About IRENA

Established in 2011.

161 Members; 22 States in accession.

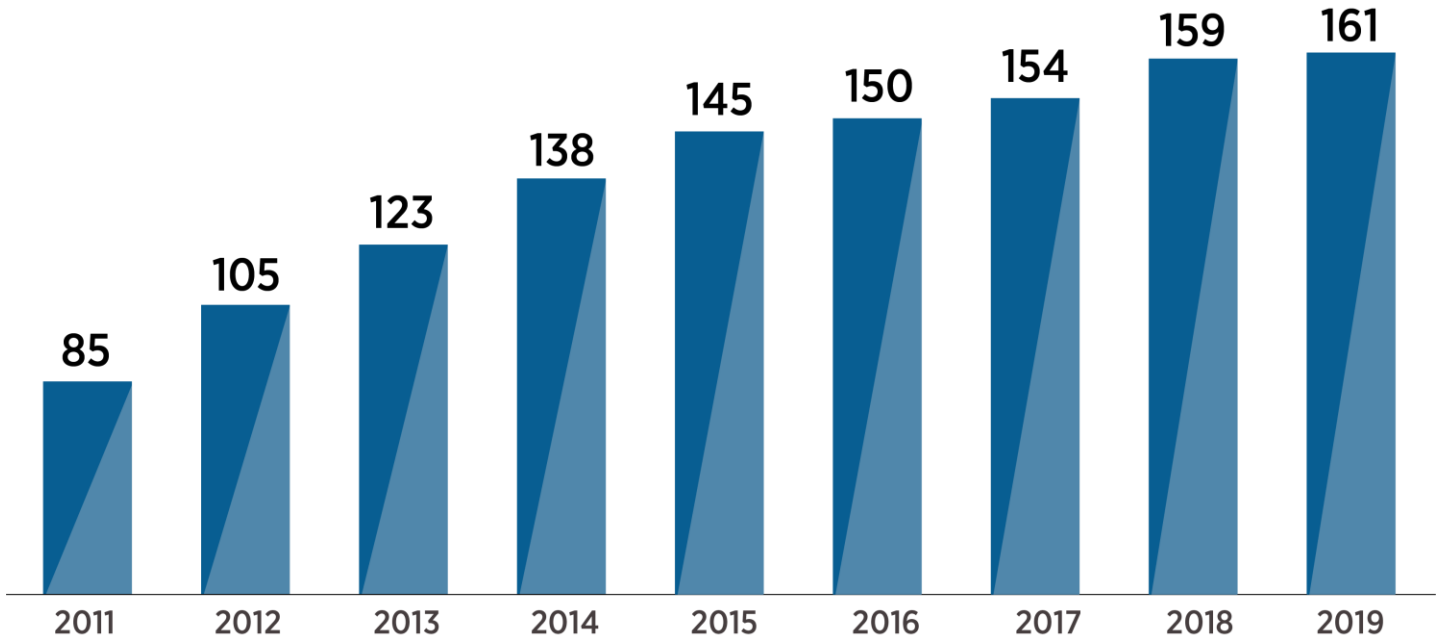
Mandate: to promote the **widespread adoption and sustainable use of all forms of renewable energy**

Scope: All renewable energy sources produced in a **sustainable manner**

IRENA serves as:

- Centre of excellence for knowledge and innovation
- Global voice of renewables
- Network hub
- Source of advice and support

BIOENERGY GEOTHERMAL ENERGY HYDROPOWER OCEAN ENERGY SOLAR ENERGY WIND ENERGY



IRENA **Offices**

IRENA Headquarters
Masdar City

IRENA Innovation and Technology Center

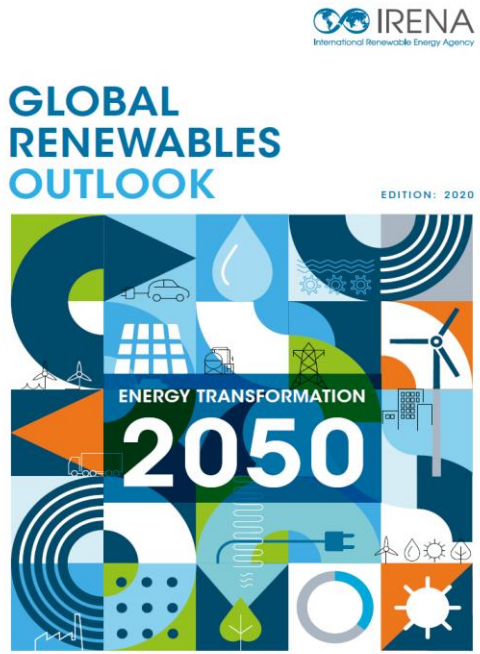
IRENA - Office of the Permanent Observer to the United Nations

This presentation has been prepared based on the report:

IRENA (2020), *Global Renewables Outlook: Energy transformation 2050*

(Edition: 2020), International Renewable Energy Agency, Abu Dhabi.

Available for download: **www.irena.org/publications**



IRENA
International Renewable Energy Agency

GLOBAL RENEWABLES OUTLOOK

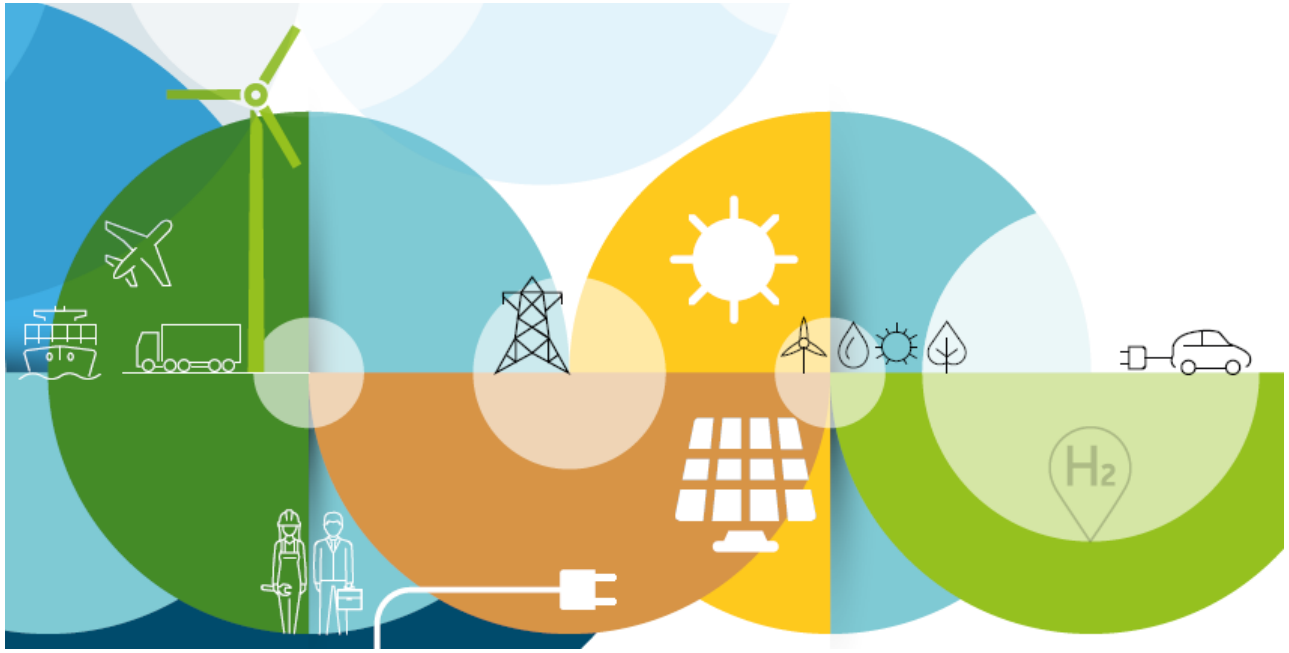
https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020

Ricardo Gorini

Scenarios and perspectives in this report

The **"Planned Energy Scenario (PES)"** is the primary reference case for this study, providing a perspective on energy system developments based on governments' current energy plans and other planned targets and policies (as of 2019), including Nationally Determined Contributions under the Paris Agreement unless the country has more recent climate and energy targets or plans.

The **"Transforming Energy Scenario (TES)"** describes an ambitious, yet realistic, energy transformation pathway based largely on renewable energy sources and steadily improved energy efficiency (though not limited exclusively to these technologies). This would set the energy system on the path needed to keep the rise in global temperatures to well below 2 degree Celsius (°C) and towards 1.5°C during this century.

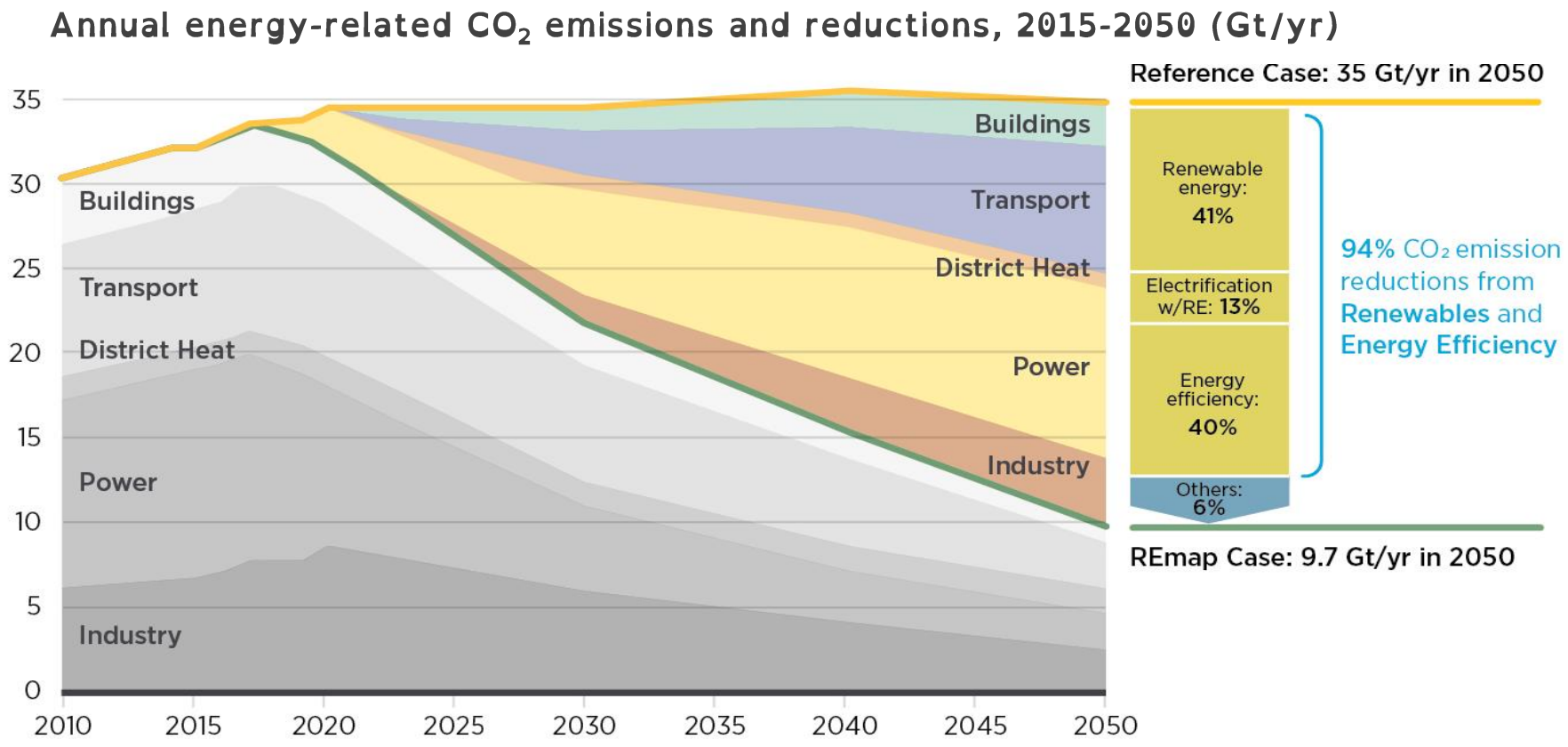


The **"Deeper Decarbonisation Perspective (DDP)"** provides views on additional options to further reduce energy-related and industrial process CO_2 emissions beyond the Transforming Energy Scenario. It suggests possibilities for accelerated action in specific areas to reduce energy and process-related CO_2 emissions to zero in 2050-2060.

