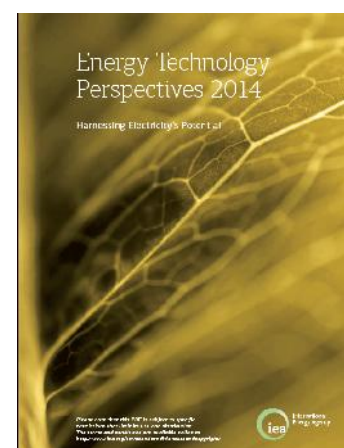
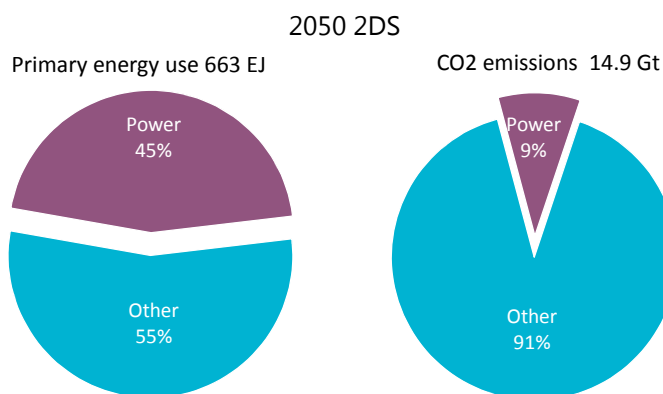
Electricity can power sustainable growth



Electricity is already the largest energy user, and the largest emitter today

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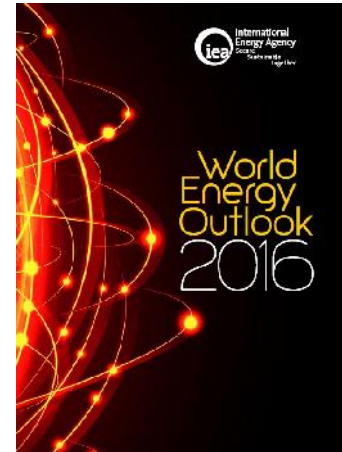
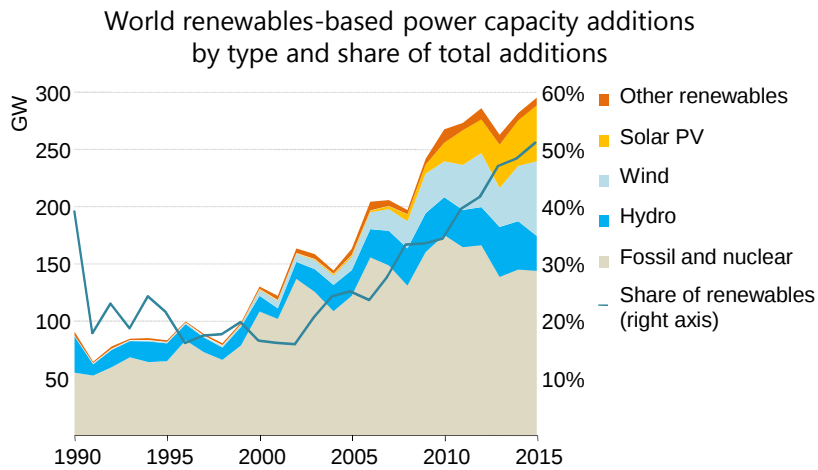
But the source of electricity is of utmost importance



The 2DS pathway disconnects primary energy used in generation from emissions

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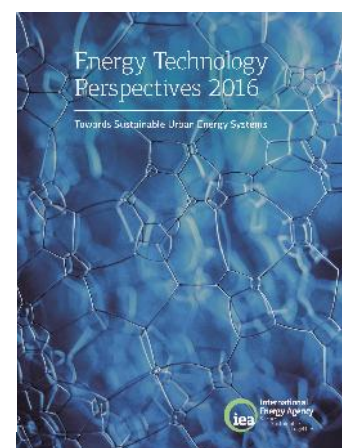
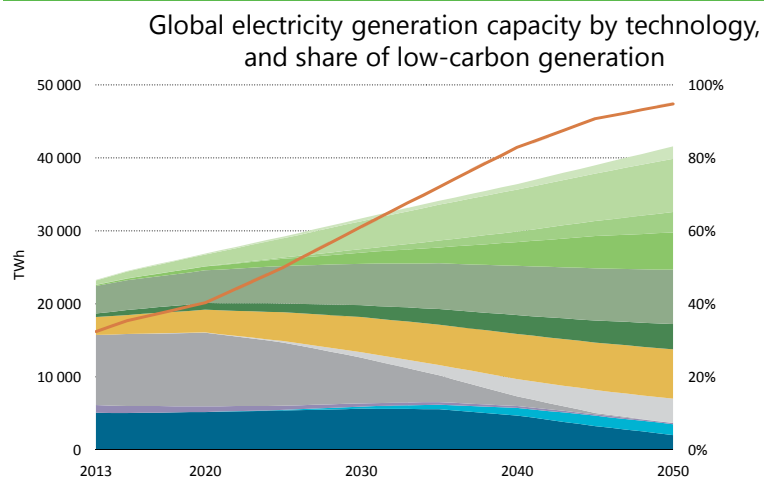
Low-carbon sources are powering up



