Tracking Clean Energy Progress 2018

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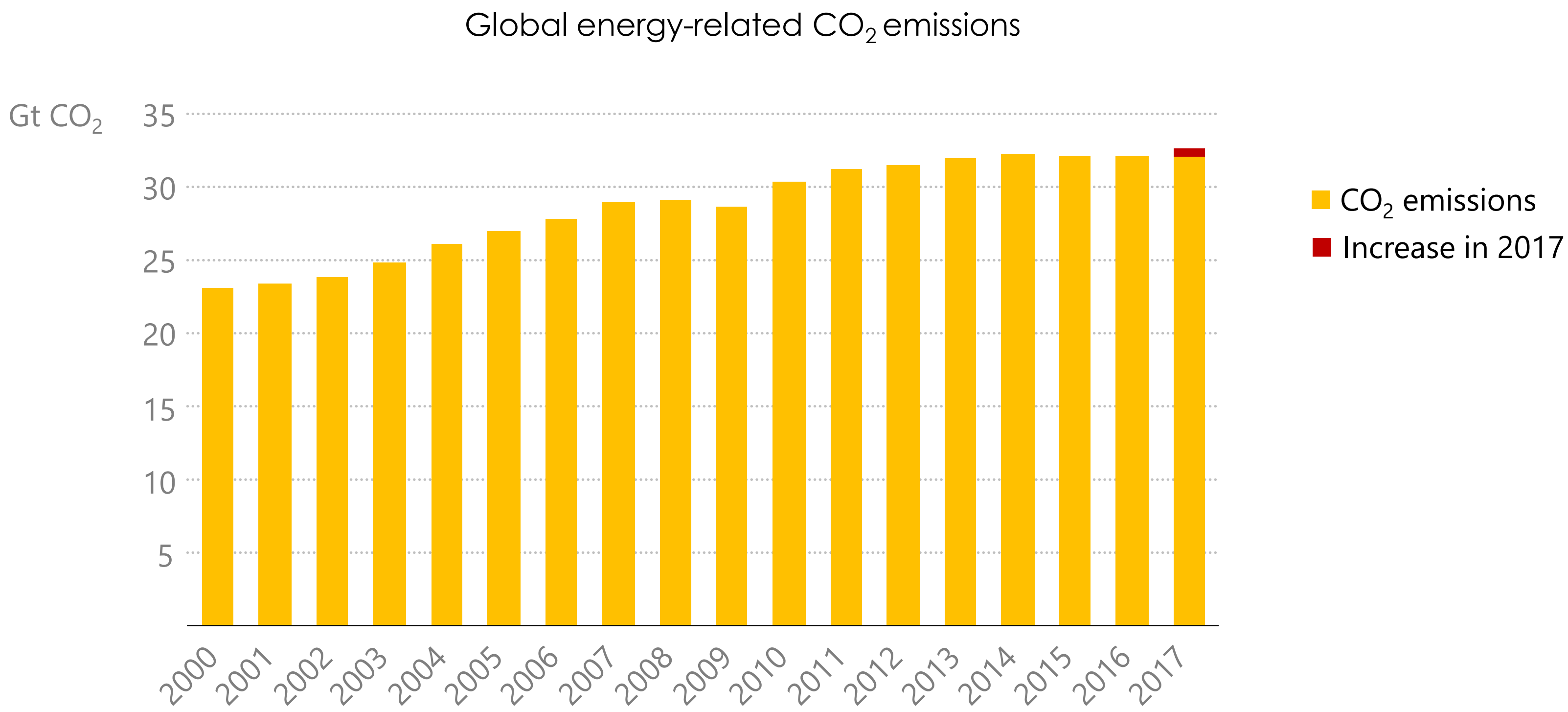
Future Energy Market Designs Research and Innovation Needs

22-23 October 2018

IEA

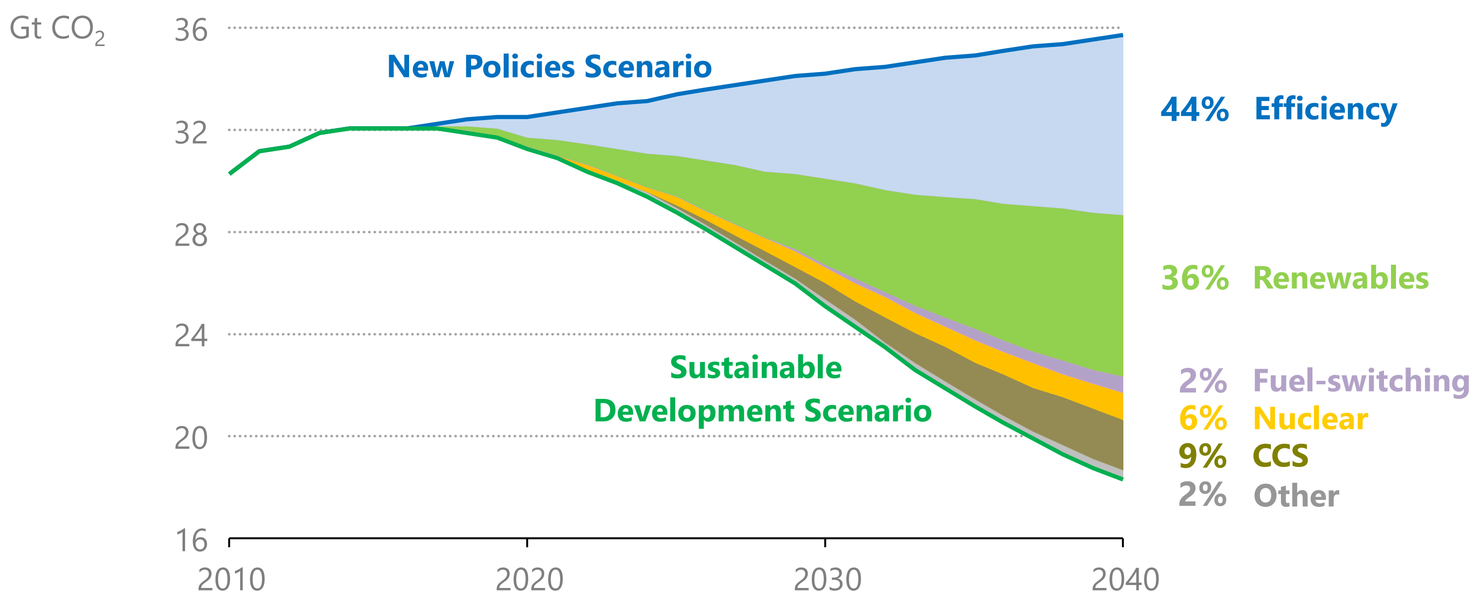
Where are we today?