The **"Baseline Energy Scenario (BES)"** reflects policies that were in place around the time of the Paris Agreement in 2015, adding a recent historical view on energy developments where needed.

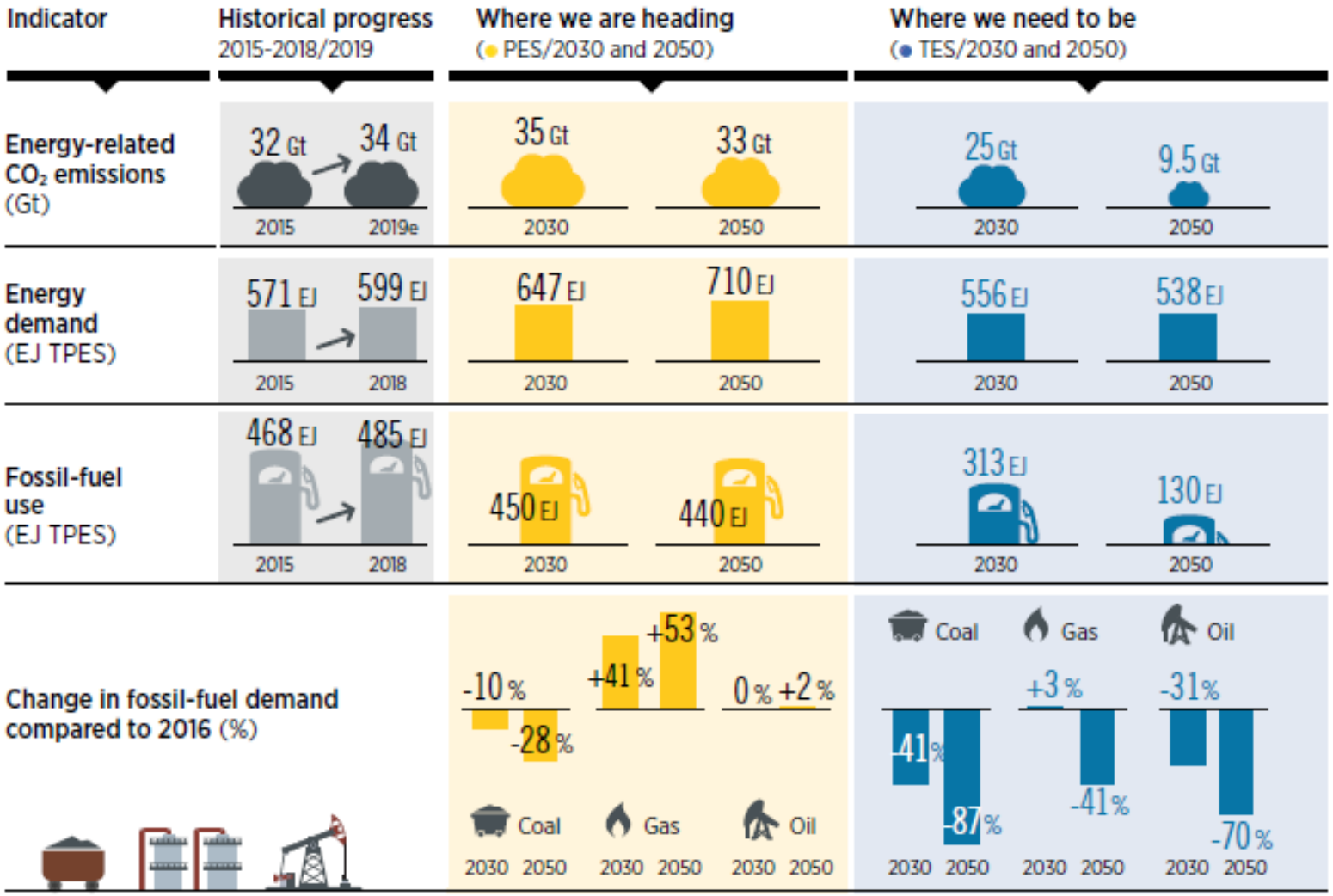
Global Energy Transformation

IRENA's pathway – todos os setores – relacionado ao consumo de energia



Emissões anuais relacionadas à energia: permanecem estáveis sob as políticas atuais, mas devem ser reduzidas em mais de 70% para manter a temperatura abaixo da meta de 2C.

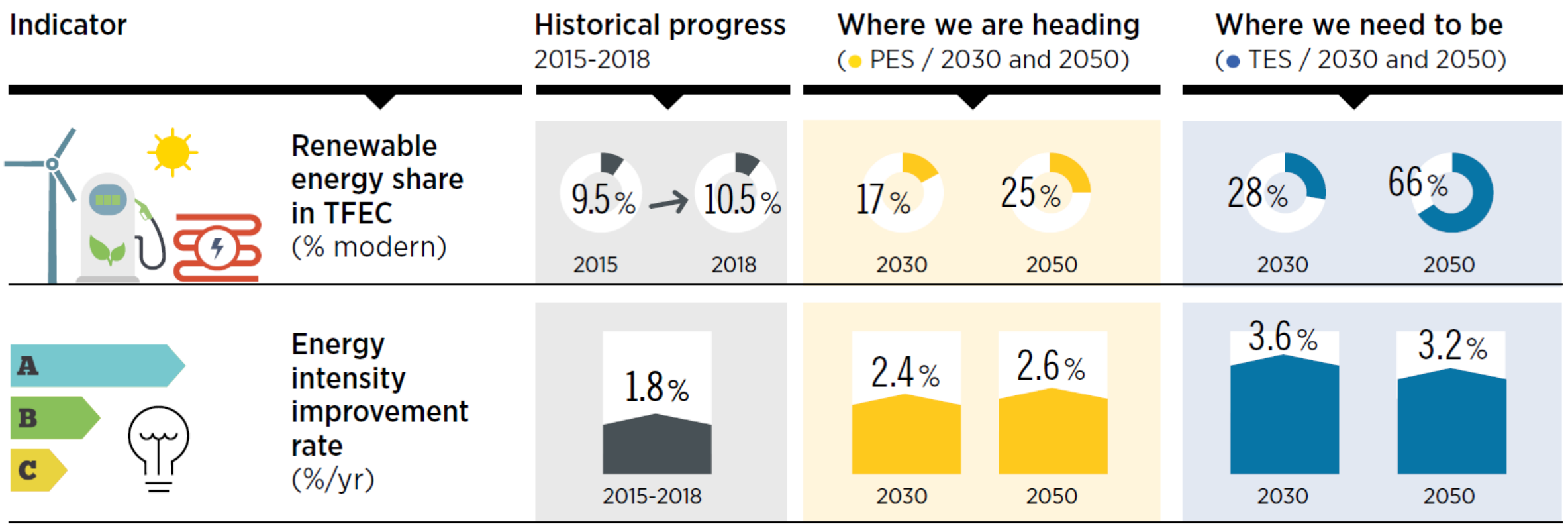
The changing nature of energy and fossil-fuel use



- Recent energy trends confirm the **need to accelerate a reduction in CO_2 emissions**.
- **Lowering energy demand**.
- The Transforming Energy Scenario would **cut fossil-fuel use by about 75%** by midcentury.
- **Natural gas would stable by 2030 and decrease by 2050**.

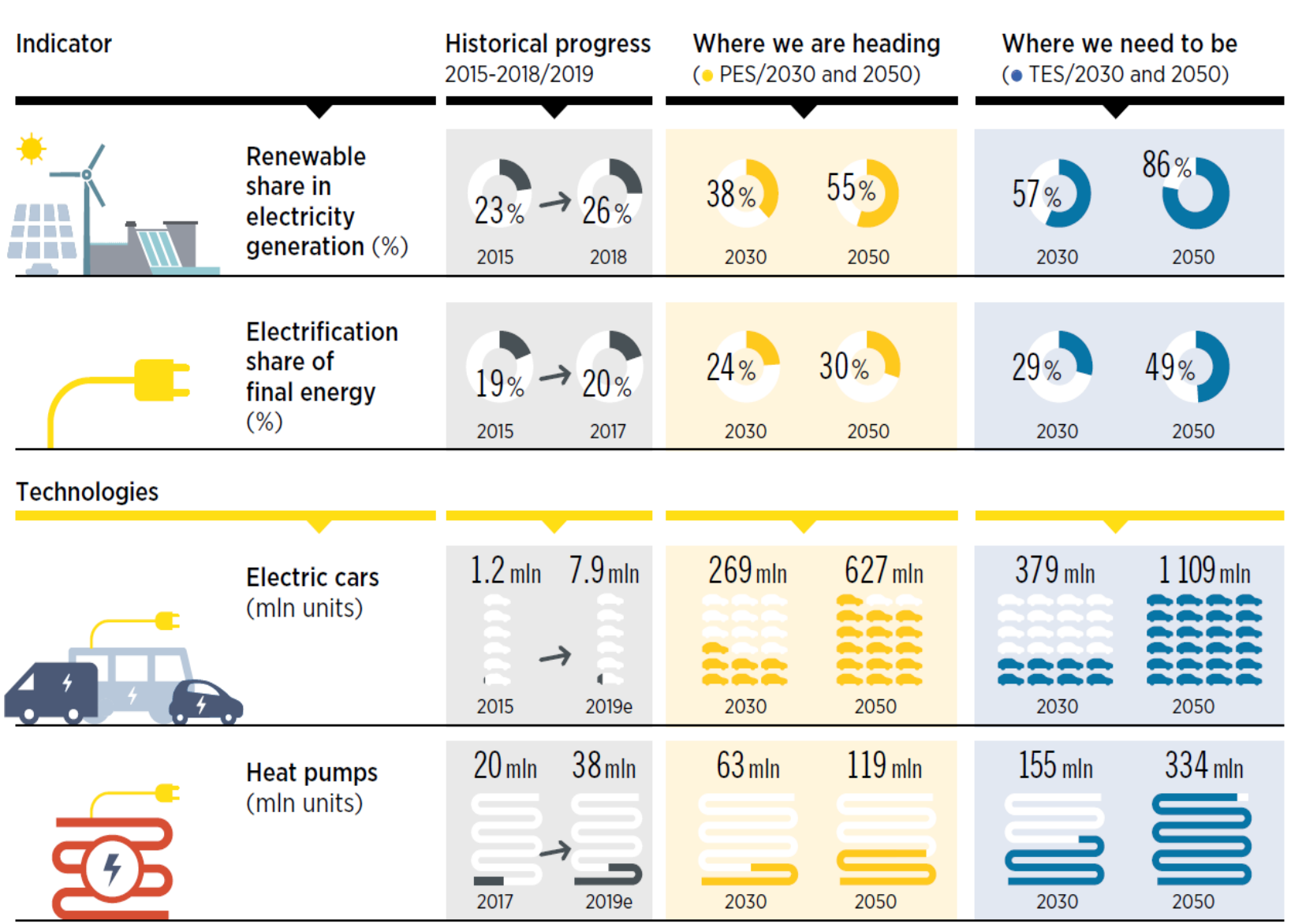
Note: TPES = total primary energy supply. e = estimate; Gt = gigatonnes; EJ = exajoules.