Renewables-based power capacity additions set a new record in 2015 and exceeded those of all other fuels for the first time

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Re-thinking electricity supply



Generation today:

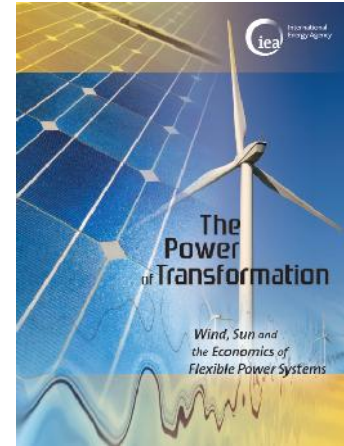
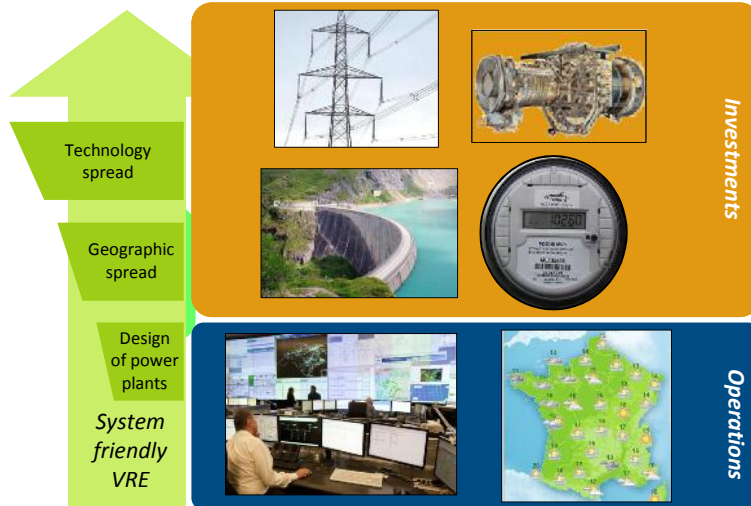
- Fossil fuels: 68%
- Renewables: 22%

Generation 2DS 2050

- Renewables: 67%
- Fossil fuels: 17%

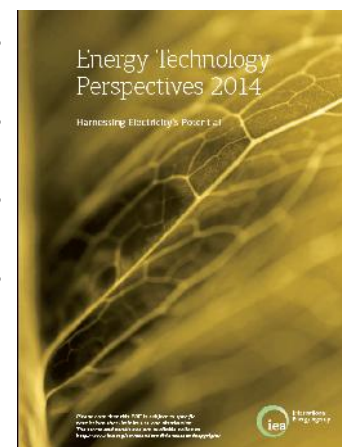
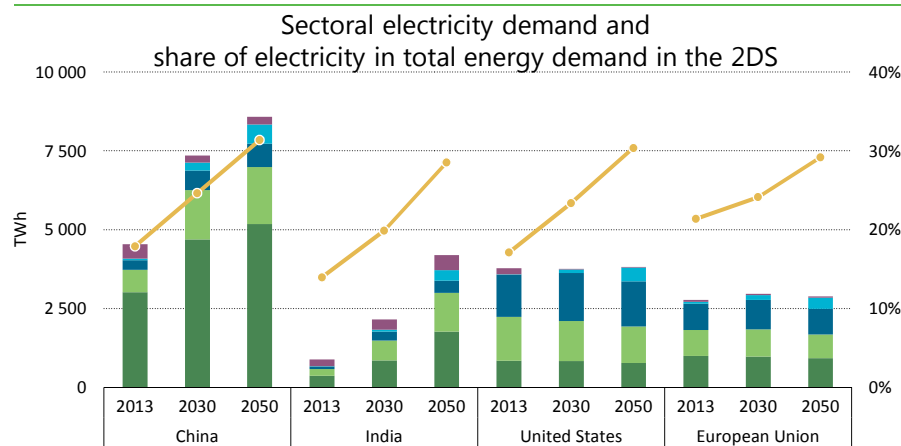
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Reaching high VRE shares: three pillars of system transformation



