The Global Energy Transformation

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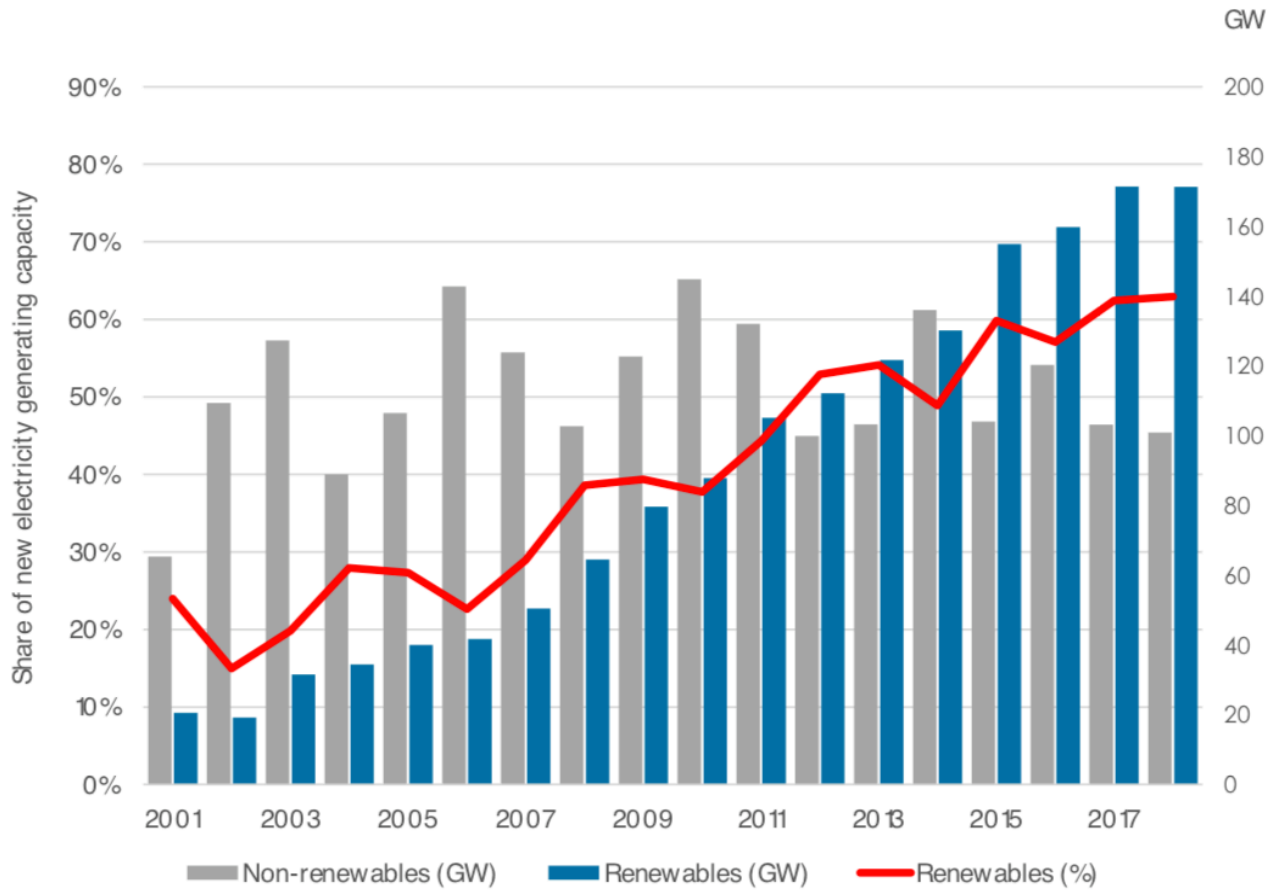
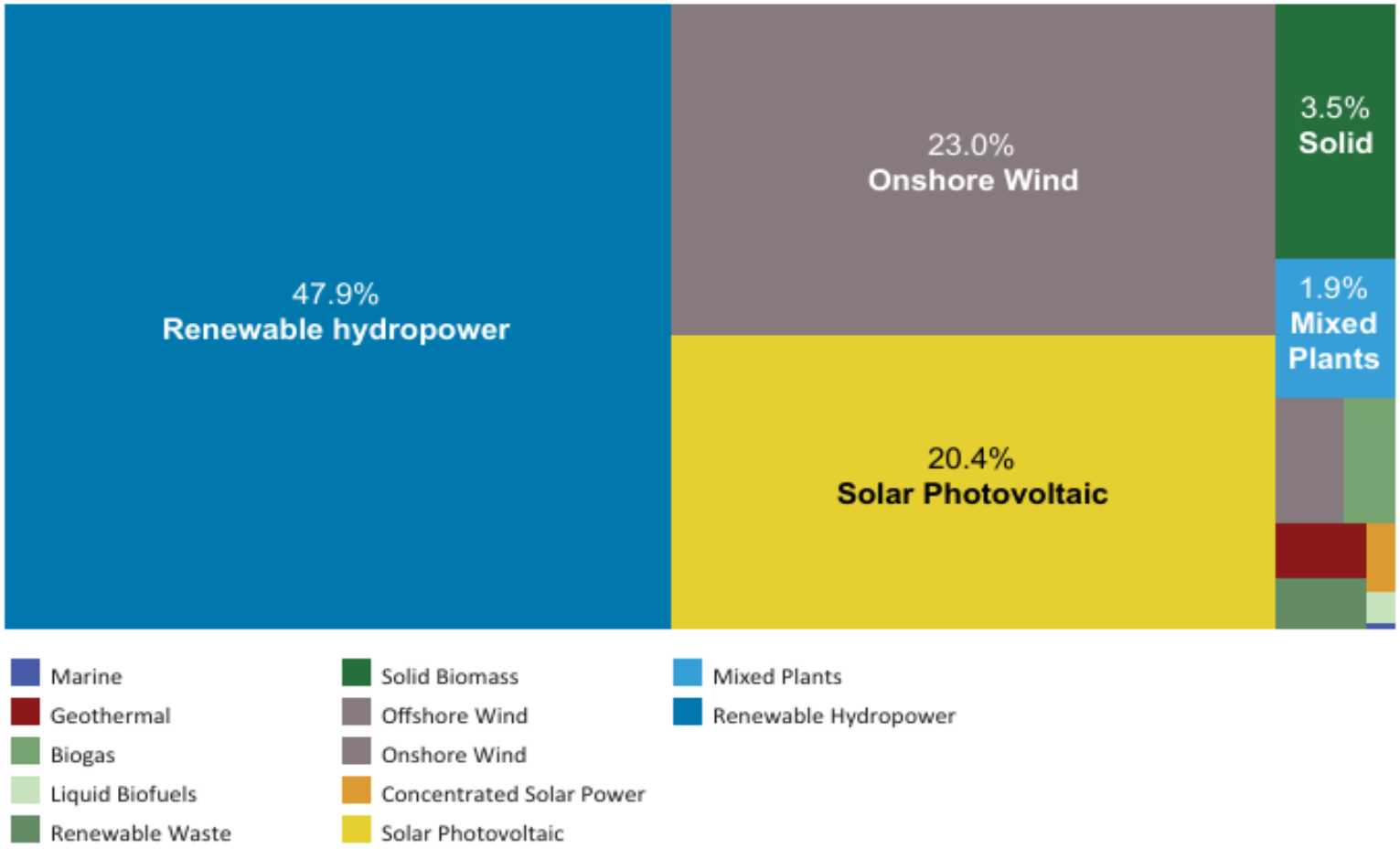
Electricity Sector: Renewables are leading the global power capacity additions