Renewables in the world's energy mix: Six-fold increase needed



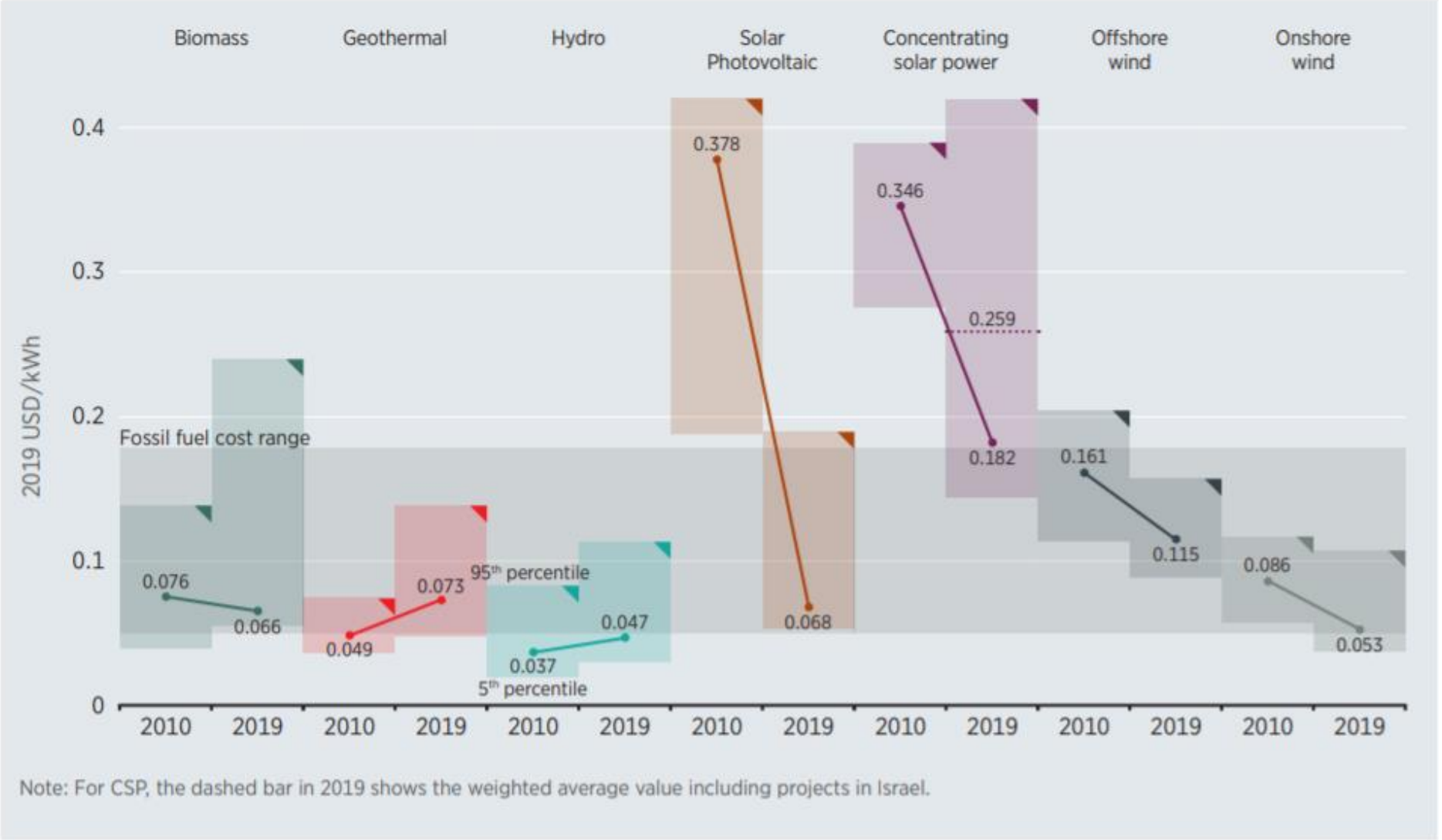
- **Energy efficiency improvements must be scaled up** rapidly and substantially.
- **Renewable energy and energy efficiency together offer over 90% of the mitigation measures** needed to reduce energy-related emissions in the Transforming Energy Scenario.

An increasingly electrified energy system



- **Renewable power generation technologies are setting records for low costs and new capacity** despite falling renewable energy subsidies and slowing global GDP growth.
- **The rate of growth in the percentage share of electricity** (percentage point "ppt") **in final energy needs to quadruple**, from an increase of 0.25 ppt/yr to 1.0 ppt/yr.
- **The electrification of end uses will drive increased power demand to be met with renewables**

Figure ES.1 Global weighted average levelised cost of electricity from utility-scale renewable power generation technologies, 2010 and 2019



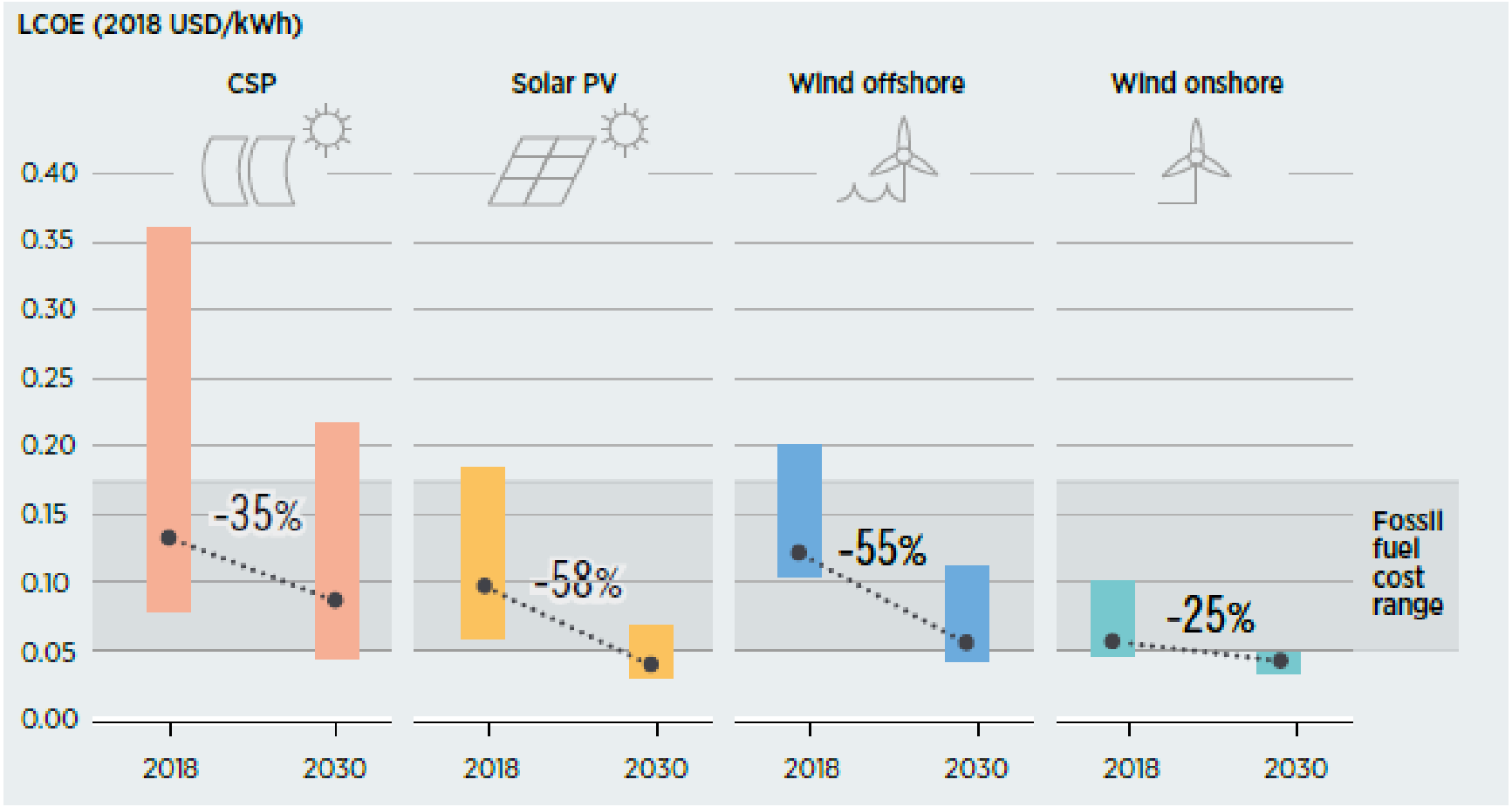
Note: This data is for the year of commissioning. The thick lines are the global weighted-average LCOE value derived from the individual plants commissioned in each year. The project-level LCOE is calculated with a real weighted average cost of capital (WACC) is 7.5% for OECD countries and China and 10% for the rest of the world. The single band represents the fossil fuel-fired power generation cost range, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

IRENA
International Renewable Energy Agency

Most renewables already compete with fossils

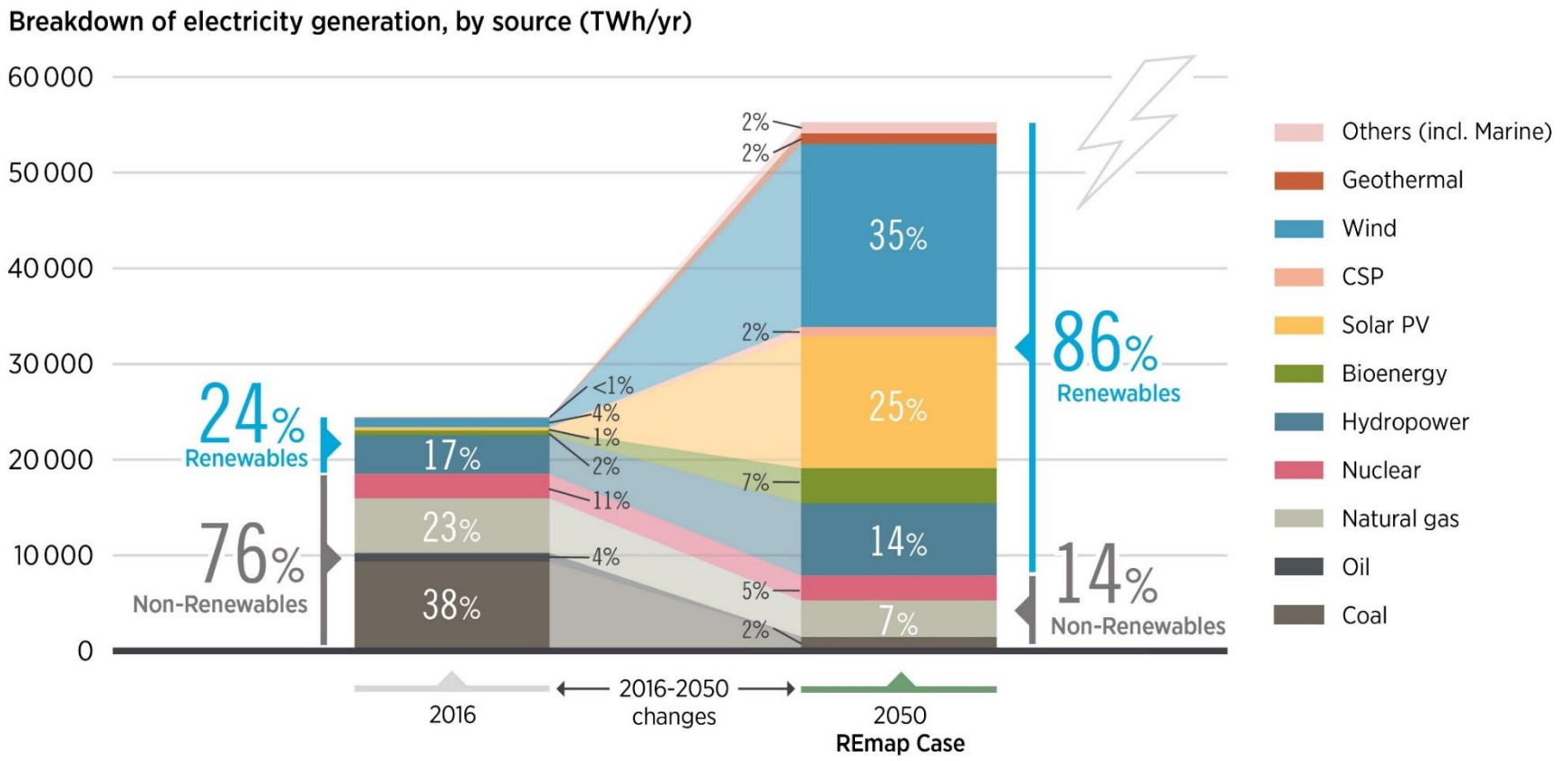
Hydro, solar and wind are already more competitive in most cases