After remaining flat for 3 years, global CO_2 emissions rose again in 2017, to an all-time high

Which future will we achieve?

Global energy-related CO_2 emissions



A wide variety of technologies are necessary to meet sustainability goals, notably energy efficiency, renewables, CCUS and nuclear

Are we on track?

Tracking Clean Energy Progress (TCEP)

For each technology TCEP provides

- **Status**
  - 🟢 **on track**
  - 🟡 **more efforts needed**
  - 🔴 **not on track**

- **Evolution of the energy source / technology under the SDS**

- **Recent trends (including investment)**

- **Innovation gaps (technologies) or policy recommendations (systems issues)**

Power

RES
- Solar PV
- Onshore wind
- Offshore wind 🔍
- Hydropower
- Bioenergy
- Geothermal
- Concentrating solar power
- Ocean

Other
- Nuclear power
- Natural gas-fired power
- Coal-fired power
- CCS in power

Energy integ-ration
- Energy storage 🔍
- Smart grids
- Demand response
- Digitalisation
- Hydrogen
- Renewable heat

Buildings
- Lighting
- Data centres and networks
- Cooling 🔍
- Appliances & equipment
- Building codes
- Heating

Transport
- Electric vehicles
- Intl. shipping 🔍
- Fuel economy
- Trucks
- Rail
- Transport biofuels
- Aviation

Industry
- Cement
- Chemicals 🔍
- Steel
- Aluminum
- Pulp and paper
- CCUS in industry

🔍 Technologies that deserve an especially close look, including those that are the focus of more detailed analysis at the IEA.

- **Innovation Tracking Framework (technologies)**

  - Key long-term "**technology innovation gaps"** across the energy mix that need to be filled in order to meet long-term clean energy transition goals

  - **100 innovation gaps** across 38 clean energy technologies

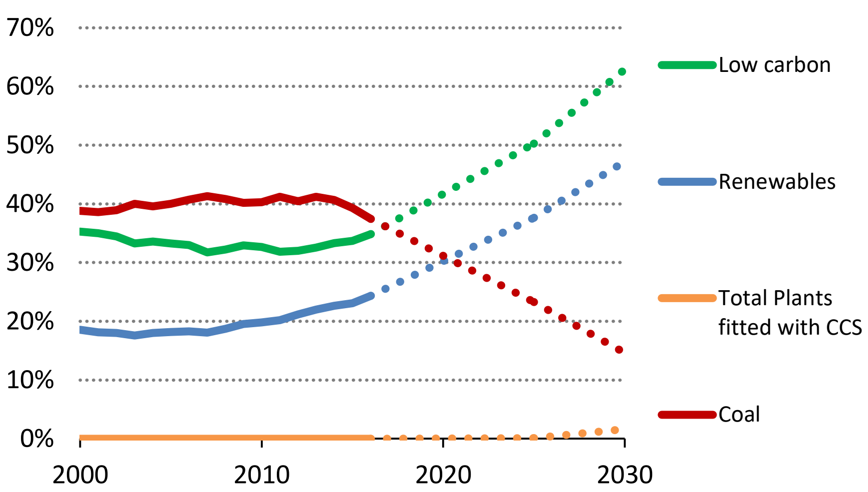
  - **Highlights opportunities for public and private R&D investment and other efforts**
    - Why is this RD&D challenge (gap) critical?
    - Key RD&D focus areas over next 5 years
    - Key initiatives (best practice)

- **Policy recommendations (systems issues)**

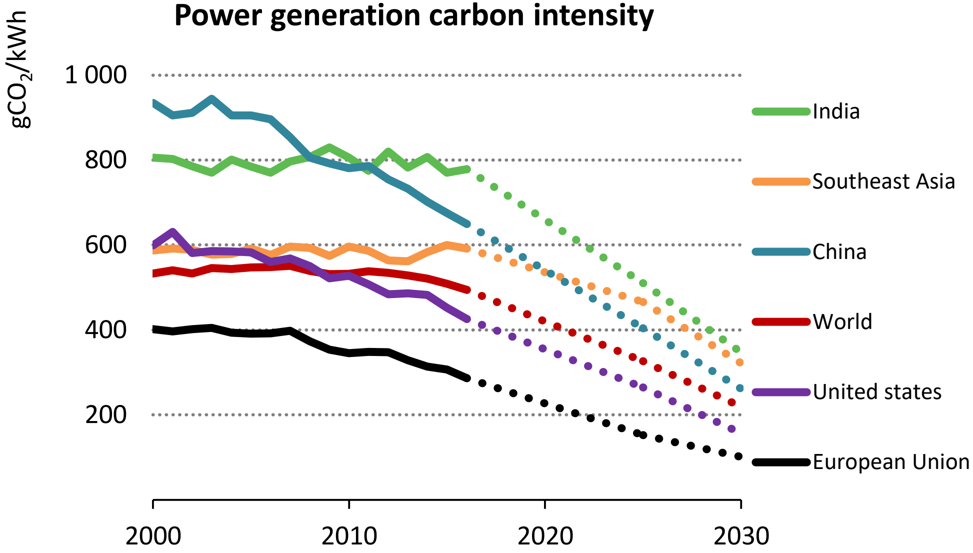
In 2017, renewable for power generation grew 6%