Global electricity capacity additions and share of renewables, 2001 – 2018 (source: IRENA, 2019)

- Renewables (incl. hydro) make up around 26.3% of global electricity generation (source: UNEP)

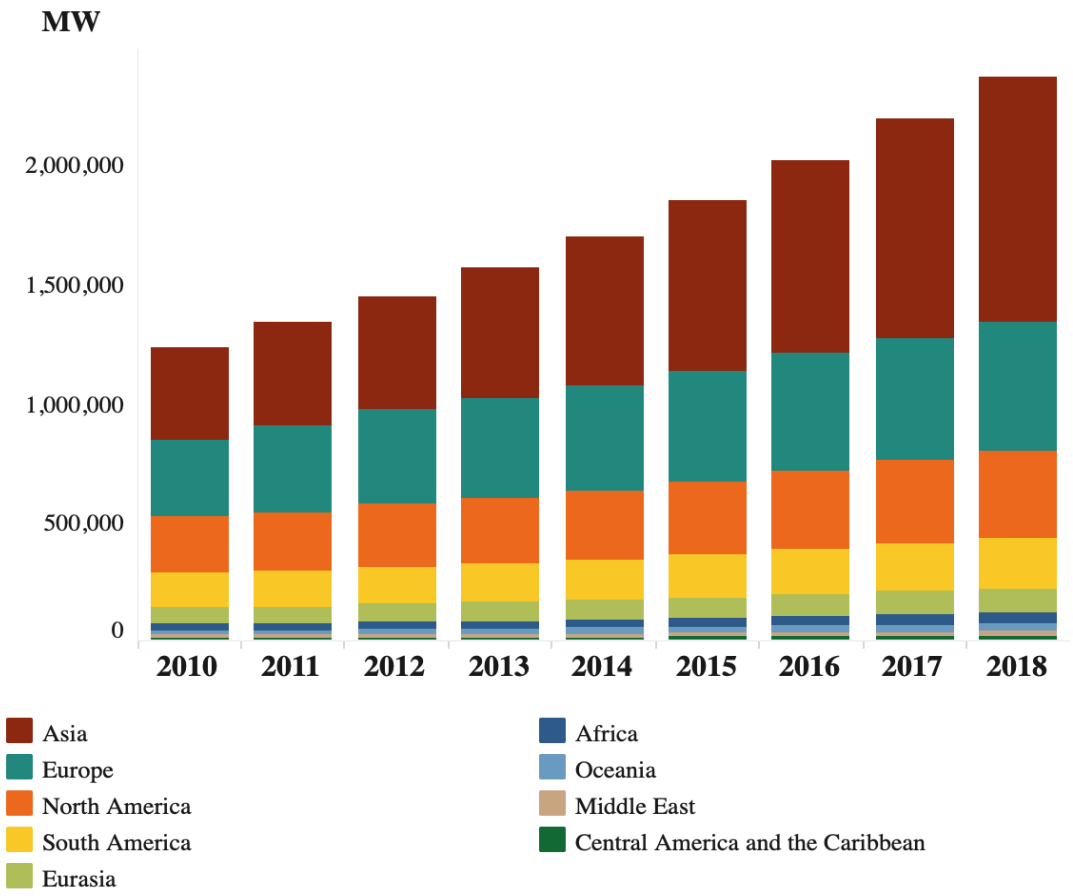
Hydropower is leading, solar and wind are catching up



Breakdown of total renewable energy generation capacity, 2018 (source: IRENA, 2019)