Cost reductions continue in key renewable power technologies



- In most parts of the world today, **renewables have become the lowest-cost source of new power generation.**
- **Cost reductions will continue over the next decade falling between 25% and almost 60%.**

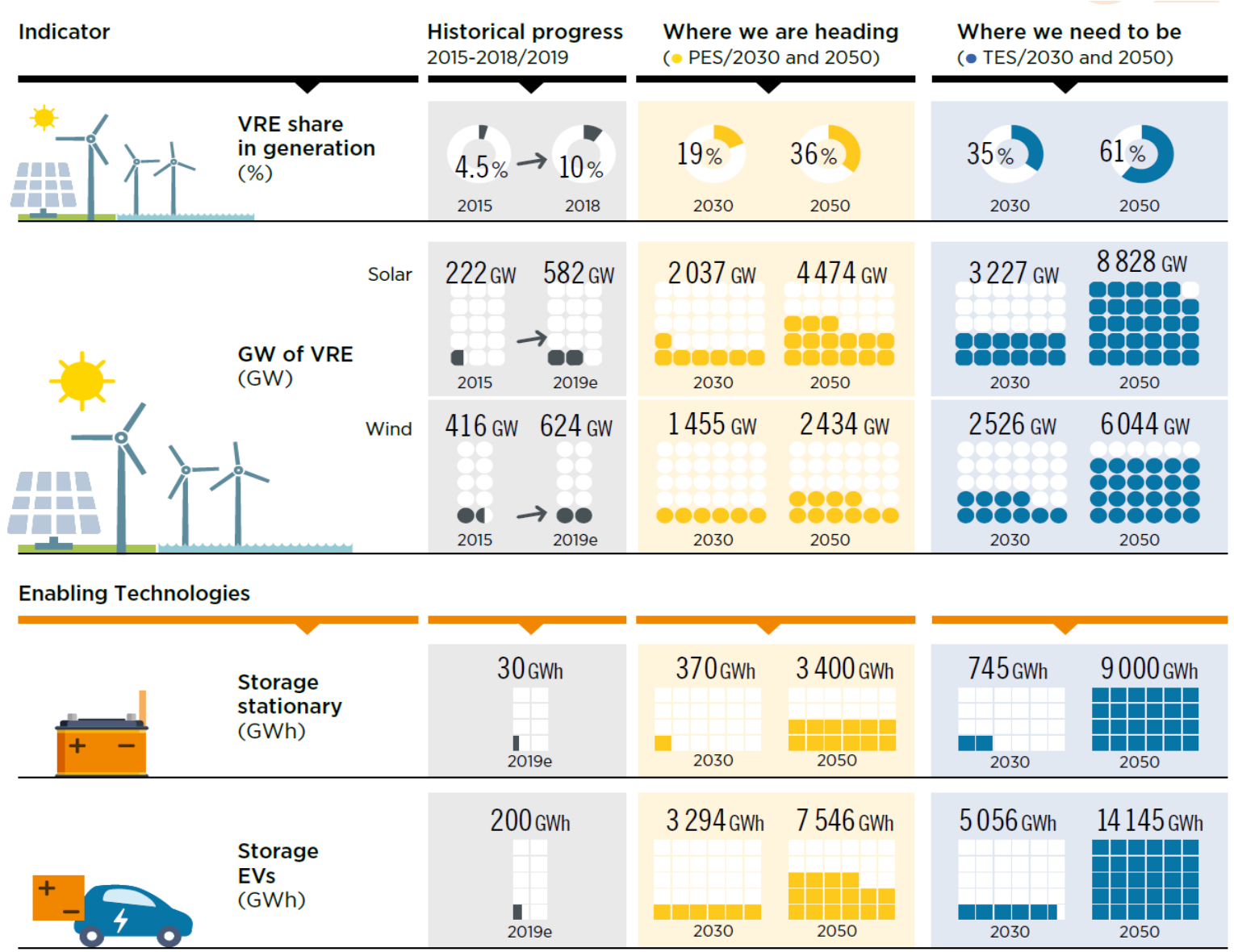
IRENA's REmap decarbonization pathway



Increasing electricity with VRE. The need of flexibility. Sector coupling solutions.

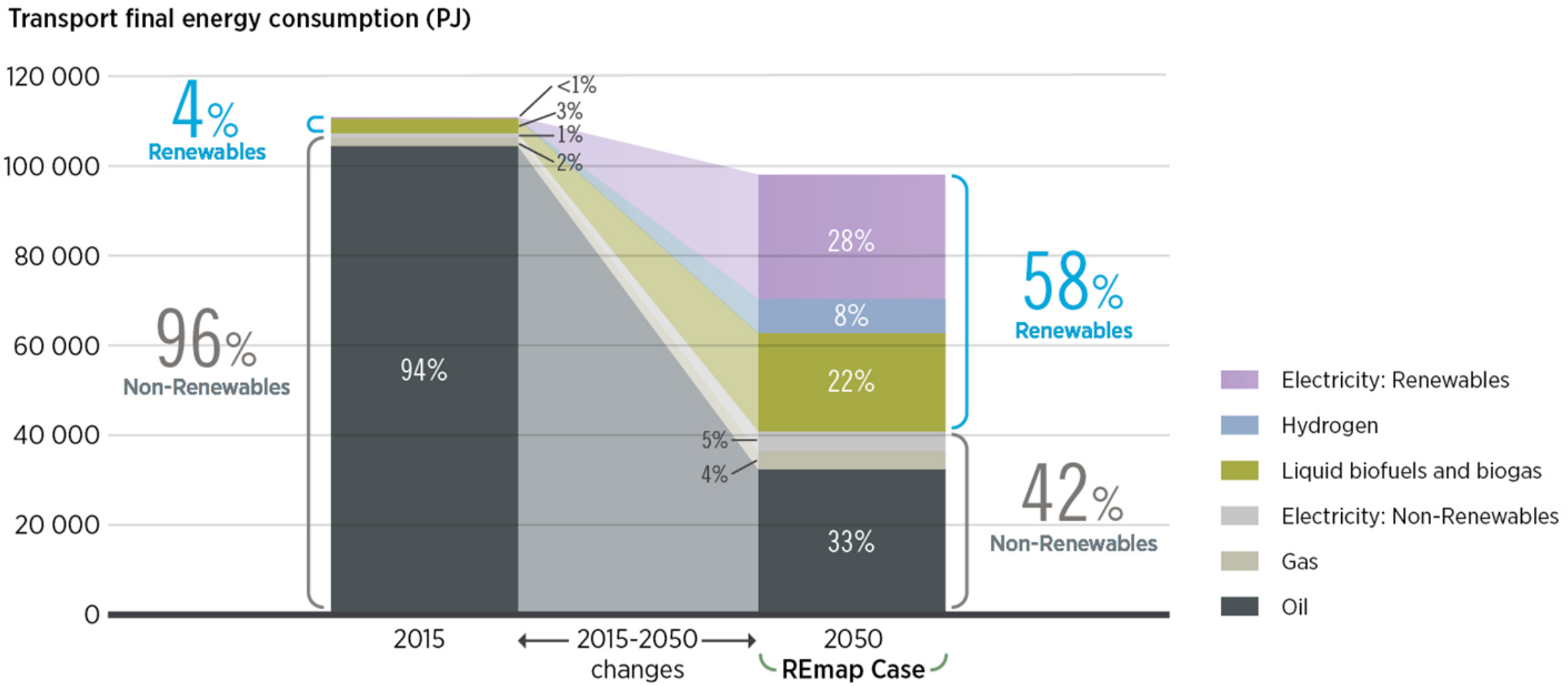
The need for power system flexibility

- **Flexibility in power systems is a key enabler for the integration of high shares of variable renewable electricity** – the backbone of the electricity system of the future.
- **Power systems must achieve maximum flexibility**, based on current and ongoing innovations in enabling technologies, business models, market design and system operation.
- On a technology level, **both long-term and short-term storage will be important for adding flexibility**.

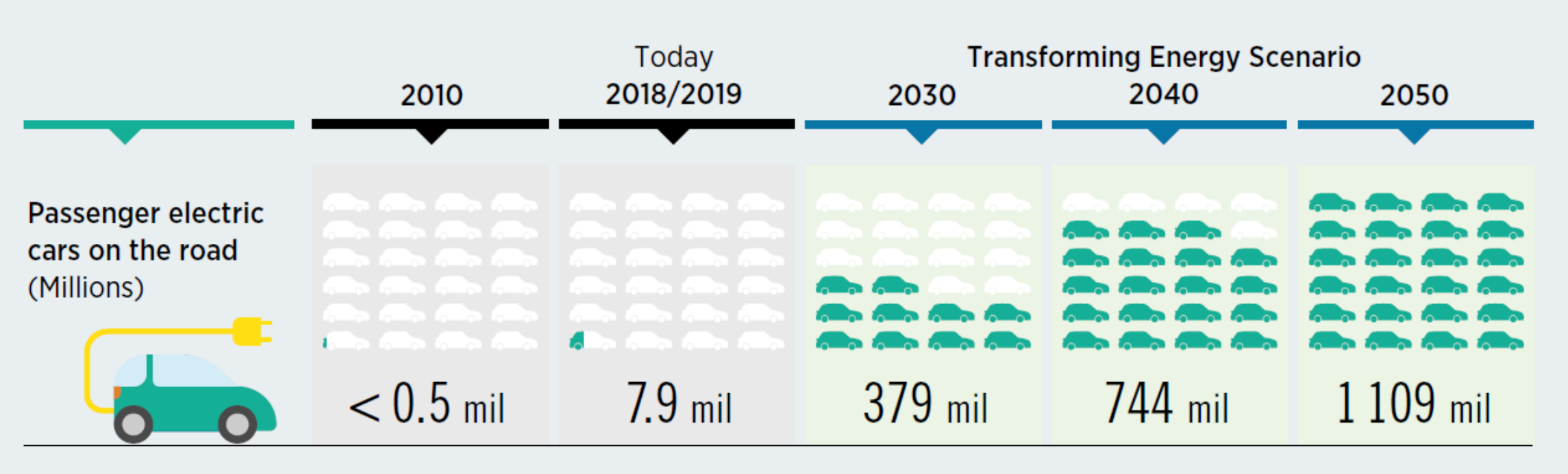


Global Energy Transformation

IRENA's pathway – setor de transporte



Low-cost electricity for transport



- The advent of **electric vehicles promises to be a game changer for the world's shift to sustainable energy** and particularly to renewable power generation.
- Steady cost reductions for renewable power generation make electricity an **attractive low-cost energy source to fuel the transport sector**.