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The regional context matters



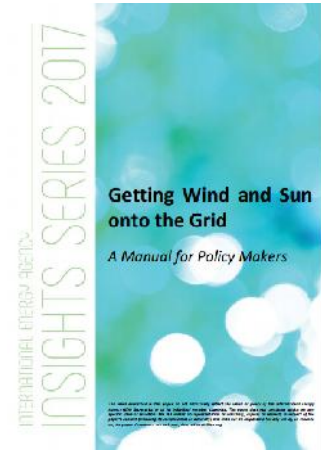
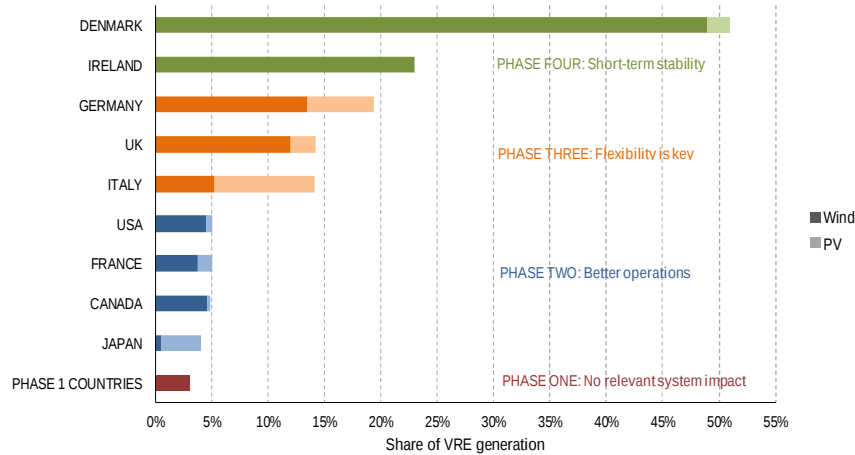
Differences in growth of electricity demand and sectoral distribution require targeted systems development plans. All regions show high growth in VRE deployment

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Different policy guidance for different system integration phases



Wind and solar share in annual generation, 2015



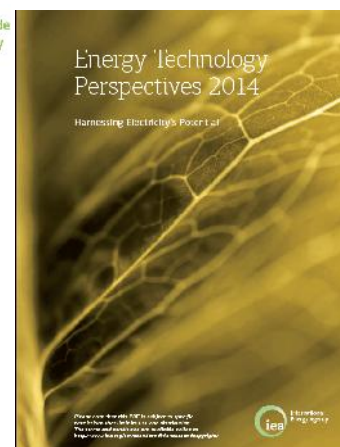
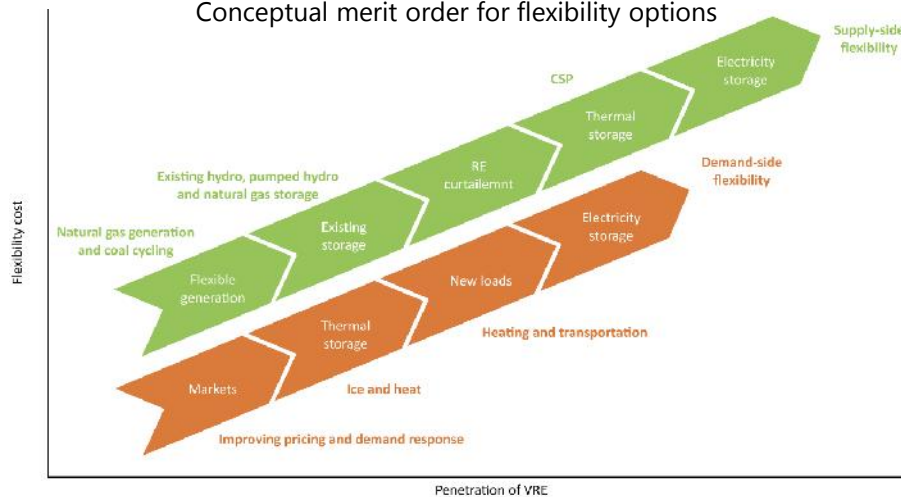
With decreasing technology costs, the new frontier for renewables are system integration, market design and addressing heat and transport sectors. Appropriate integration strategies critical to protect security of supply and contain costs.