- The highest rate among all energy sources
- Net annual capacity additions for all renewables must increase steadily over 2017-30 to meet SDS goals
- Carbon intensity needs to more than halve by 2030

Share of new capacity additions



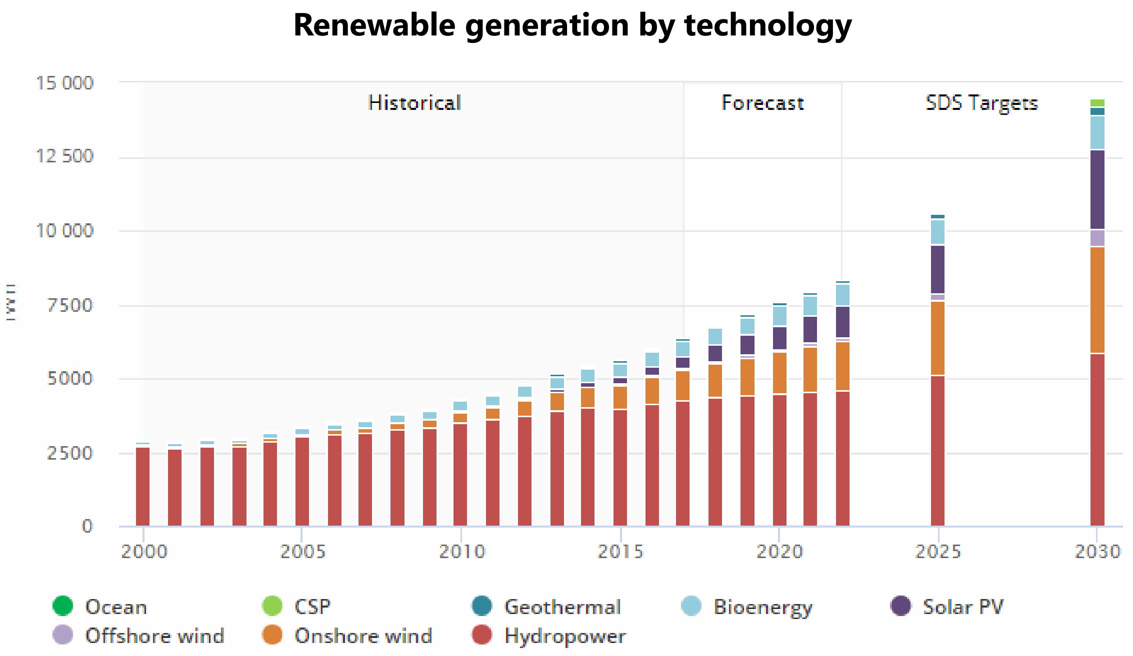
Power generation carbon intensity



Renewables for power generation – more efforts needed

In 2017 RE represented 25% share of total generation

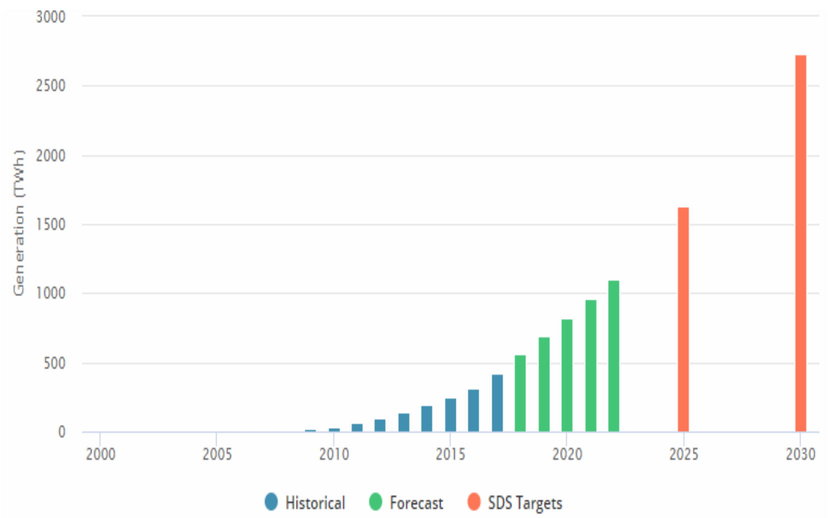
- To meet SDS targets it must reach 47% by 2030



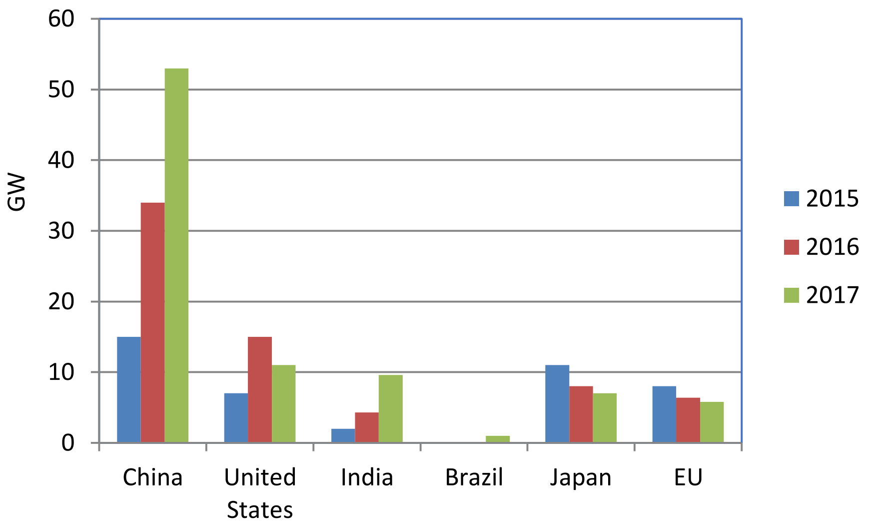
Solar photovoltaics (PV) – only RE source 'on track'