- Globally, total renewable energy generation capacity reached 2,351 GW in 2018

Fastest renewables capacity growth happens in Asia and Europe

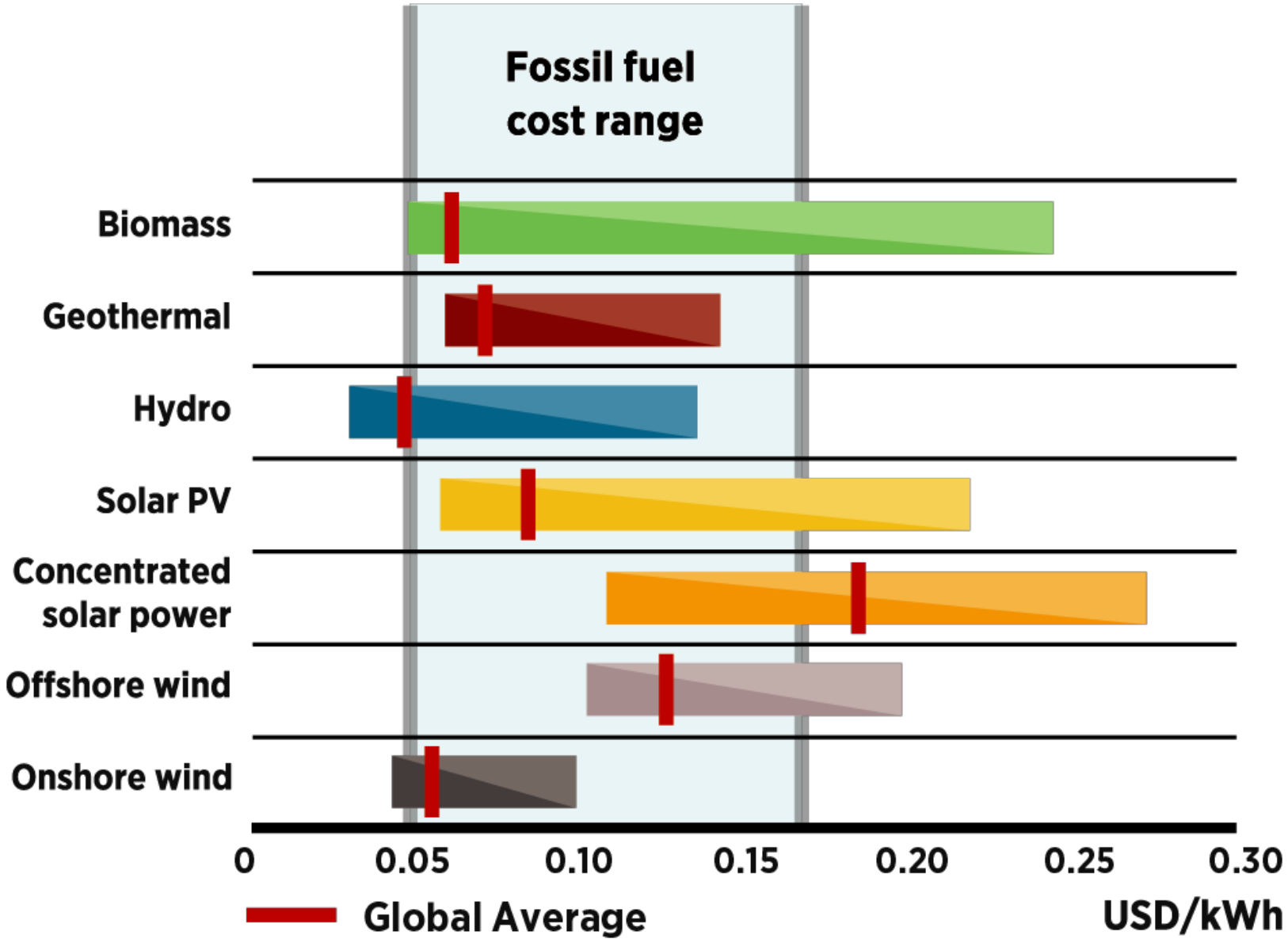


Source: IRENA Statistics, 2019

Case study: Morocco

- In 2018, 711 MW solar capacity and 1.22 GW wind capacity (35% renewables share in total)
- National goals for generating 42% of its electricity from renewables by 2020, and 52% by 2030
- Plan: 2,000 MW wind and 2,000 MW solar capacity by 2020 (adding 1.5GW renewable capacity annually)
- E.g. 580-MW Noor Ouarzazate PV-CSP solar complex

The strong business case of renewables continues to solidify



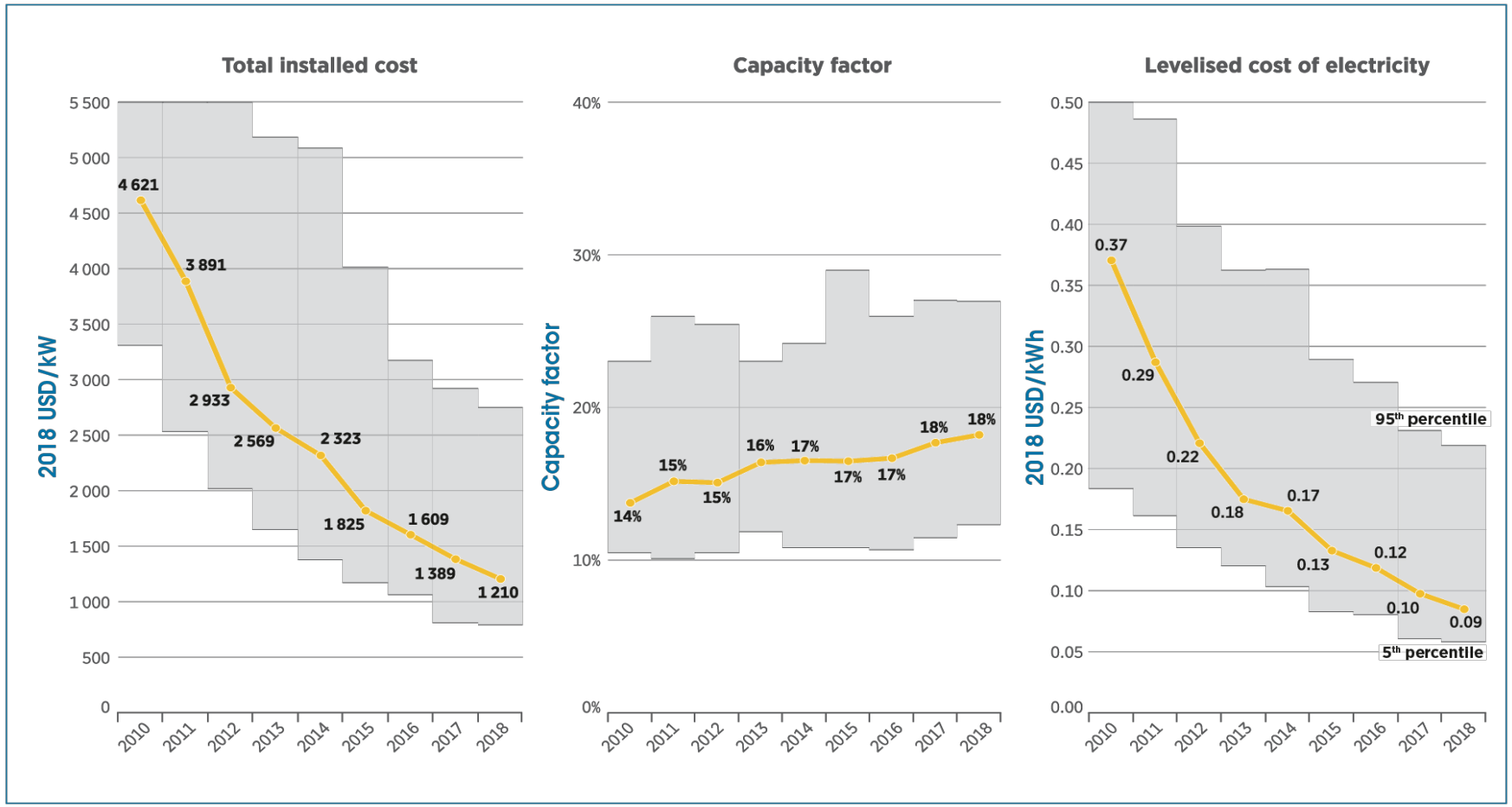
Cost of Electricity

Global LCOE from utility-scale renewable power generation technologies (2010-2018)

- **Bioenergy** 0.062 USD/kWh
- **Geothermal** 0.072 USD/kWh
- **Hydro** 0.047 USD/kWh
- **Solar PV** 0.085 USD/kWh
- **CSP** 0.185 USD/kWh
- **Onshore wind** 0.056 USD/kWh