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Evaluating a suite of options for providing flexibility



Conceptual merit order for flexibility options



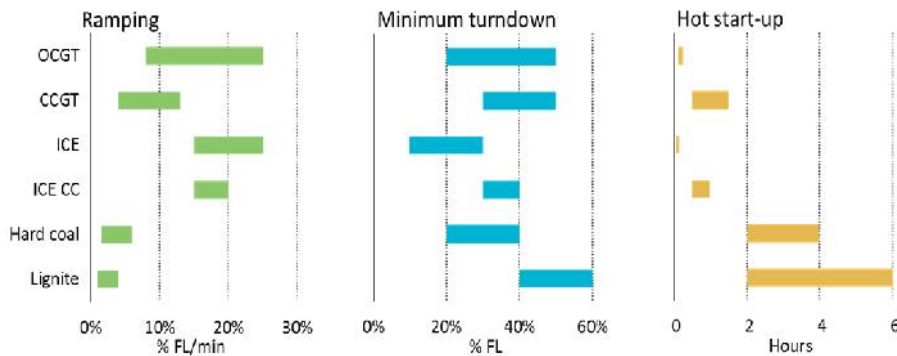
The many sources of systems flexibility have various costs and values that need to be assessed

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The changing role of Power plants



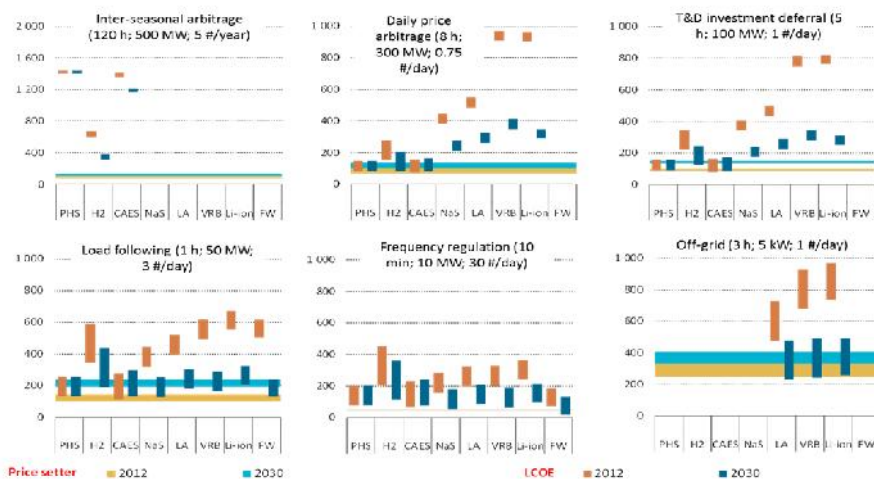
Ranges of flexibility parameters for thermal electricity generation technologies



Thermal power plants' role will vary with electricity markets evolution. Shifting from base-load operation towards flexibility may change generation technology choices.

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Evaluating storage: Matching technology to application



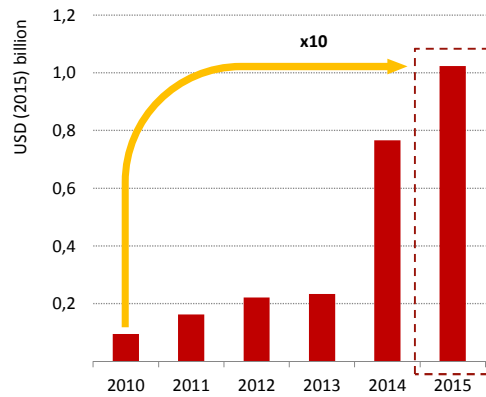
The cost of electricity storage depends on its application

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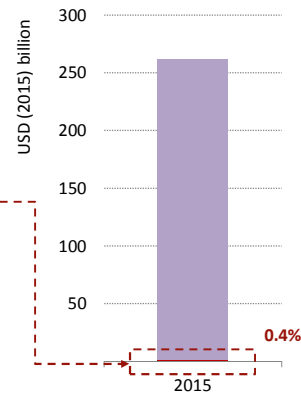
Battery investment has taken off