- Record 34% growth in 2017
- The only renewable source to be well on track to meet SDS target of 17% annual growth 2017-2030

PV historical generation and forecasts



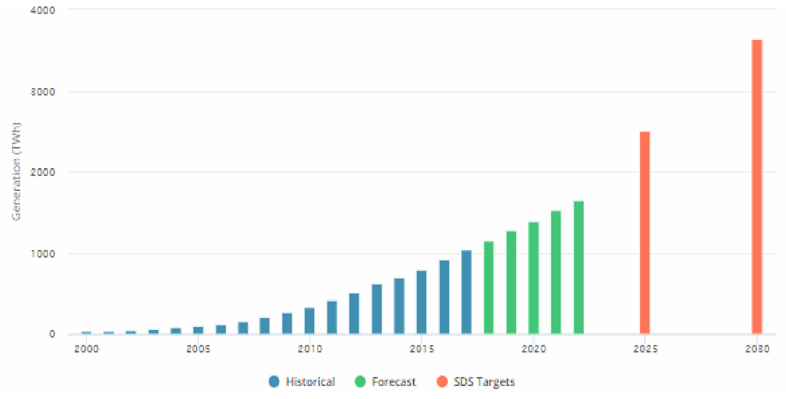
PV deployment



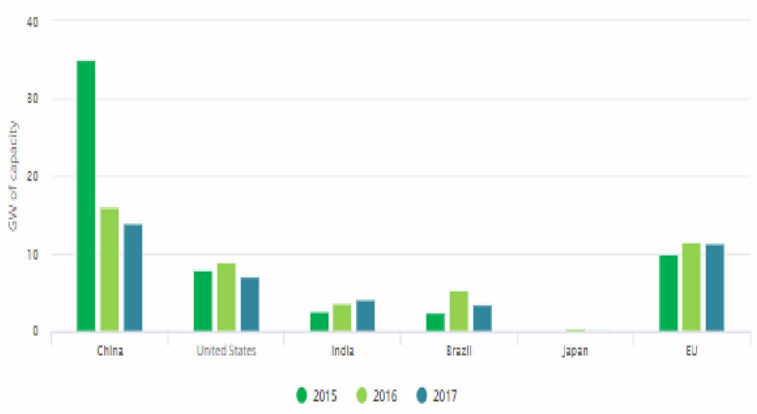
Onshore wind - Lost 'on track' status

- Capacity additions need to grow by 5% each year, to 90 GW in 2030 from 44 GW in 2017
- Capacity additions declined by 10% in 2017 for second consecutive year

Wind historical generation and forecasts



Wind annual capacity additions 2015-2017



Onshore wind, cont'd

- **China:** Curtailment problems with no sign of a significant rebound in the short term
- **United States:** Phase-out of production tax credits and the corporate tax reduction may limit economic attractiveness and financing in the medium term and signal challenging market conditions
- **Brazil:** Macroeconomic and financial challenges
- **India:** Operational and grid integration problems are preventing onshore wind from operating at full capacity; new auction system is expected to promote strong capacity growth
- **Europe:** Policy uncertainty remains over the post-2020 governance of wider 2030 targets

Onshore wind, cont'd

- **Innovation gaps**

  Innovation in installation processes

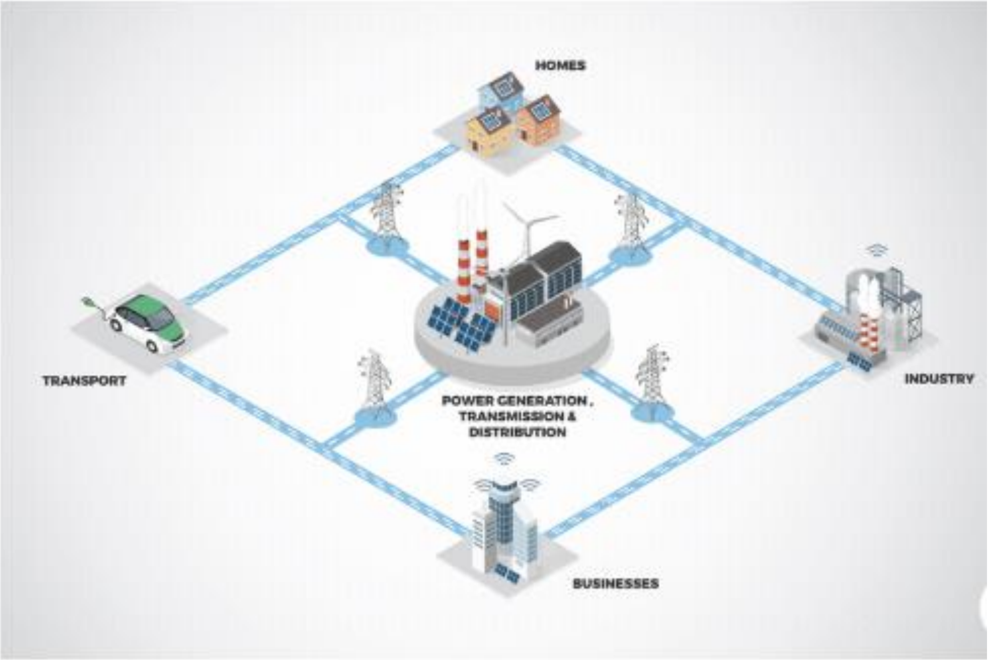
  Next-generation turbine and drivetrain technology