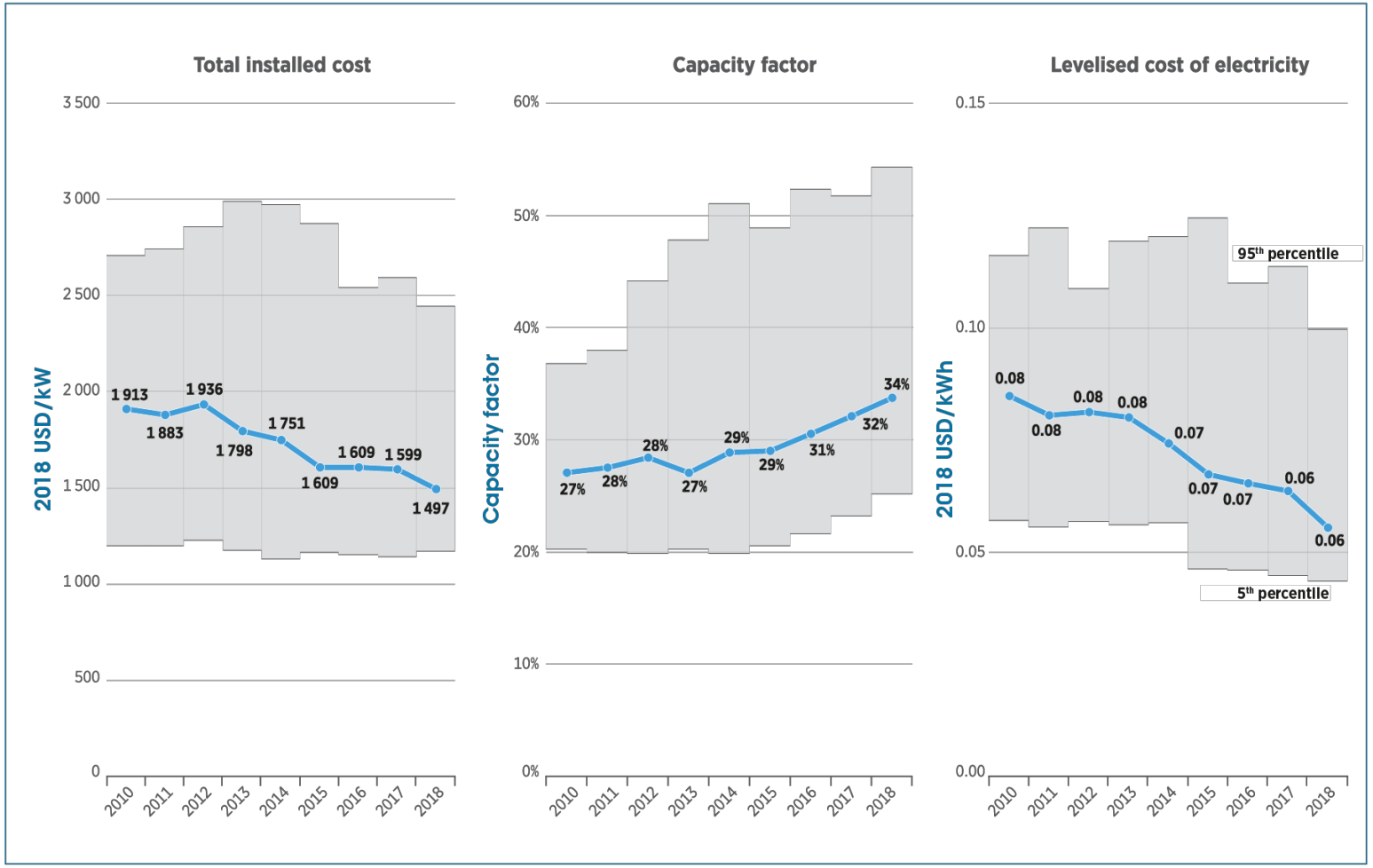
Global LCOE of utility-scale renewable power generation technologies, 2010–2018 (Source: IRENA Cost Database, 2019)

Solar PV: technology cost and LCOE are continuously decreasing, while technology performance improves



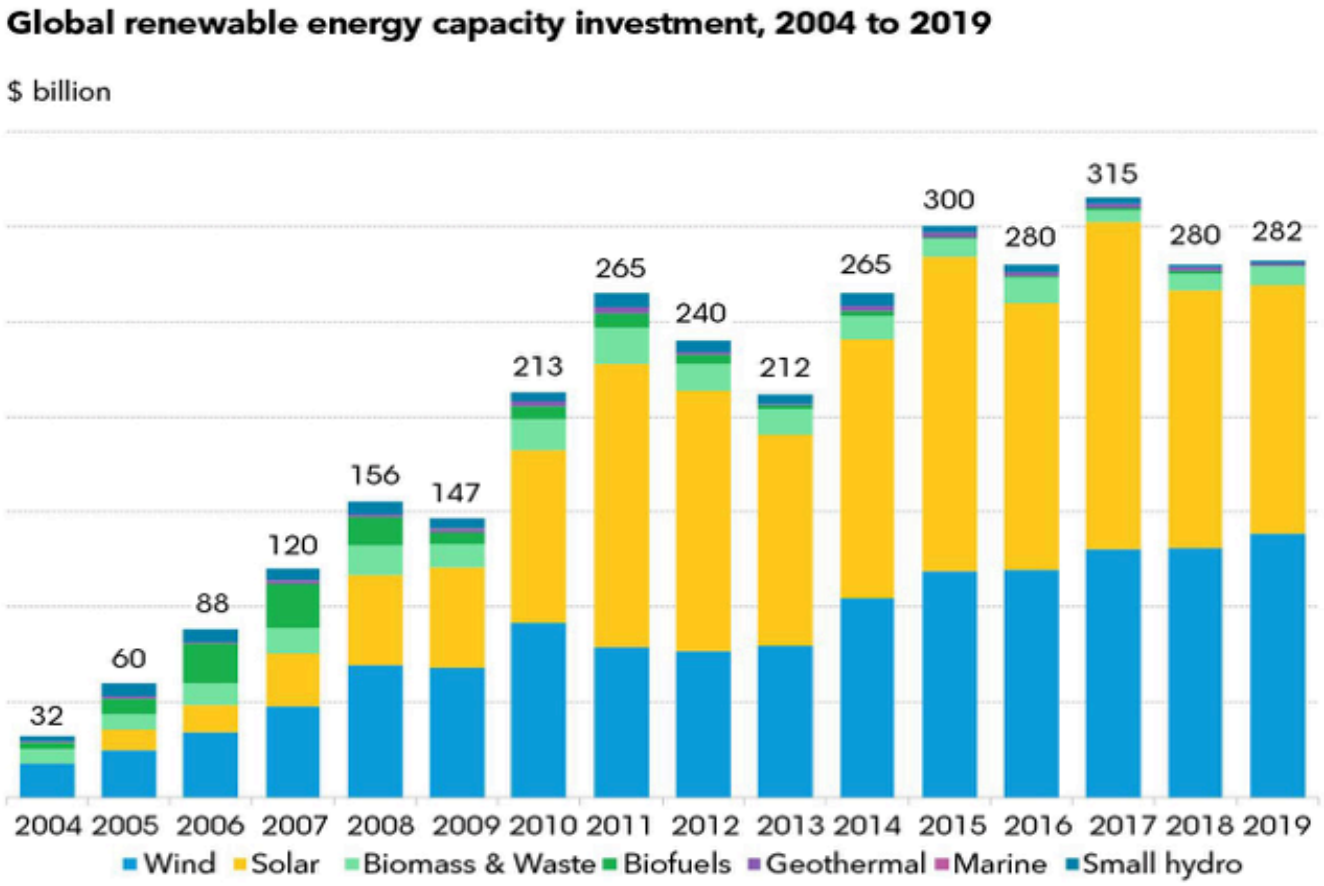
Global utility scale solar PV cost trends, 2010 – 2018 (Source: IRENA Renewable Cost Database, 2019)