Emerging innovations - flexibility of the grid and VRE

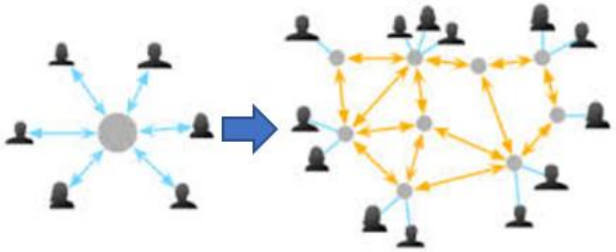
Value spatial complementarities - interconnections

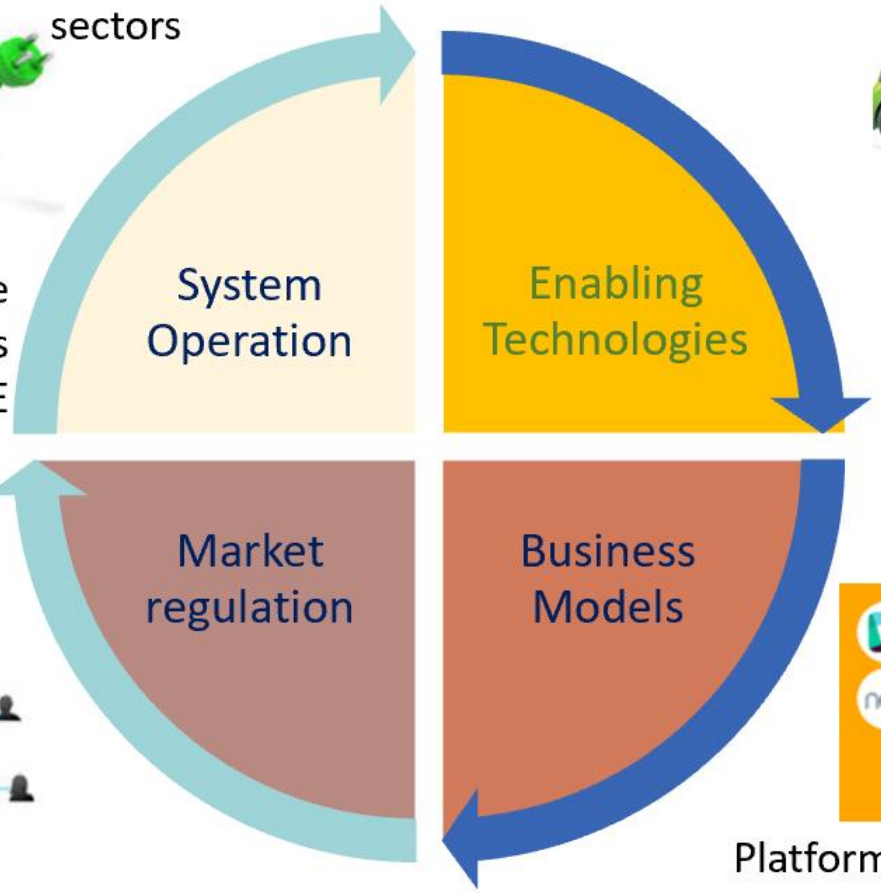
Encourage Flexibility

Electrification of other sectors

Value complementarities in VRE

Decentralized system





Electric Vehicles

Storage

Digitalization - IoT

Blockchain

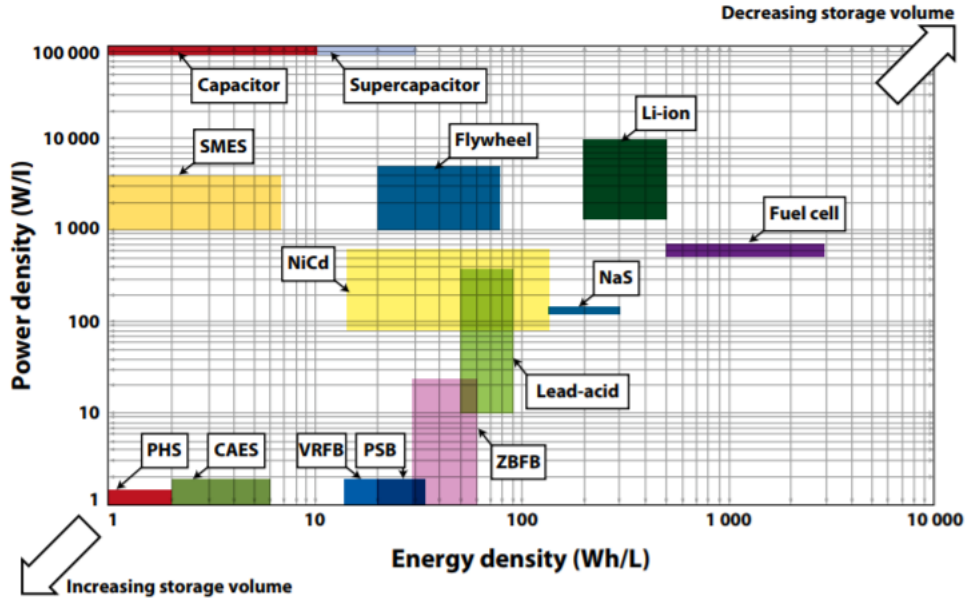
Platform business model

Aggregators- VPP

Melhorias tecnológicas disruptivas

Baterias: Eficiência crescente e redução de custo

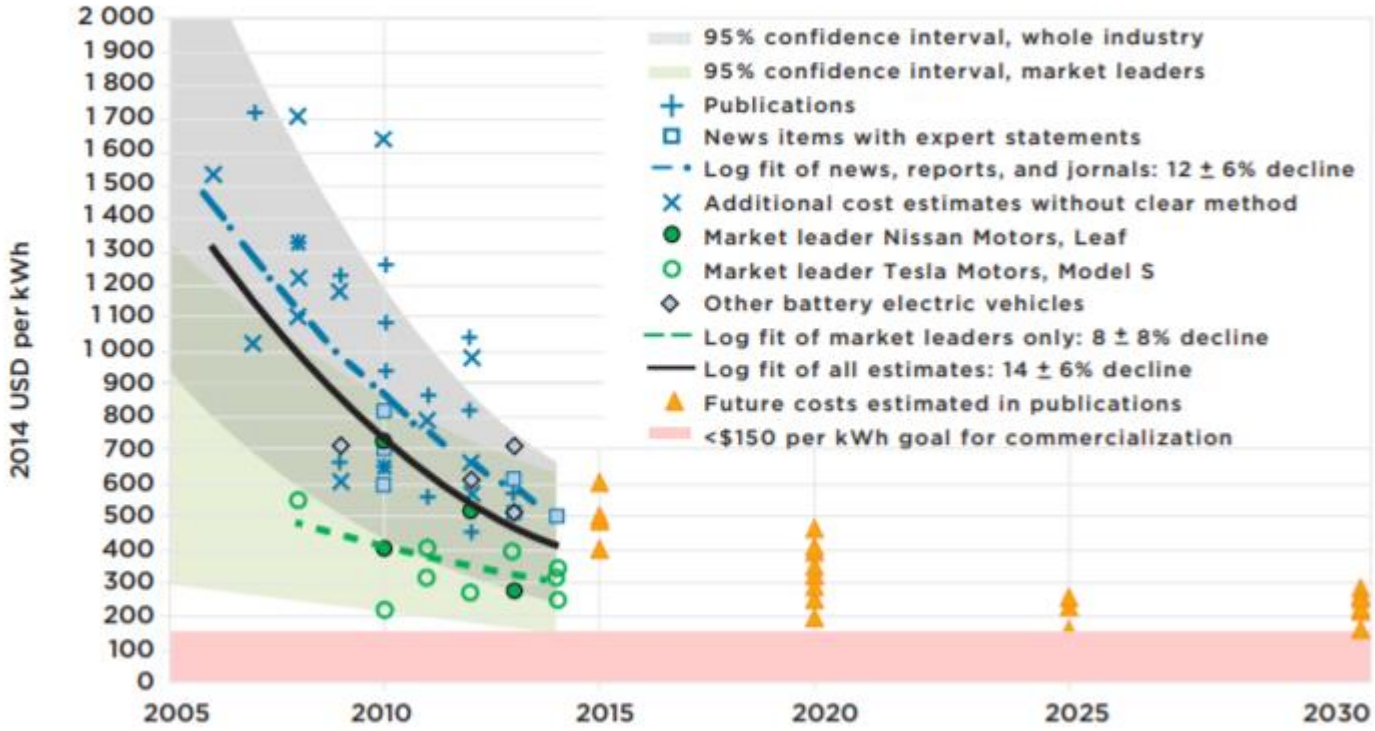
Figure 12: Comparison of power density and energy density for selected energy storage technologies



Source: Luo *et al.*, 2015.
Note: SMES = superconducting magnetic energy storage; NiCd = nickel cadmium; NaS = sodium sulphur; PHS = pumped hydro storage; CAES = compressed air energy storage; VRFB = vanadium redox flow battery; PSB= polysulfide bromine flow battery; ZBFB = zinc bromine flow battery.

IRENA_Electricity_Storage_Costs_2017

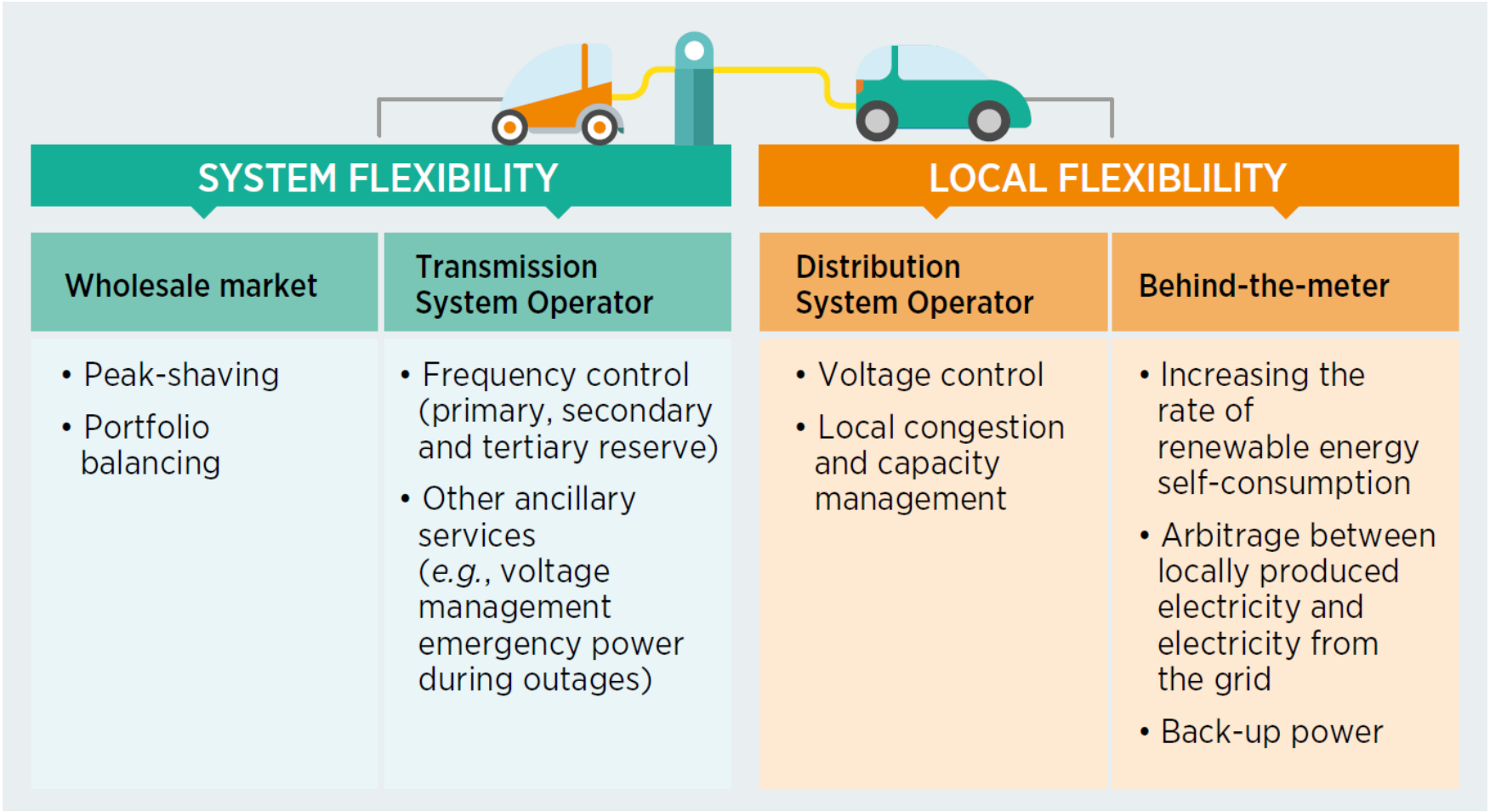
Figure 2: Estimates of costs of lithium-ion batteries for use in electric vehicles