Global grid-scale battery storage investment



Total networks investment



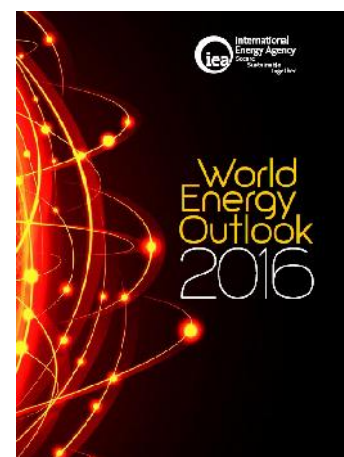
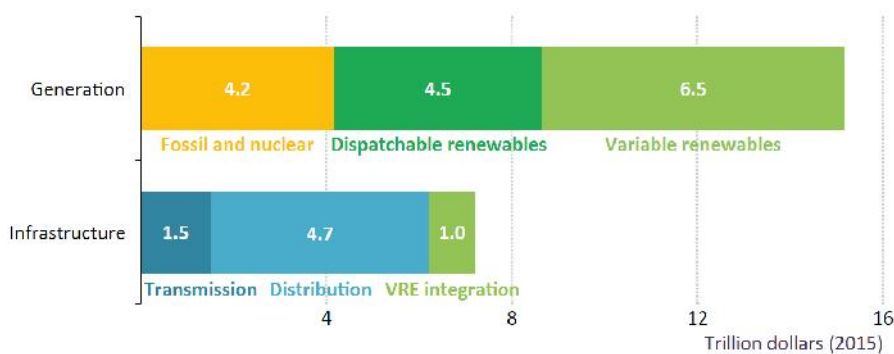
Grid-scale battery storage spending has expanded tenfold since 2010.
Their value lies most in complementing centralised grids that constitute the bulk of investment.

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Investment in electricity grids needs to accelerate



Total global power generation and T&D investment in the 450 Scenario
 2016-2040



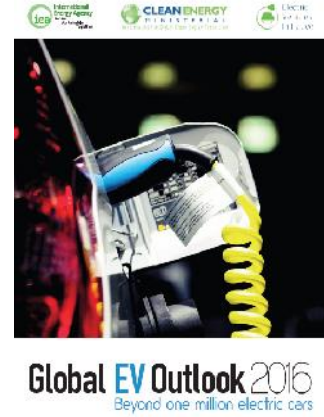
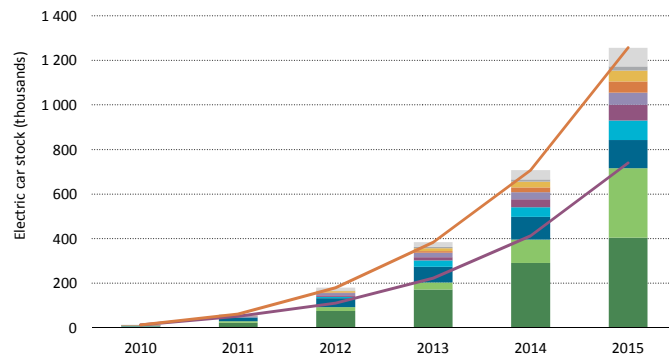
Investments in transmission and distribution grids for integrating VRE are a small portion of the total investments in the power sector

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Crossing the 1 million EVs threshold



Evolution of the global BEV and PHEV stock, 2010-2015



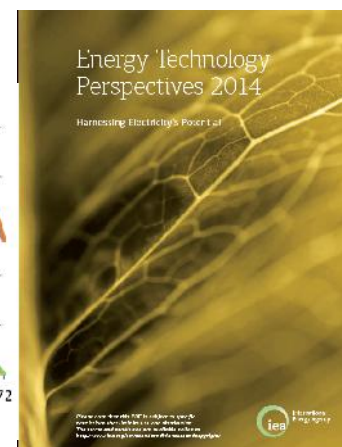
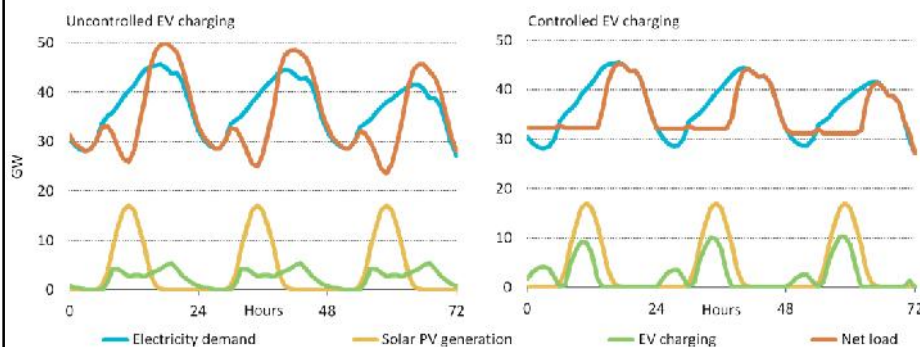
Annual EV sales grew by 70% over 2014, with increasing impacts on electricity grid flexibility