Wind: same story as solar PV (while to a slightly lesser degree)



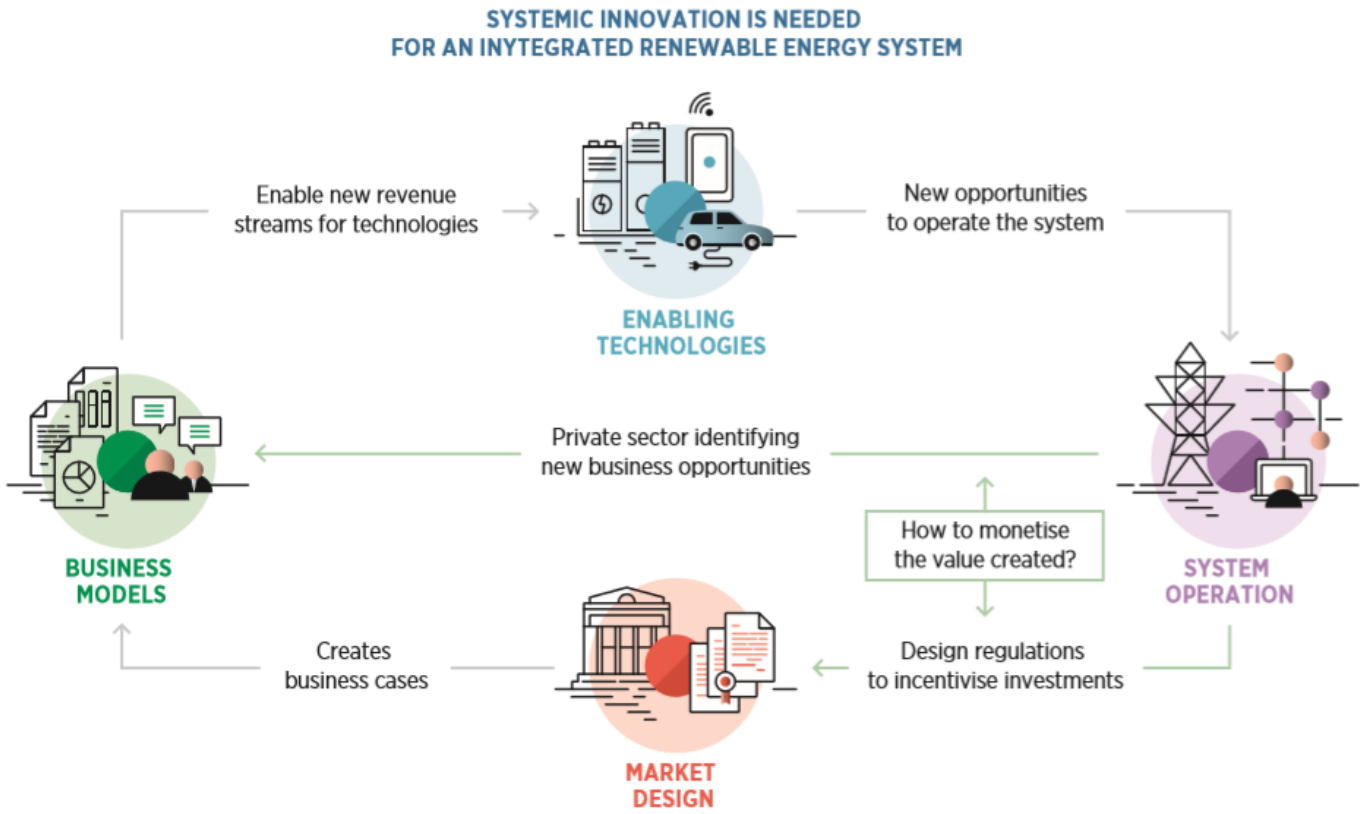
Global utility scale wind cost trends, 2010 – 2018 (Source: IRENA Renewable Cost Database, 2019)

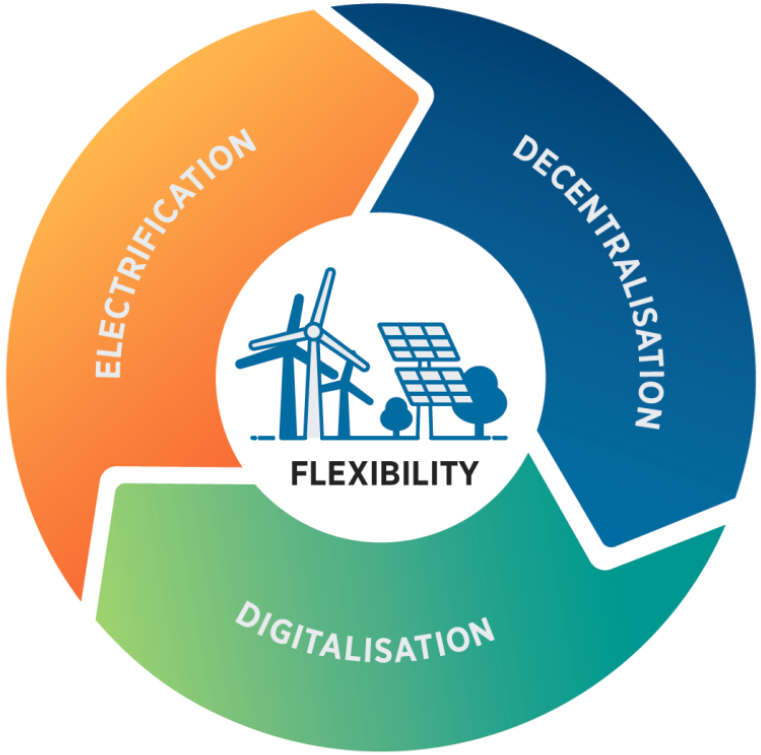
Strong global renewable energy capacity investment



Source: BloombergNEF. Note: The figures represent utility-scale asset finance of new wind, solar, biomass and waste-to-energy, geothermal, small hydro and marine power projects, plus small-scale solar systems. Prior years' totals have been revised in this round, to reflect new information. Totals are rounded to nearest billion dollars