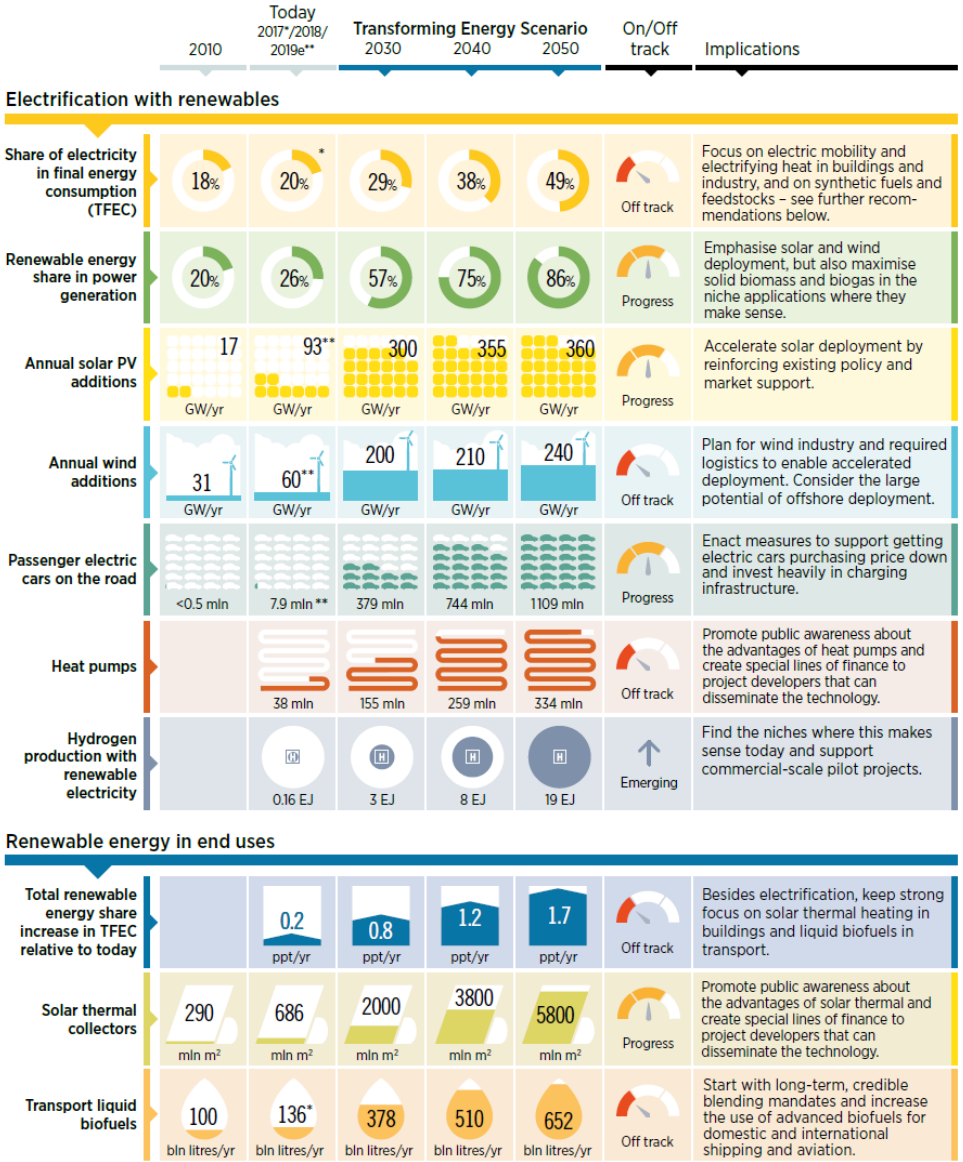
Source: Nykvist and Nilsson (2015).

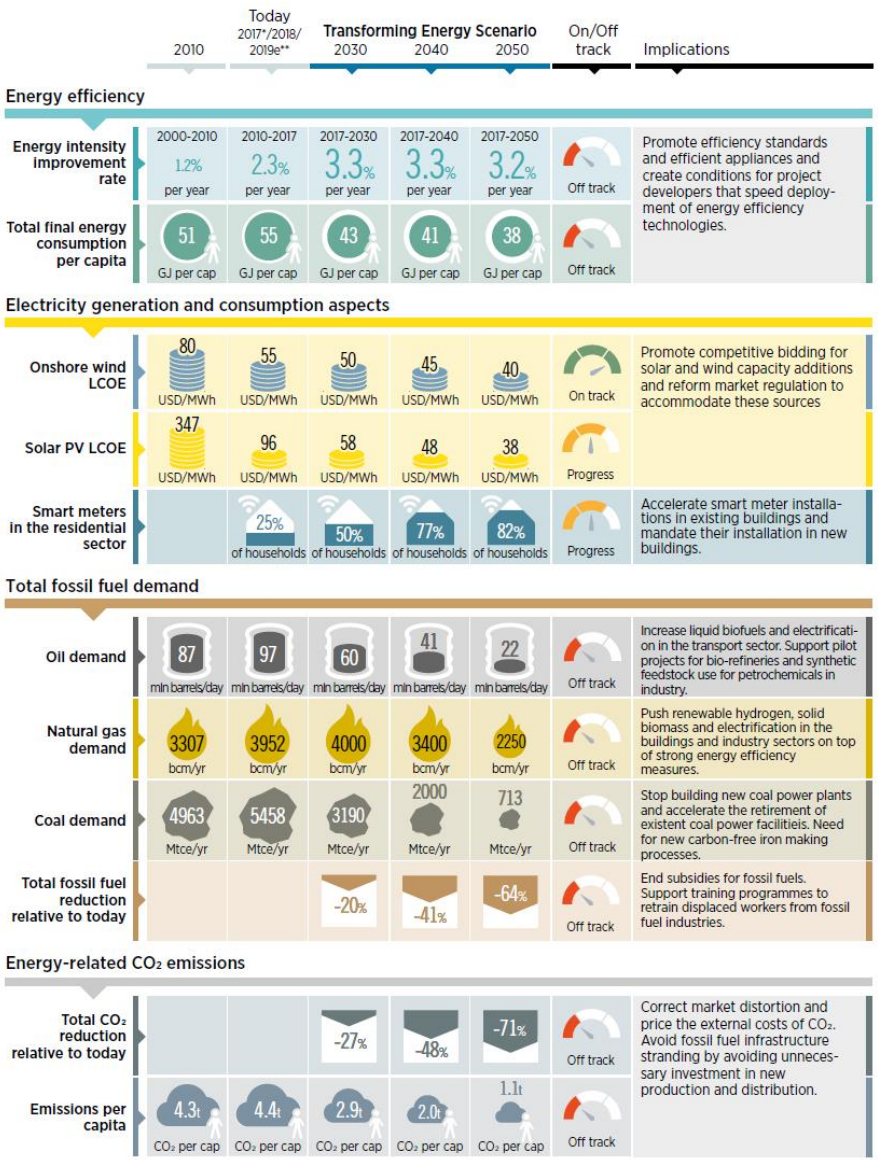
IRENA_Electric_Vehicles_2017

Smart charging: System-level and local flexibility via electric vehicles



- **Smart charging could provide flexibility at both the system and local levels**.
- Emerging innovations in smart charging for EVs span not just **technologies** but also **business model**s and **regulatory frameworks**.





IRENA
International Renewable Energy Agency

System-wide transformation: Changes in all sectors of energy use

The energy transformation will require **widespread and profound changes** in all sectors of the energy system.

Note: The findings in this report consider targets and developments as of April 2019. The wind and solar PV capacities in Transforming Energy Scenario in 2030 in this report are slightly higher than the estimates presented in IRENA's reports (IRENA, 2019d; 2019e) which consider developments as of the third quarter of 2019. Today LCOE values are G20 weighted averages.

Global energy decarbonisation: Swift action needed all sectors

IRENA
ternational Renewable Energy Agency

Power

ACCELERATE RENEWABLE CAPACITY ADDITIONS TO GENERATE ADEQUATE POWER WITH LOW-CARBON TECHNOLOGIES

1) Identify and map renewable energy resources and develop a portfolio of financeable projects for the medium to long term.
2) Construct no new coal power plants and plan and implement an end-of-life phase-out of coal capacities.

UPDATE GRID PLANNING TO ACCOMMODATE RISING SHARES OF VARIABLE RENEWABLE ENERGY (SOLAR AND WIND)

1) Develop a flexible power system (with flexible supply, storage, demand response, power-to-X, electric vehicles, digital and ICT technologies, etc).
2) Update grid codes.
3) Deploy micro-grids to improve resilience and expand energy access with renewable sources.
4) Deploy super-grids to interconnect regions.
5) Deploy cost-reflective tariff structures by properly readjusting the balance between volumetric charges (USD/kWh), fixed charges (*e.g.* USD/meter-month) and, where applicable, demand charges (USD/kW).

SUPPORT DISTRIBUTED ENERGY RESOURCE DEPLOYMENT

1) Incentivise energy consumers to become prosumers.
2) Support regulatory and pricing policies, including rights to generate and sell electricity, tariff regulation and grid-arrival policies.
3) Enable energy aggregators to foster use of distributed energy resources.

Transport

REDUCE TRANSPORT VOLUME AND CONGESTION

1) Adopt advanced digital communication technologies to improve urban transport planning and services (*e.g.* re-routing to reduce traffic congestion).
2) Promote mobility services (*e.g.* automonous driving, vehicle-sharing).
3) Accelerate the shift from passenger cars to public transport (electric railways, trams or buses).
4) Deploy low-emissions city trucks.

ACCELERATE THE SHIFT TO ELECTRIC MOBILITY

1) Set minimum standards for vehicle emissions.
2) Give electric vehicles (EVs) priority in city access.
3) Incentivise the development of charging infrastructure.
4) Strengthen links between the power and transport sectors with integrated planning and policy designs (vehicle-to-grid services).

PRIORITISE BIOFUELS IN ROAD FREIGHT, AVIATION AND SHIPPING

1) Introduce specific mandates for advanced biofuels, accompanied by direct financial incentives and financial de-risking measures.
2) Adopt supporting policies to scale up sustainable production of first- and second-generation biofuels.
3) Eliminate fossil-fuel subsidies and implement carbon and energy taxes to increase the competitiveness of renewable-fuelled shipping and aviation.