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Stacking the benefits through demand-side integration



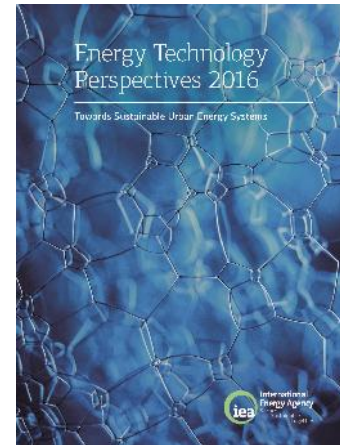
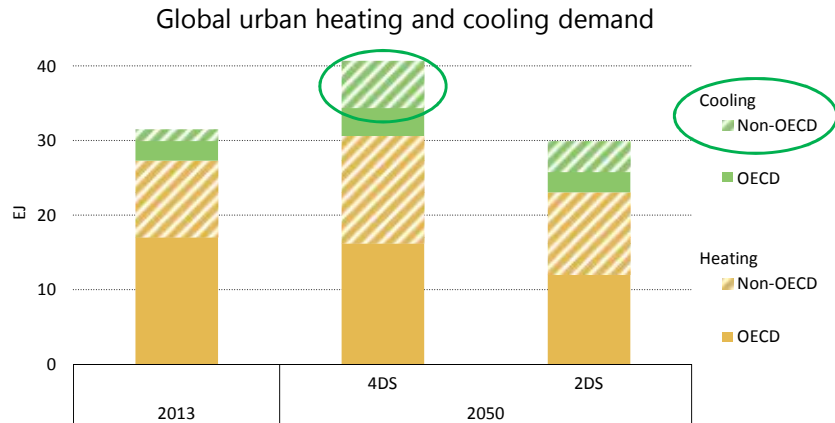
Controlled versus uncontrolled EV charging effects on load net of PV



Controlled charging of electric vehicles could facilitate the integration of solar PV

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Heating and cooling: the elephant in the room



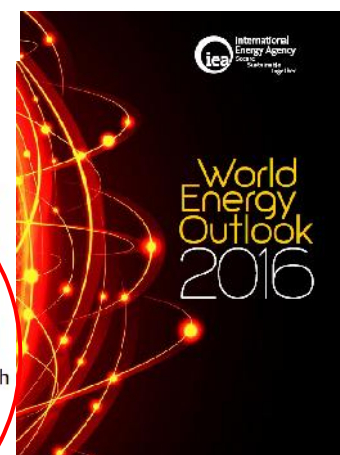
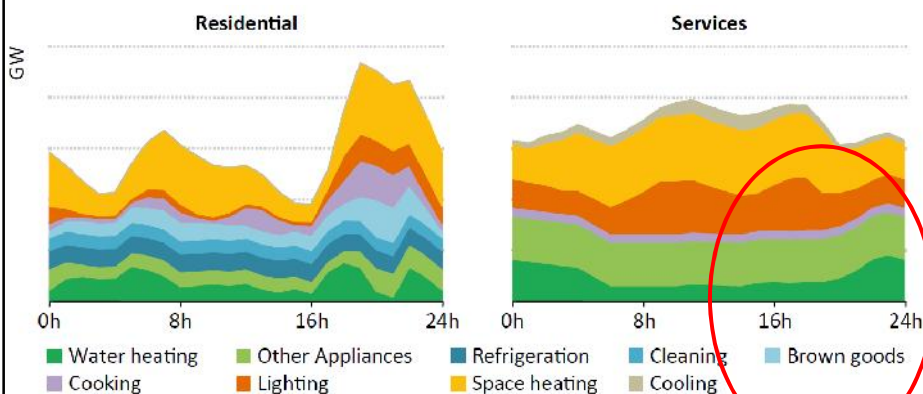
H&C energy demand in cities can be reduced by 25% without compromising thermal comfort, notably cooling in emerging economies

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Multiple benefits from building sector electrification