Innovation is the other key driver of the power sector transformation

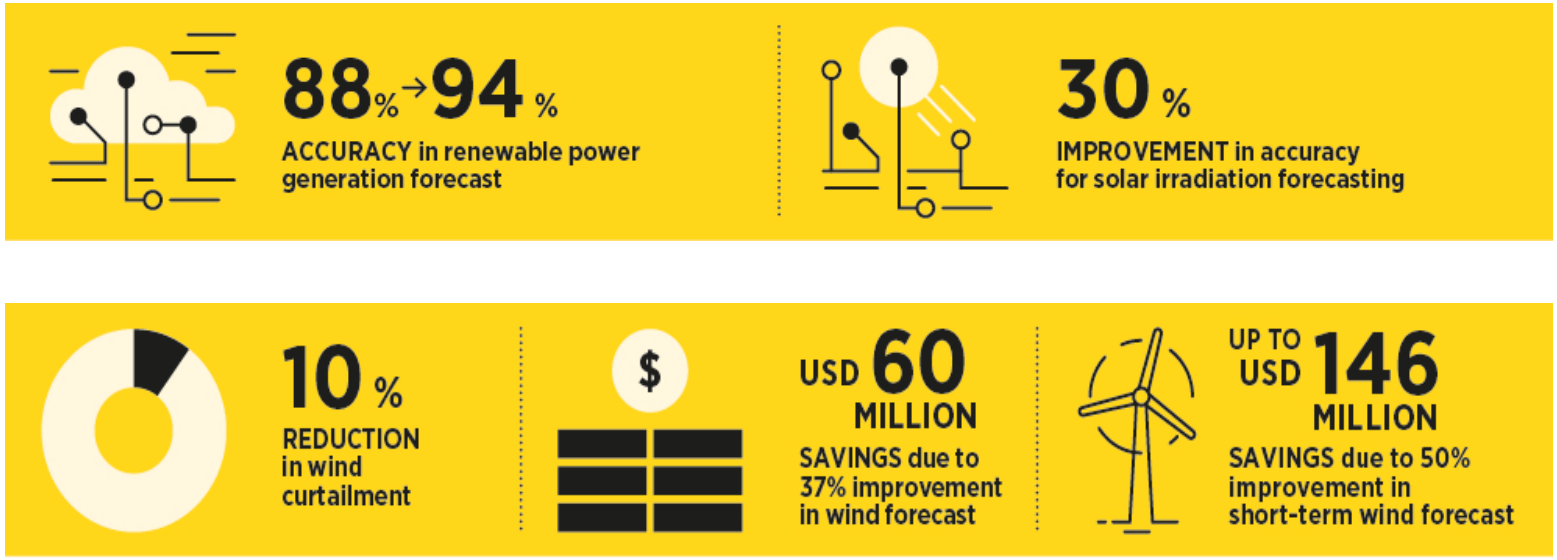




Source of graphics: IRENA Landscape report, 2019

Spotlight: Digitalisation as driver of operational flexibility

- Improved & early forecasting enables smart response (e.g. reduced curtailment)
- Artificial Intelligence: learning algorithms (day-ahead forecasts with 94% accuracy)



Source of graphics: IRENA Landscape report, 2019

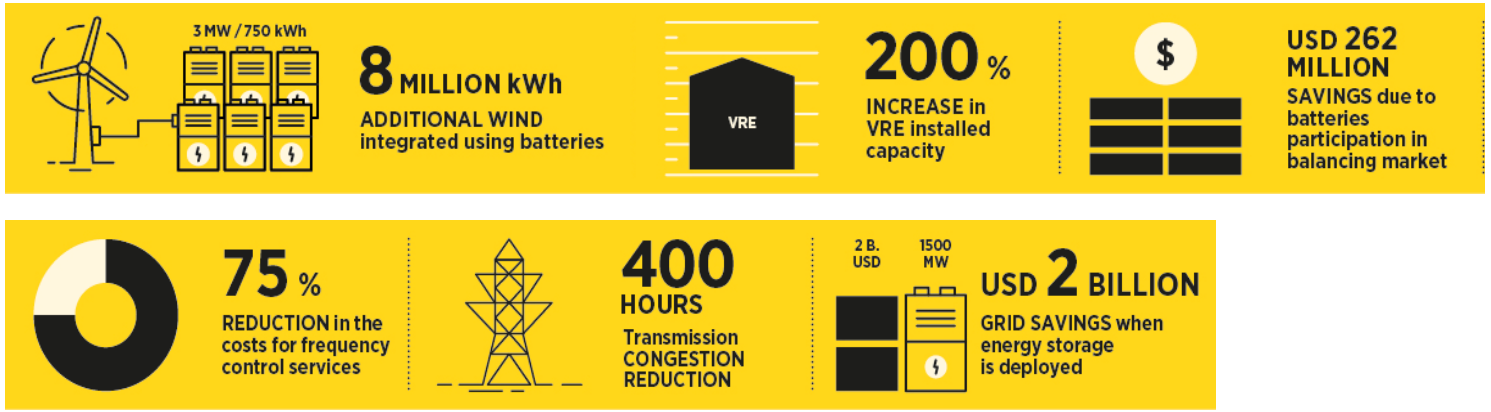
Case studies: Germany and China

- **Germany: EWeLiNE** (new forecast product, focusing on grid stability)
- **China: Envision** (cloud-based platform, that helps manage over 100GW energy assets globally, connecting over 50 million sensors and smart devices)

Source: Envision website

Systems are increasingly moving to flexible solutions: focus on electricity storage

- In 2017, around **4,700 GWh** of electricity storage existed, **96%** of which from pumped hydro.
- Trend: IRENA expects up to **11,900 – 15,300** GWh of electricity storage by 2030 (only 51% of which pumped hydro)
- Battery storage has witnessed rapid cost reductions (due to wider deployment and commercialization).
- Battery storage in stationary applications is set to grow from only **2 GW** in 2017 to around **175 GW** in 2030.
- Electric cars offer an additional source of flexibility (i.e. could provide about **8,000 GWh** of battery storage by 2030)