Industry

REDUCE ENERGY CONSUMPTION IN INDUSTRIES

1) Promote circular economy (material recycling, waste management, improvements in materials efficiency, and structural changes such as reuse and recycling).
2) Establish energy efficiency standards and ramp up actual efficiency levels.

ENABLE CORPORATE SOURCING OF RENEWABLES

1) Support a credible and transparent certification and tracking system for corporate renewable energy use.
2) Consider an energy market structure that allows for direct trade between companies of all sizes and renewable energy developers, *e.g.* through power purchase agreements (PPAs).
3) Work with utilities and other electricity suppliers to provide green corporate procurement options.
4) Empower companies to invest directly in self-generation.

ACCELERATE LOW-CARBON TECHNOLOGY DEPLOYMENT FOR INDUSTRIAL PROCESS HEATING

1) Remove existing barriers and Incentivise low-carbon heating methods (*e.g.* solar thermal heating, modern bioenergy and heat pumps).
2) Support emerging biomass and hydrogen technologies. Replace fossil fuel-based with renewable-based feedstocks and process heat (*e.g.* in iron and steel subsectors, ammonia production).

Buildings

REDUCE ENERGY CONSUMPTION IN BUILDINGS

1) Establish or enhance energy-efficient building codes and standards (including for appliances and equipment).
2) Adopt retrofitting and renovation programmes, including financing schemes.
3) Incentivise retrofits and adjust construction codes in cities and states.
4) Combine energy efficiency and renewable energy measures (*e.g.* public policies to integrate these technologies in renovations of public buildings).

SUPPORT AND FOSTER DER DEPLOYMENT

1) Remove barriers that prevent prosumers from actively helping to transform the energy system.
2) Promote community ownership models and innovative financing schemes.
3) Accelerate the roll-out of smart meters.
4) Capitalise on smart-home and digitalisation schemes to allow demand management and strengthen grid services.

SCALE UP THE RENEWABLE SHARE IN THE BUILDINGS SECTOR

1) Promote low-carbon heating technologies (*e.g.* heat pumps, solar heating, modern bioenergy for heating and cooling).
2) Apply these renewable energy technologies through district heating.
3) Phase out traditional biomass as a cooking fuel and replace it with clean and efficient cookstoves (biogas, modern solid biomass, electricity).

Decarbonising the global energy system requires **swift and decisive policy action** in the power, industry, buildings and transport sectors.

Racional da eletrificação: Pela ótica da Indústria de mobilidade

Nova indústria de mobilidade emergindo: mais do que apenas eletrificação

Tesla …

Crescente ameaça de nova entrada

Condução Autonoma Compartilha -mento

Menor poder dos produtores

Maior ameaça de substitutos

Crescente rivalidade competitiva

Crescente número de competido -res

Poder dos compradores mais forte

On line shopping

Figure. Porter's Five Forces. From Glaser and Traynor 2018.
http://www.hearingreview.com/2018/07/survival-strategies-competitive-hearing-healthcare-market-2/

Racional da eletrificação: Global

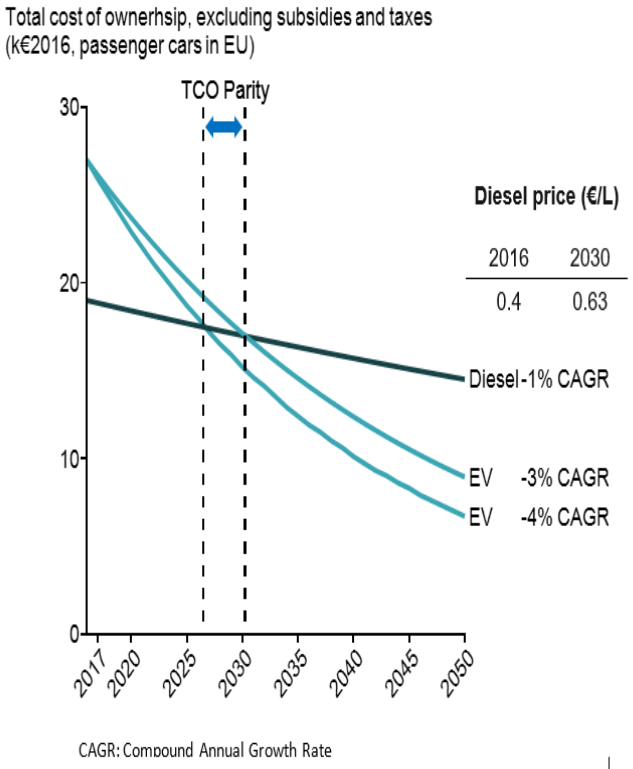
Sinais de mudança global

- **Melhorias tecnológicas disruptivas**
  - O custo das baterias (por kWh armazenado) caiu mais de 70% nos últimos 8 anos (~ 20% de redução de custos por duplicação de volume de fabricação).
  - A densidade de energia da bateria (Wh / kg) deve dobrar até 2030.
- **Evolução de Políticas**
  - Vários países europeus anunciaram planos de longo prazo para eliminar gradualmente os veículos ICE.
  - A China - o maior mercado de EV do mundo - estabeleceu uma quota de vendas de EV de 10% para 2019.
  - Cidades cada vez mais restringindo o acesso aos carros da ICE para reduzir a poluição.
- **Desenvolvimento do mercado**
  - Os maiores fabricantes mundiais de automóveis anunciaram planos de eletrificação de longo prazo.
  - Mais de 50 novos veículos elétricos a bateria (BEV) para chegar ao mercado antes de 2022.
  - Mercado de veículos elétricos crescendo exponencialmente (> 40% ao ano)

Melhorias tecnológicas disruptivas

EV: Competitividade crescente

Figure 25: Illustrative total cost of ownership (TCO) outlook for electricity and diesel-powered cars until 2050

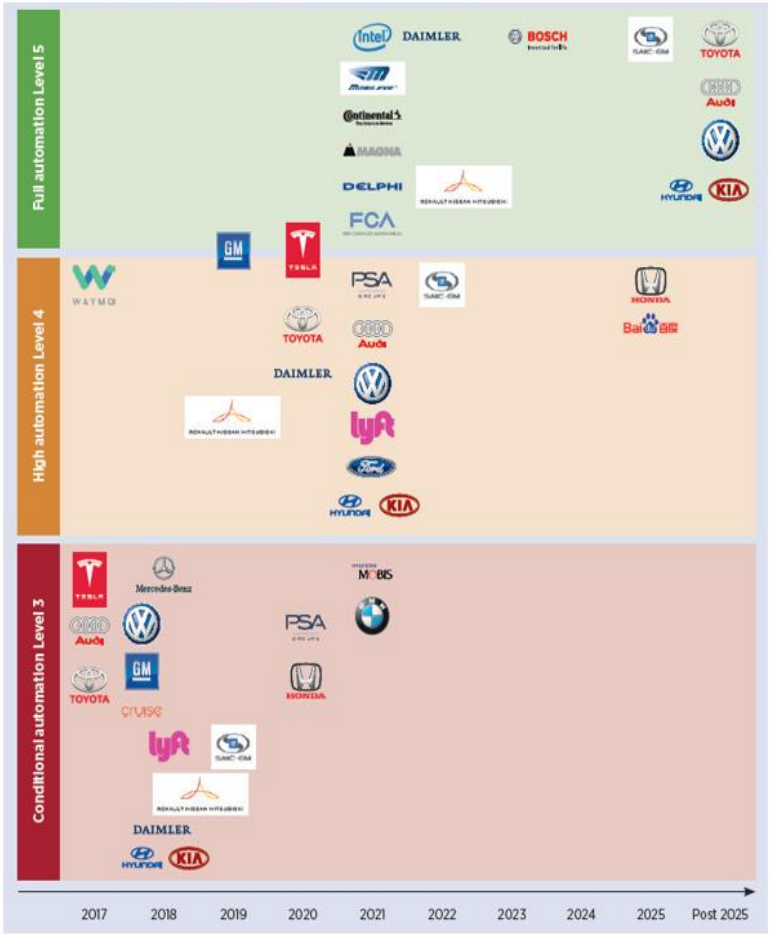


CAGR: Compound Annual Growth Rate

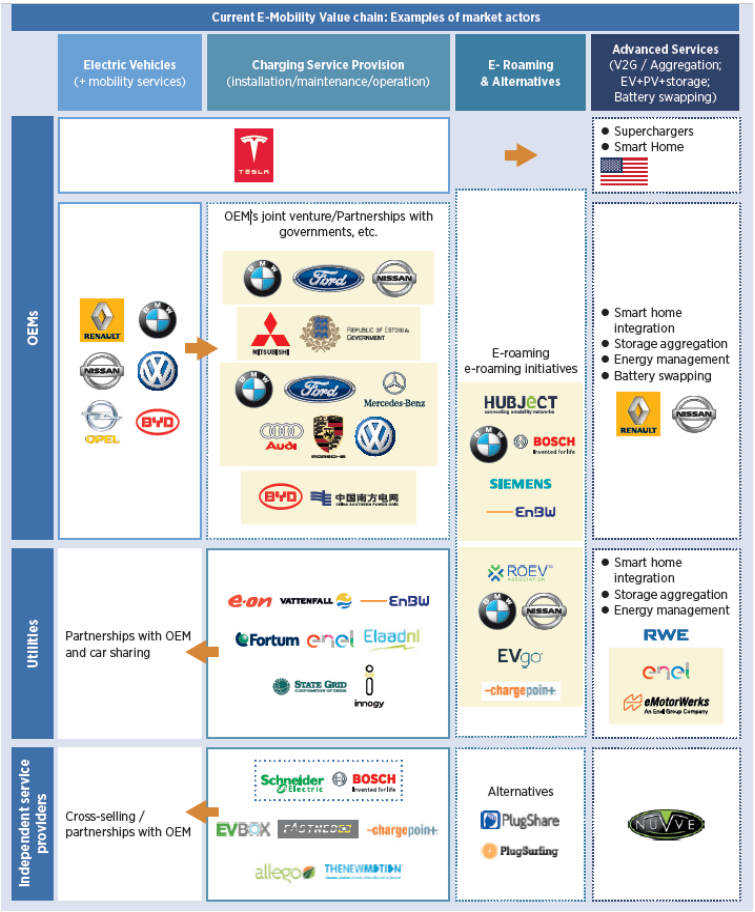
Based on (BNEF, 2017d) (McKinsey&Company, 2014) (Union of Concerned Scientists, 2017)

Drivers: Digitalização e condução autônoma; Novo business – serviço de mobilidade e compartilhamento