  Improve resource assessment and spatial planning

  Reduce plant-level integration costs and increasing overall efficiency

Energy integration – more efforts needed

- Energy storage
- Smart grids
- Demand response
- Digitalization
- Hydrogen

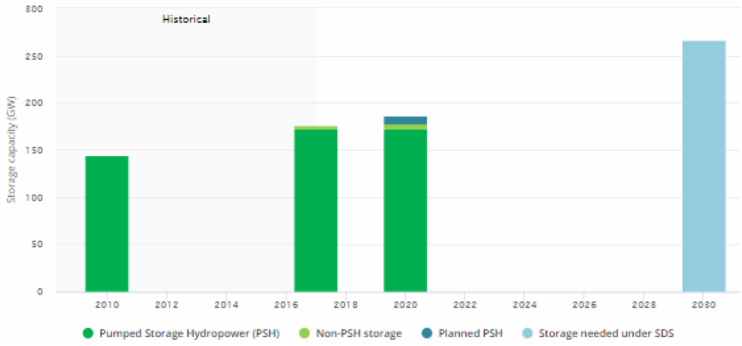


Meeting the SDS goals will require scaling up of technologies that help different parts of the energy system work together.

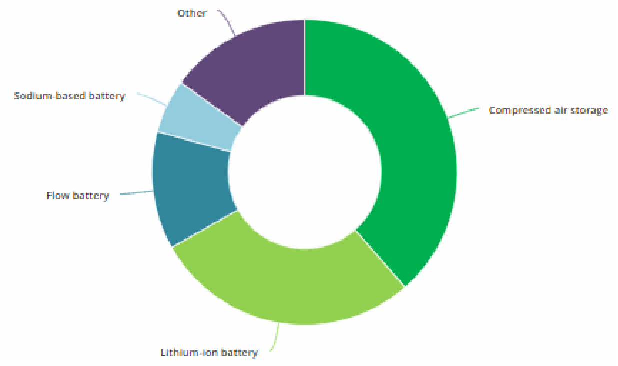
Energy storage

- **Prices fell 22% but utility-scale deployment remained flat**
  - 2017 additional utility-scale deployments for all storage technologies (excl. pumped hydro) remained flat at around 620 MWh, insufficient to meet SDS target of additional 80 GW of additional capacity by 2030
  - Storage production reached 15 300 MWh as of 2017
  - Additional policy support and ensuring a wider range of storage technologies become cost-effective are crucial

Energy storage capacity – historical, planned and SDS targets



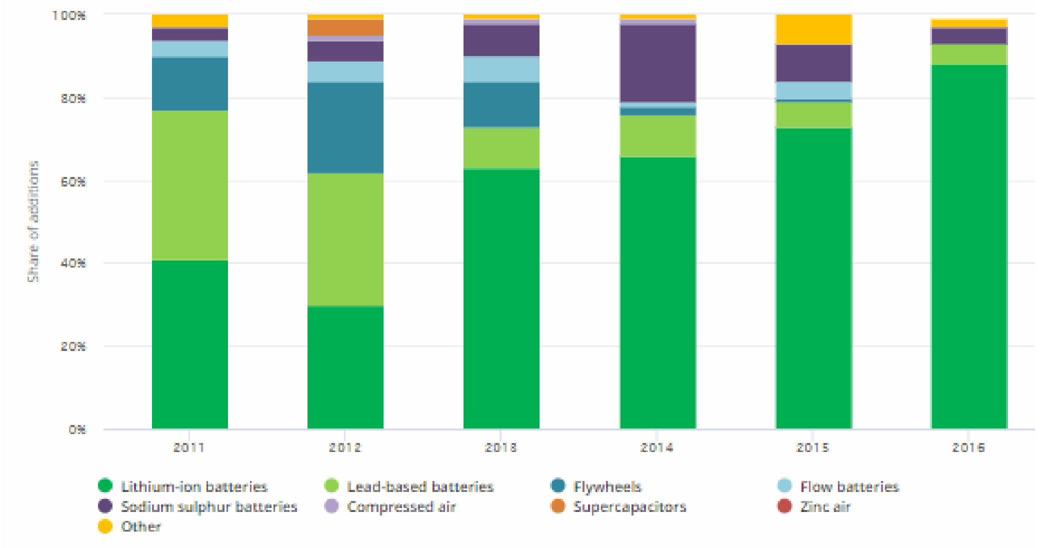
Total available storage volume (excl. pumped hydro)



Energy storage, cont'd

- The increasing dominance of lithium-ion continues
- Reserves of critical materials lithium and cobalt are expected to meet demand until 2040