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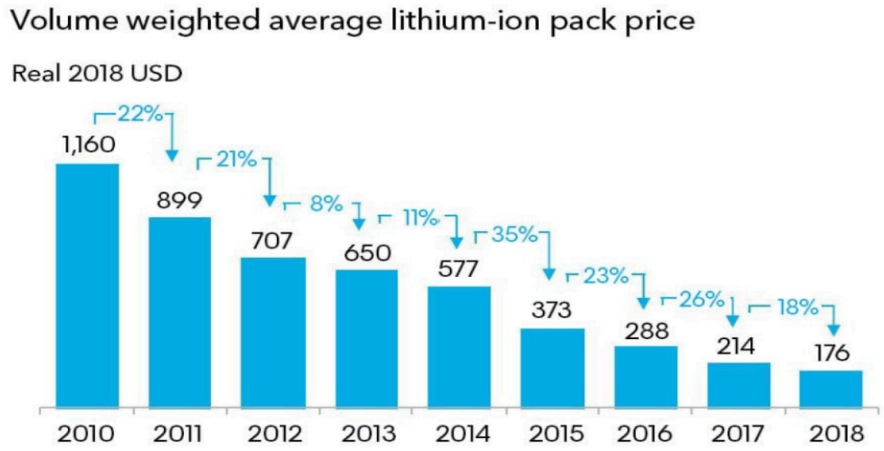
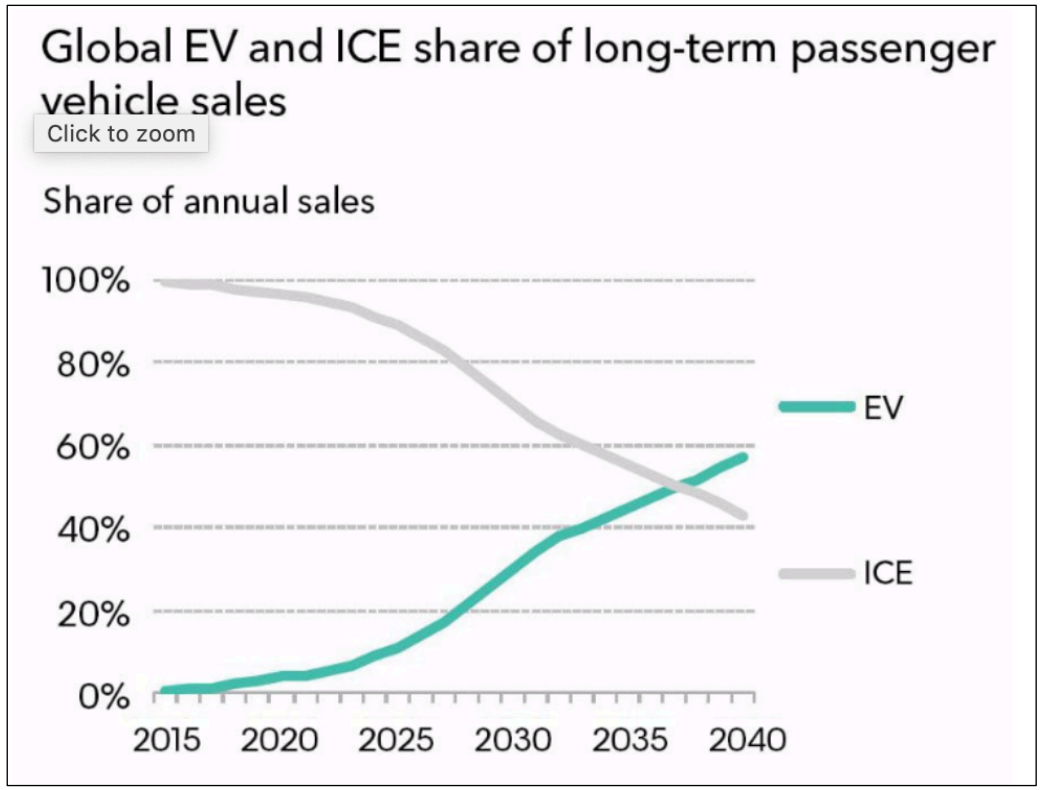


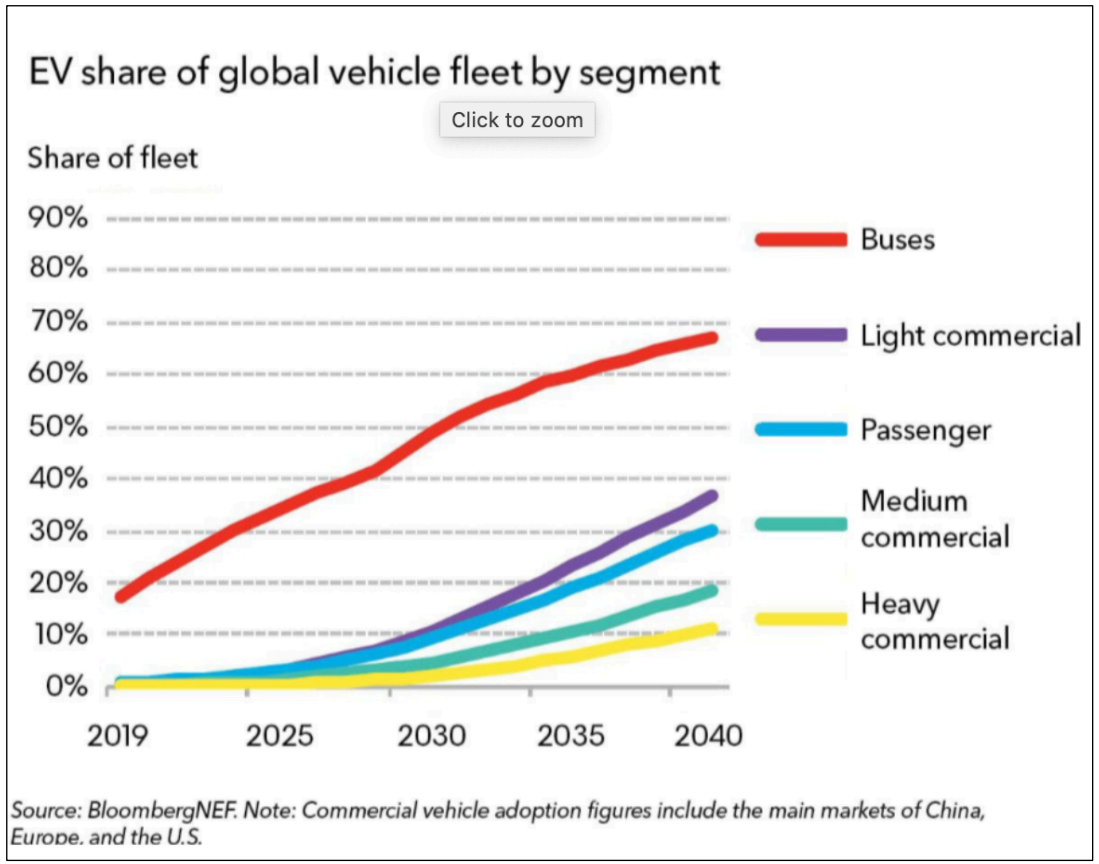
Source: BNEF, 2019

Transportation Sector: electric cars are spreading in global markets

- **Passenger cars**: By June 2018, already **4 million** passenger EVs were on the road worldwide
- Annual passenger EV sales to rise to **10 million** in 2025, **28 million** in 2030 and **56 million** by 2040 (Source: BNEF)
- By 2040, **57%** of all passenger vehicle sales, and over **30%** of the global passenger vehicle fleet, will be electric