Figure 28: Expected launch times of autonomous vehicles

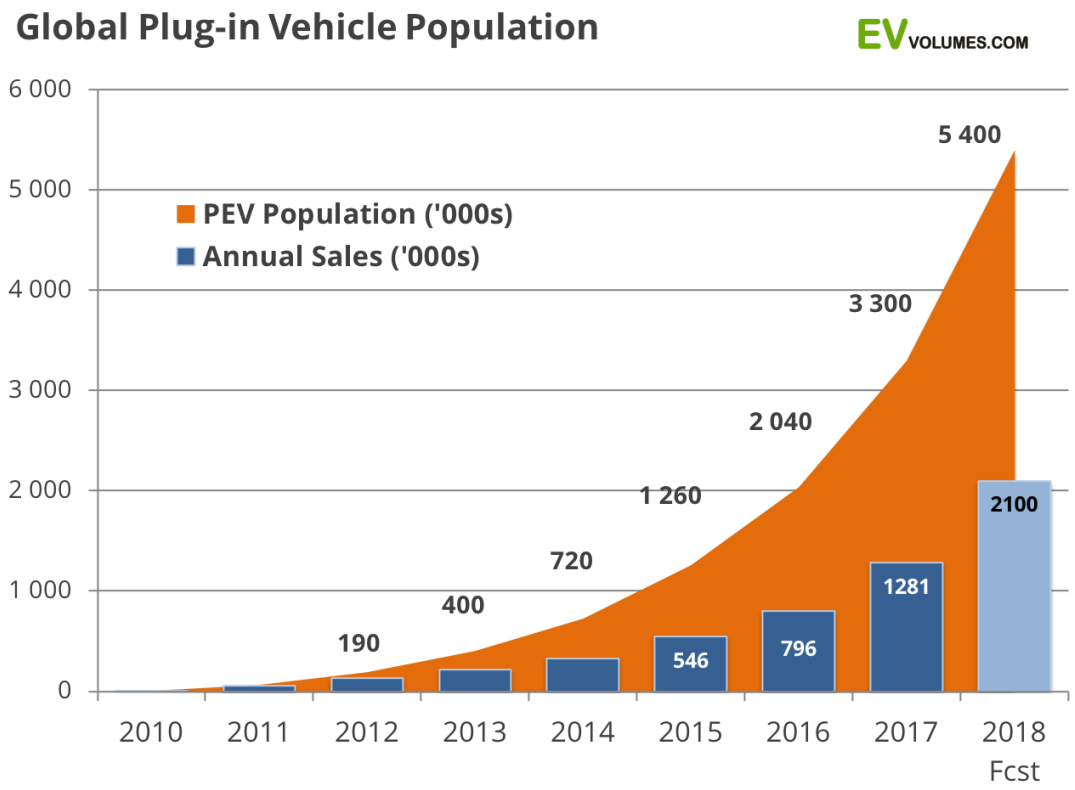


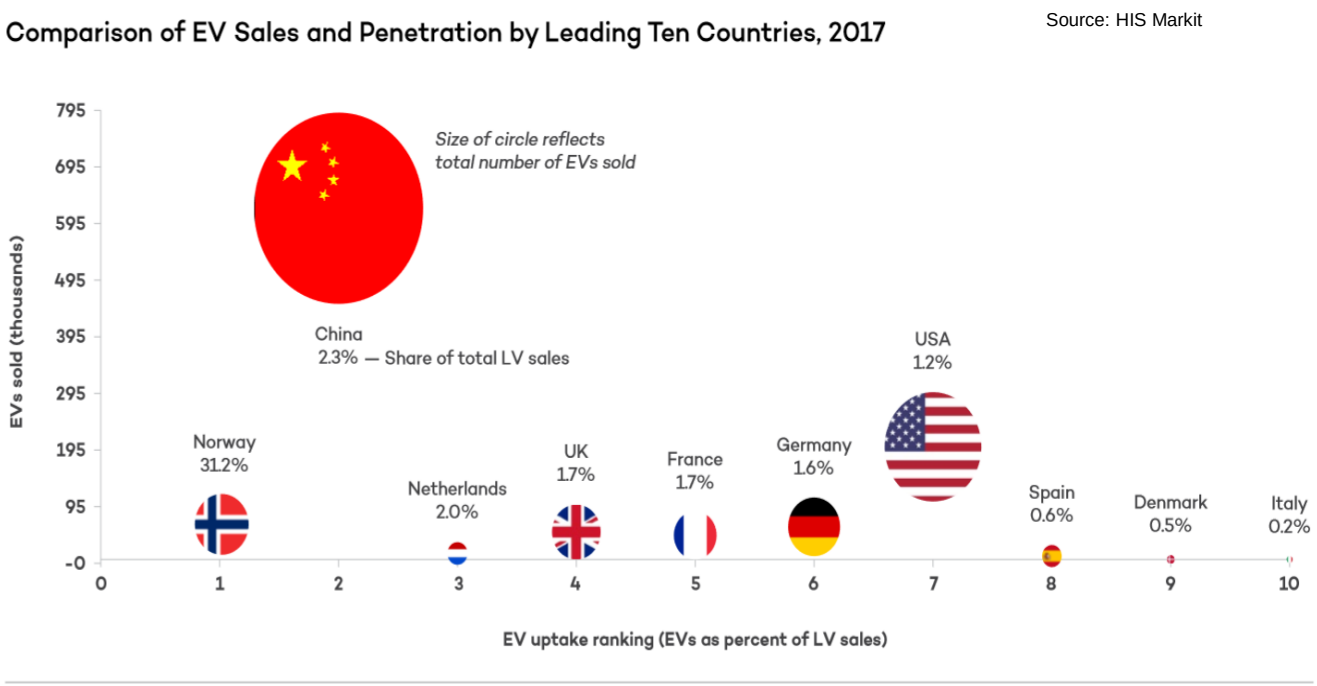
Source: Updated from (BNEF, 2018a)



Global Market developments

Crescimento rápido & cobertura regional



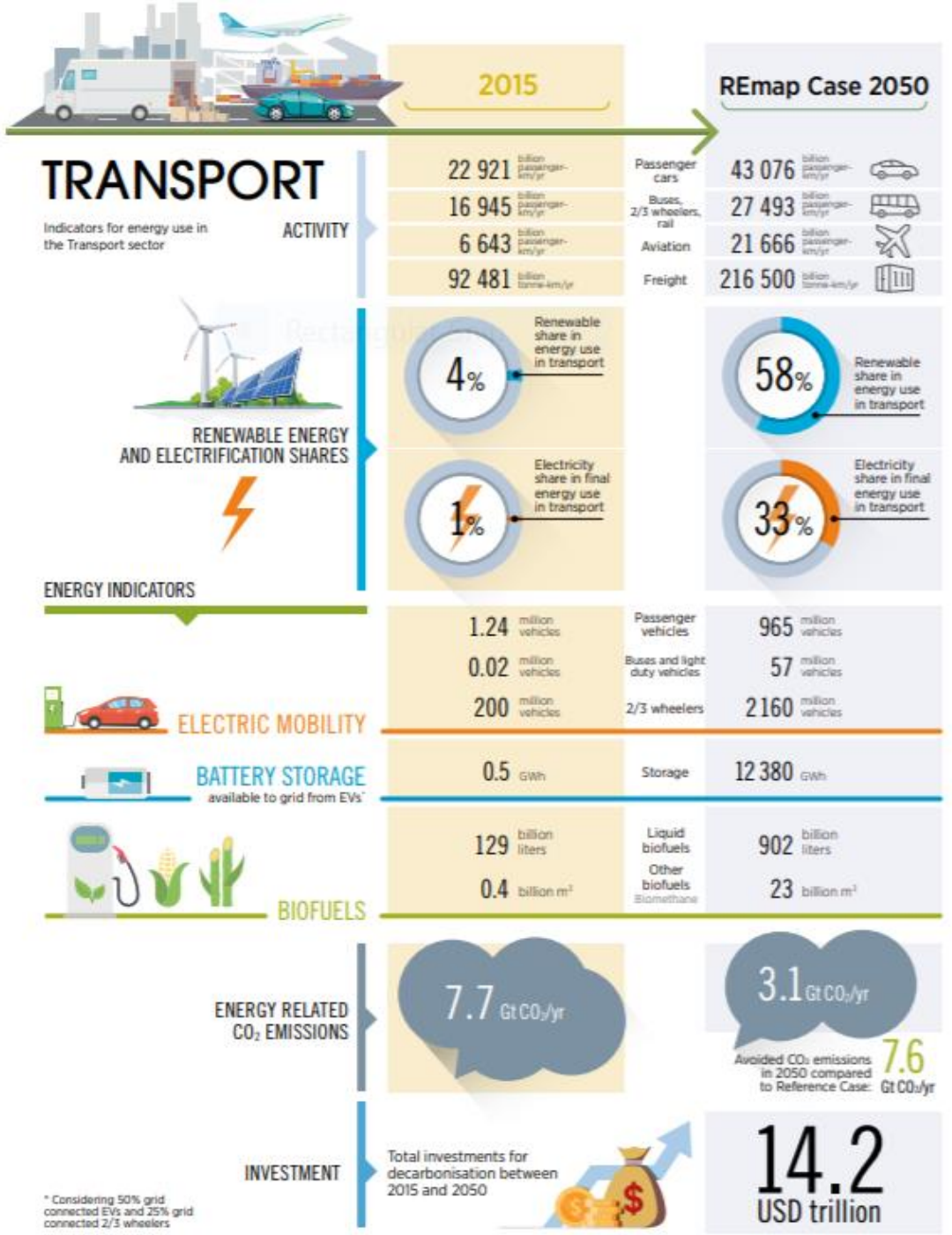


In 2017, the U.S. was the second largest purchaser of EVs, after China. However, six countries, including China, had greater EV sales as a percentage of their domestic market.

Global Energy Transformation

Mas: não EV vs Etanol

- **Tanto biocombustível quanto eletromobilidade são necessários**
  - Os níveis de descarbonização implícitos pelo acordo de Paris levam a uma quase eliminação do uso de combustíveis fósseis no setor de transporte
  - Isso pode ser melhor alcançado com uma mistura de biocombustíveis e eletromobilidade
  - A análise da IRENA propõe um **aumento da eletromobilidade de 1% em 2015 para mais de 33% em 2050** em termos de consumo final de energia no setor de transportes, globalmente
  - Os biocombustíveis líquidos crescem de cerca de **130 bilhões de litros em 2015 para mais de 600 bilhões de litros em 2050**, mais do que quadruplicando seu tamanho de mercado



Global Energy Transformation

Global vs. Brasil - perspectiva

- **Energy transition: de acordo com as especificidades e prioridades de cada país**
- **Brasil é um caso muito especial**
  - O uso de biocombustíveis (etanol e biodiesel) já é uma realidade, generalizada e crescente – destaque mundial na participação de biocombustíveis no setor de transportes
  - O uso continuado de biocombustíveis - promovido e mais incentivado como refletido na política RENOVABIO recentemente aprovada
  - Embora o potencial de energia elétrica de RE no Brasil seja enorme, e
  - A mobilidade elétrica - uma realidade crescente em vários países, sendo um mercado promissor
- **Questões centrais: pathway para eletromobilidade no Brasil**
  - O que: escopo da eletromobilidade no Brasil?
  - Por que: adicionalidade de benefícios?
  - Quando: timing?
  - Como: o Brasil assumindo a liderança global em algum segmento de mercado?

https://www.irena.org/publications/2019/May/Innovation-Outlook-Smart-Charging

https://www.irena.org/publications/2017/Feb/Electric-vehicles-Technology-brief

https://www.irena.org/publications/2017/Oct/Electricity-storage-and-renewables-costs-and-markets

https://www.irena.org/publications/2017/Feb/Biofuels-for-aviation-Technology-brief

https://www.irena.org/publications/2013/Jul/Road-Transport-The-Cost-of-Renewable-Solutions

https://www.irena.org/publications/2016/Aug/The-Renewable-Route-to-Sustainable-Transport-A-working-paper-based-on-REmap

REmap products

Global

- Status of the energy transition
- Perspective for the global energy system to 2050 based on current and planned policies (the Reference Case).
- Detailed REmap transition pathway to 2050 – an energy pathway aligned with the well-below 2oC target of the Paris climate goals.
- r

Regional

- Assessment of technology options and regional disaggregation
- Identification of key technologies and trends, and cross-country opportunities
- 3 regional reports (Africa, ASEAN and EU)
- **3 in preparation (SEE, CA, ASEAN 2.0)**

Country

- Insights for policy and decision makers for areas in which action is needed at a country level
- 13 country reports for major economies
- **3 near finalization, 2 more in pipeline**

Thematic

- Provide detailed technical and economic analysis on specific topics (i.e. Future of Wind/Solar PV,RE investments, stranded assets, district heating and cooling etc.)
- **9 thematic studies**

RGorini@irena.org

OBRIGADO