Share of annual battery storage additions, by technology



Energy storage, cont'd

- **Innovation gaps**

  Reducing metal demand

  Advanced chemistries to reach beyond 80 USD/kWh

  Advanced battery re-use and recycling

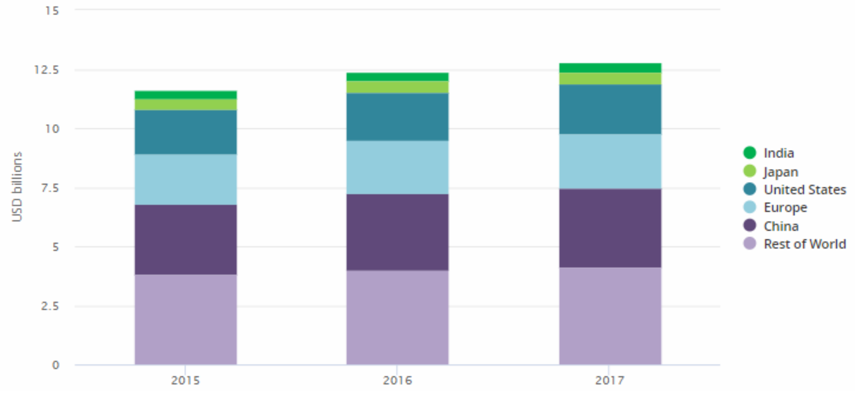
  Long duration storage

Energy integration – more efforts needed

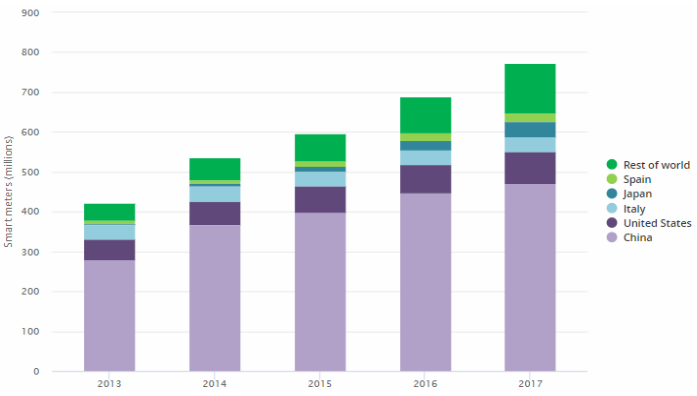
Smart grids (SG)

- **Investment in SG technologies +12% between 2014 and 2016 overall**
- **Investment in SG distribution network only +3% in 2017**
- **Progress in smart meter deployment is uneven across countries**
  - Further regulatory change and new business models needed to enable critical integration role in clean energy transition

Investment in smart grid technology by country



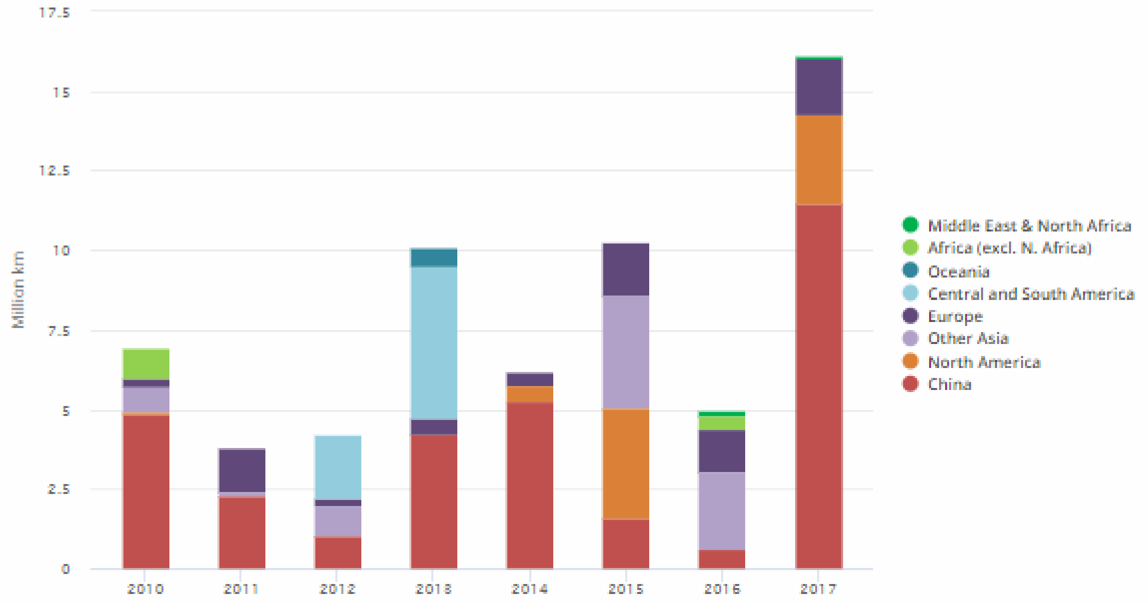
Global cumulative smart meter installations



Smart grids, cont'd

- **China accounted for over two-thirds of all line-kilometres commissioned globally**

Deployment of national and regional high-voltage transmission and interconnection lines



Demand response (DR)

- **Can significantly shift and shape demand to match availability of RE generation**
  - 15% of total electricity demand
  - Europe and the United States currently leading growth in this relatively new approach

Impact of demand response on a daily load curve

Source IEA (2017), World Energy Outlook .

Current status of demand-side response in selected markets

	Wholesale	Ancillary Services	Capacity*	Aggregator	ToU**			RTP***		
					I	C	R	I	C	R
France	● green	● yellow	● green	● green	● green	● green	● green	● green	● yellow	● yellow
Germany	● red	● yellow	● red	● red	● green	● yellow	● yellow	● red	● red	● red
UK	● green	● green	● yellow	● yellow	● green	● green	● green	● red	● red	● red
ERCOT	● green	● green	● green	● green	● green	● green	● green	● green	● green	● green
CAISO	● green	● green	● green	● green	● green	● green	● green	● red	● green	● green
PJM	● red	● green	● green	● green	● green	● green	● green	● red	● red	● green
NYISO	● green	● green	● green	● green	● green	● green	● green	● red	● red	● red
China	● red	● red	● red	● red	● green	● green	● yellow	● red	● red	● red
India	● yellow	● red	● red	● red	● red	● red	● red	● red	● red	● red