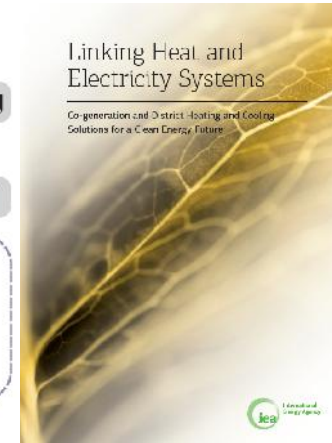
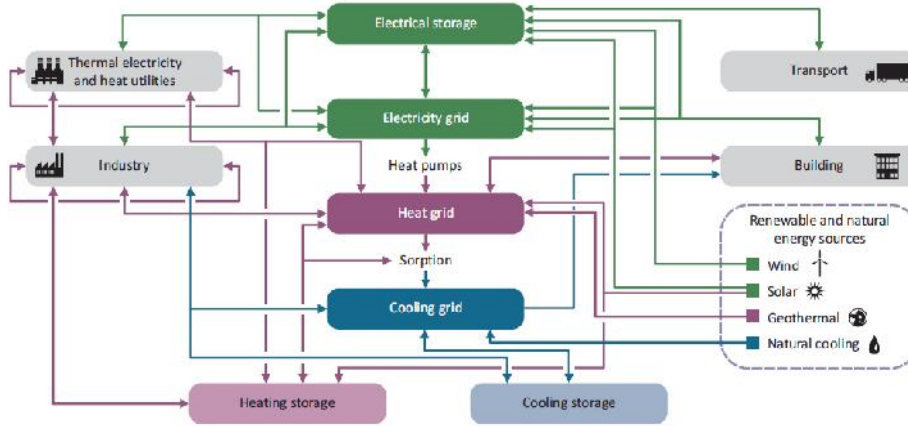
Illustrative load curves by sector for a weekday in February in the EU compared with the observed load curve by ENTSO-E in 2014



Increasing electricity use helps reduce CO₂ footprint AND fossil fuel dependency, while providing additional systems flexibility opportunities

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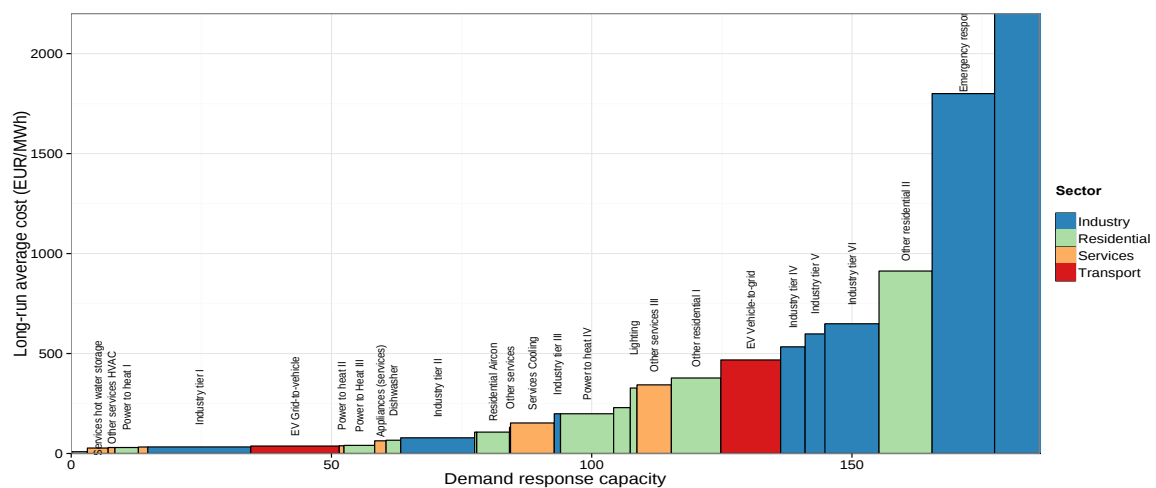
Focusing on cross-sectoral integration



Potential for greater multi-carrier efficiency in more integrated systems

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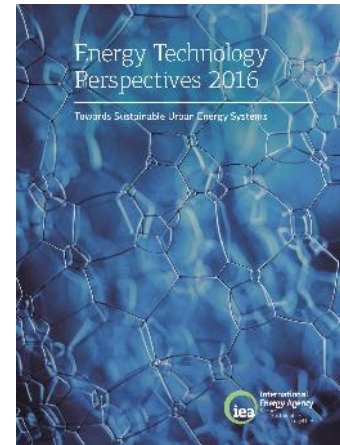
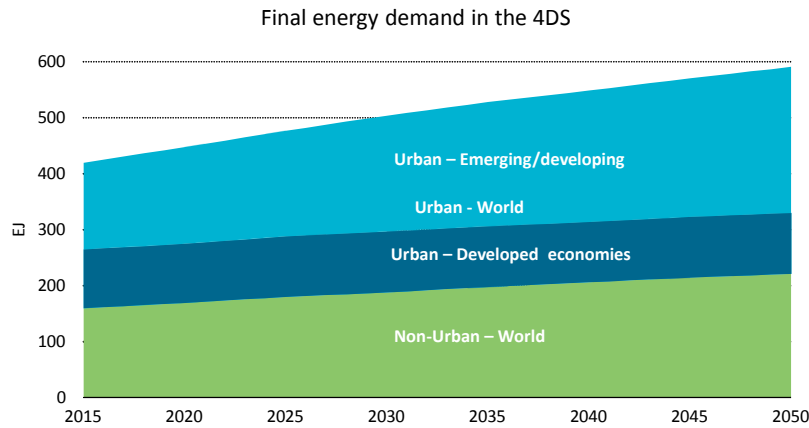
Identifying the Potential: Region-by-region assessment