Source: BNEF, 2019

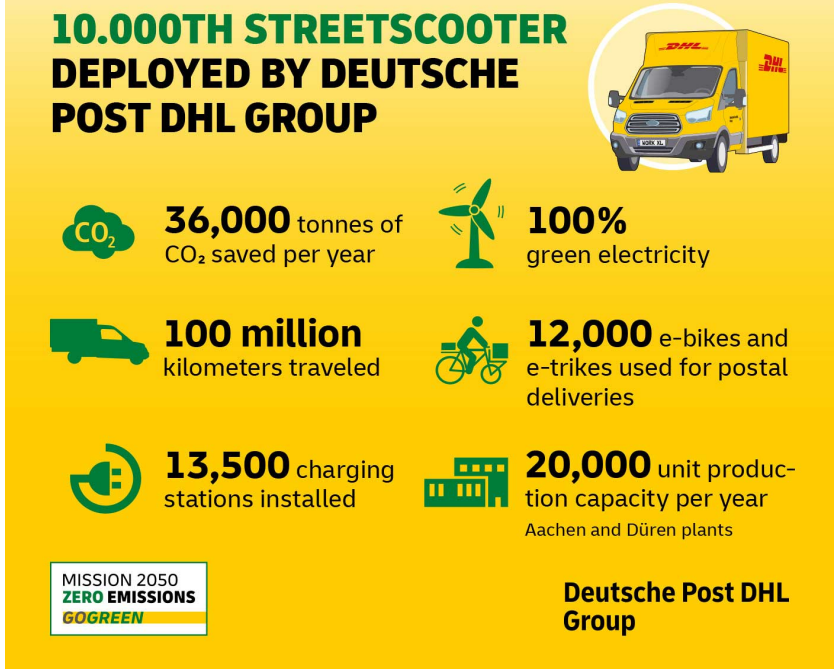


Electrification is also spreading in other segments of road transportation

- **Electric buses**: Overall, more than 400,000 electric buses are on the road
- **Ride hailing**: Ola (India) raised $250 million for “electric mass transport projects” (build charging infrastructure, bring electric vehicles on to its app)
- **Small trucks**: The cost/kWh capacity of battery packs for trucks fell from $500 in 2013 to $200 in 2019. Uptake is set to accelerate in 2020s (Source: BNEF)
  - Examples: Tesla Semi; Ford invested $500 million in an electric truck

Case study: **DHL**

- In 2014, DHL acquired StreetScooter to electrify its own fleet
- This enabled it to vastly cut costs and meet emissions regulations
- In 2020, DHL will debut a fully electric delivery van in the US
- Other logistics companies follow (UPS, FedEx, Amazon)



Various countries have made commitments to phasing out fossil-fuel cars

Country commitments for banning the sale of all (semi-)fossil fuel-powered cars

- **UK**: phase out new petrol, diesel and hybrid cars (ICE) by 2035 (likely already in 2032)
- **Japan** (# 3 global auto market) has comprehensive plans for a "hydrogen economy" by 2040
- **China:** eventually ban the sale of all fossil fuel-powered cars, researching a timeline

Spotlight electric mobility: China

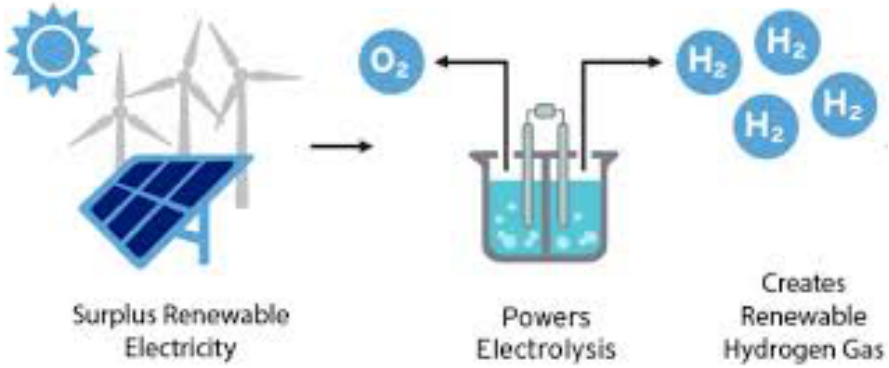
- Chinese e-vehicles account for 60% of global sales: 876,000 vehicles were produced in 2018
- China accounts for about 99% of the world's total electric bus fleet
- Shenzhen (population: 12.5 million people) runs a 100% electric bus fleet and 22,000 e-taxis
- China has the largest high-speed railway in the world (19,000 miles of track; all major cities)

Transportation: Hard-to-electrify segments

- **Large Trucks** (long-haul, heavy duty): electricity, natural gas and hydrogen fuel cells will play a role (BNEF, 2019)
- **Ships**: huge challenge is to power the more than 50,000 tankers, freighters and cargo carriers
    - Success: Fleet of fully operational e-powered ferries for light, short-range travel in Norway
- **Airplanes**: more than 200 start-ups are working on building some sort of electric aircraft
    - Short-distance air taxis, passenger drones and other small applications are ready
    - Firm magniX: first fully electric commercial aircraft flew for 15 minutes (Canada in 2019)
    - Ampaire (California): will build 19-seater electric hybrid plane for commercial distance by 2021

Spotlight: Hydrogen

- **Blue Hydrogen**: fossil fuel-based hydrogen production combined with carbon capture, utilisation and storage (CCUS)
- **Green Hydrogen**: hydrogen from renewables; electrolysis of water (H_2O) is a simple method of producing hydrogen
- <u>Key constraints</u> for low-carbon hydrogen production
  - Cost & availability of electrolysers
  - Infrastructure (distribution and storage)



- <u>Potential</u>:
  - Green hydrogen costs are projected to decrease by up to **60%** by 2030
  - Global economic potential for **19 exajoules (EJ)** of green hydrogen in TFEC by 2050 (IRENA, 2018)
- E.g. Germany has target of 20% hydrogen from renewables by 2030. For this, 3-5 GW of electrolysers are to be built.

Larry Fink (CEO of BlackRock): unlikely environmentalists

- “Climate change has become a defining factor in companies’ long-term prospects”
- “Awareness is rapidly changing, and I believe we are on the edge of a fundamental reshaping of finance.”
- “In the near future – and sooner than most anticipate – there will be a significant reallocation of capital.”
- “sustainability- and climate-integrated portfolios can provide better risk-adjusted returns to investors.”

Market valuations race to bottom and (some) industry responds

- **Market valuation of companies: examples**
  - **ExxonMobil**: market valuation fell by $210 billion since 2014 ($448 billion → $238 billion)
  - **Shell:** $190.6 billion (down from $315 billion in mid-2018)
  - **BP:** $115.6 billion (down from $157 billion in 2018)
  - **Schlumberger**: share prices have fallen from $117 in mid-2014 to $33 currently

→ Oil companies have a **collective $654 billion in debt**

→ **Fracking industry**: rising bankruptcy risk ($86 billion in debt maturities start to come due)

- **What is the industry response to the changing landscape?**
  - **Shell**: committed to reduce its emission intensity by 3% by 2021, and by around 50% by 2050
  - **Repsol** (Spanish): committed to being carbon-neutral by 2050 and wrote down many of its oil assets
  - **BP**: announced to be net zero by 2050, progressive – but: details of plan not yet clear
  - **ExxonMobil** and **Chevron:** staying the course, hoping to outlast their competitors

The Geopolitics of the Energy Transformation

- Project led by the Global Commission on the Geopolitics of Energy Transformation

- **Selected key insights:**
  - Shift in economic model from stocks (fossil fuels) to flows (renewable energy)
  - The new ‘resources’ are technology and innovation (not location-dependent)
  - AI and digitalisation play a major role (e.g. China: massive web of smart meters)
  - Vulnerability of oil exporters (peak demand; volatile markets)
  - Decentralisation and democratisation of energy systems (e.g. prosumers)
  - Value chains will by heavily disrupted (e.g. automobile sector)

Source: IRENA, 2019

Thank You

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