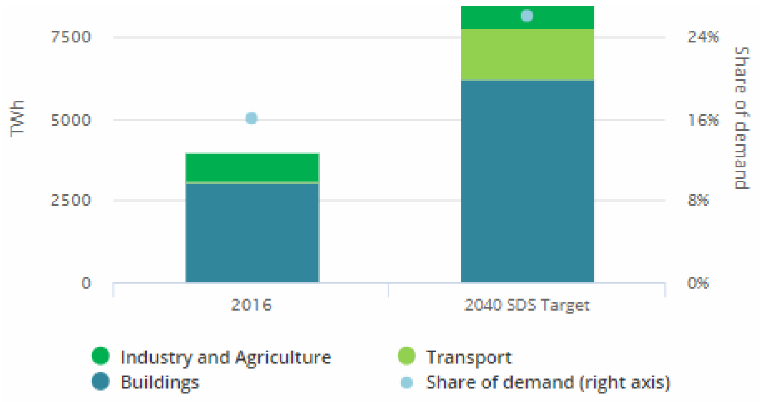
● (green) Fully implemented ● (yellow) Partially implemented or only in some States ● (red) Not implemented

Source World Energy Outlook 2017.

Demand response, cont'd

- **Current global theoretical DR potential is nearly 4 000 TWh per year**
  - Under the SDS, this annual potential rises to over 9 000 TWh by 2040
  - By 2040 almost 1 billion households and 11 billion appliances could participate in DR programmes
  - Policies to facilitate DR are emerging in a number of regions, but only a small share of the full potential is being used today

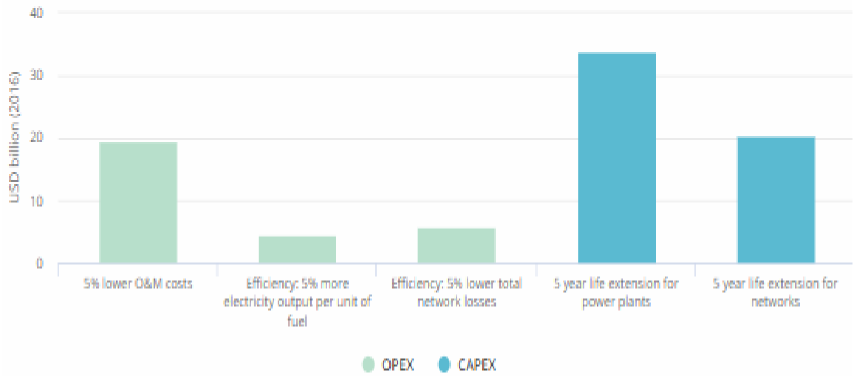
Global demand response potential



Digitalization

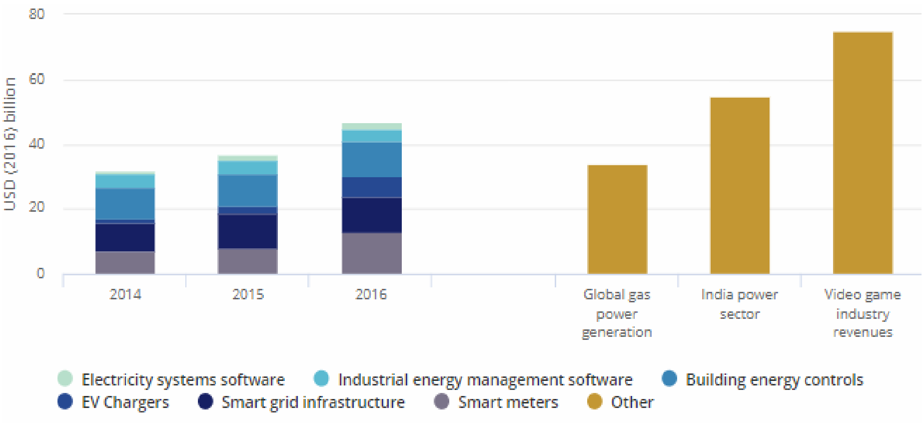
- **Energy sector increasingly digitalized**
  - Spurred by falling costs for sensors and data storage, rapid progress in advanced analytics
  - Faster and cheaper data transmission
  - Huge potential remains to further leverage digital tools (e.g. AI, additive manufacturing, digital twins)

Cost savings from enhanced digitalization in power plants and electricity networks



Sources IEA (2017), Digitalization and Energy.

Investments in digital electricity infrastructure and software



Sources IEA analysis based on *Markets and Markets (2016), Internet of Things in Utility Market; BNEF (2016),* and *Digital Energy Market Outlook.*

Digitalization, cont'd

- Digitalization can facilitate positive change - if policy makers make efforts to understand, channel and harness the impacts and minimise risks
- Digitalization and analytics can reduce power system costs by:
  - Reducing operations and maintenance costs;
  - Improving power plant and network efficiency;
  - Reducing unplanned outages and downtime; and
  - Extending the operational lifetime of assets.

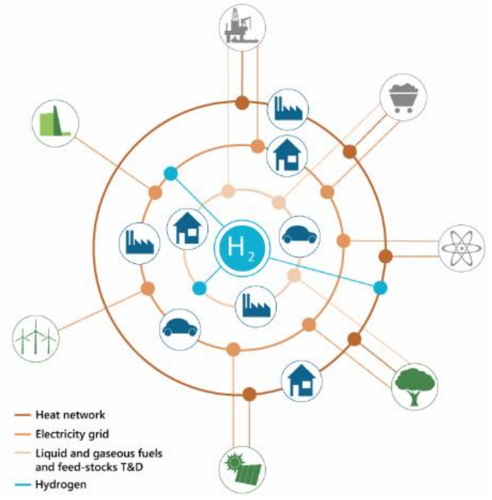
Hydrogen and fuel cells

- An increasing focus on hydrogen in a variety of countries and companies, with the IEA also strengthening our own analytical capability – major report in 2019
- In Europe, there is growing interest for renewable hydrogen via electrolysis fuelled by wind and solar to produce methane or ammonia.