Large cost effective flexibility potential exists, but depends on local conditions, market frameworks and "smartness" of the energy system

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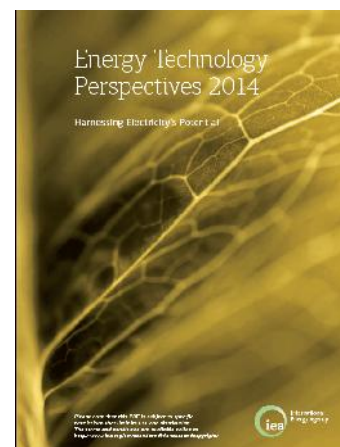
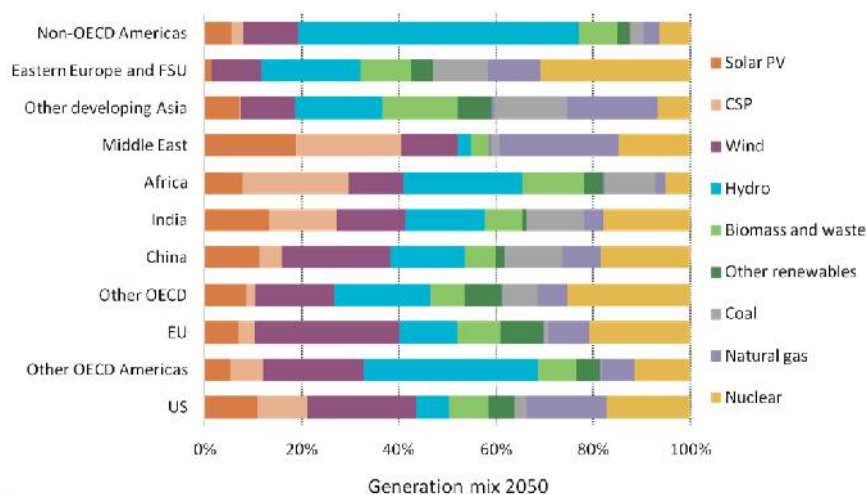
Local and national actions need to be coordinated



Two-thirds of the growth in global energy demand to 2050 comes from cities, mostly in emerging and developing economies

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Strategies to decarbonise electricity vary across regions



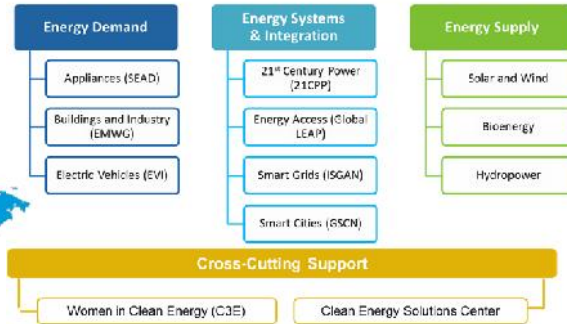
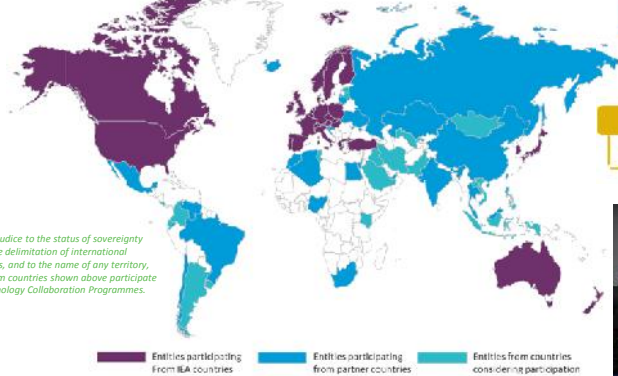
Local circumstances will drive different solutions and strategies

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Collaboration is key to accelerating innovation



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