- **Innovation gaps**

  Next-generation fuel cells (stationary)

  Cost-competitive hydrogen turbines

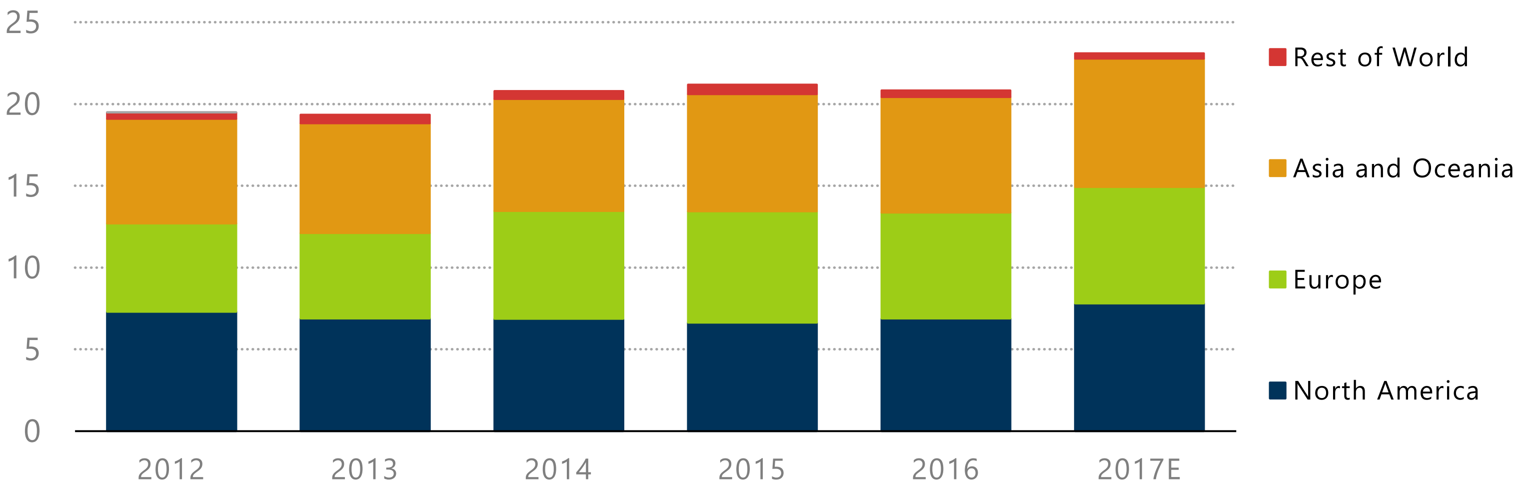


Clean energy R&D allocations are finally on the rise…

Public funding for R&D

- **Investment in clean energy R&D grew by 13% in 2017 to an all-time high**
  - More is needed
  - Mission Innovation is having an impact – members' commitment will ensure annual growth

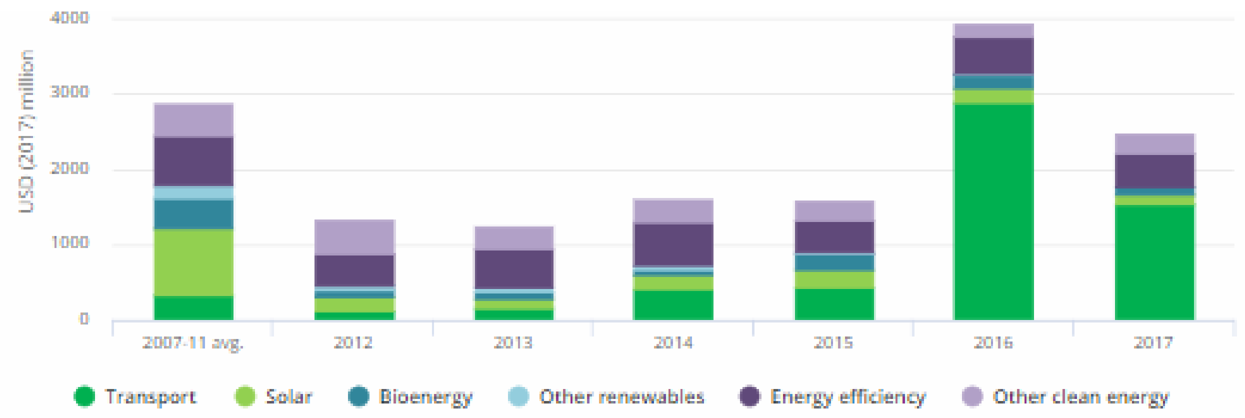
Total public spending on clean energy technology RD&D (in billion USD)



Private sector funding for R&D

- **Investments grew to USD 58 billion in 2017**
  - Five years of 5% annual growth
  - Yet clean energy only 40% of total reported corporate energy R&D

Venture capital deals in clean energy technology areas



Source: IEA (2017), *Early-stage venture capital for energy Financing models, trends and policy implications.*

Key messages

- **Energy technologies are not on track to achieve a sustainable future**
  - **4 on track**
  - **23 more efforts needed**
  - **11 not on track**
- **Accelerated technology innovation can spur economic growth and improve energy security and sustainability**
- **Government policy, market design and R&D will be instrumental to spur innovation, deployment and private investment**

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