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International Renewable Energy Agency

GLOBAL RENEWABLES OUTLOOK

The global energy transformation and its implications on technology pathways, investment needs and costs

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About IRENA

Established in 2011.

161 Members; 22 States in accession.

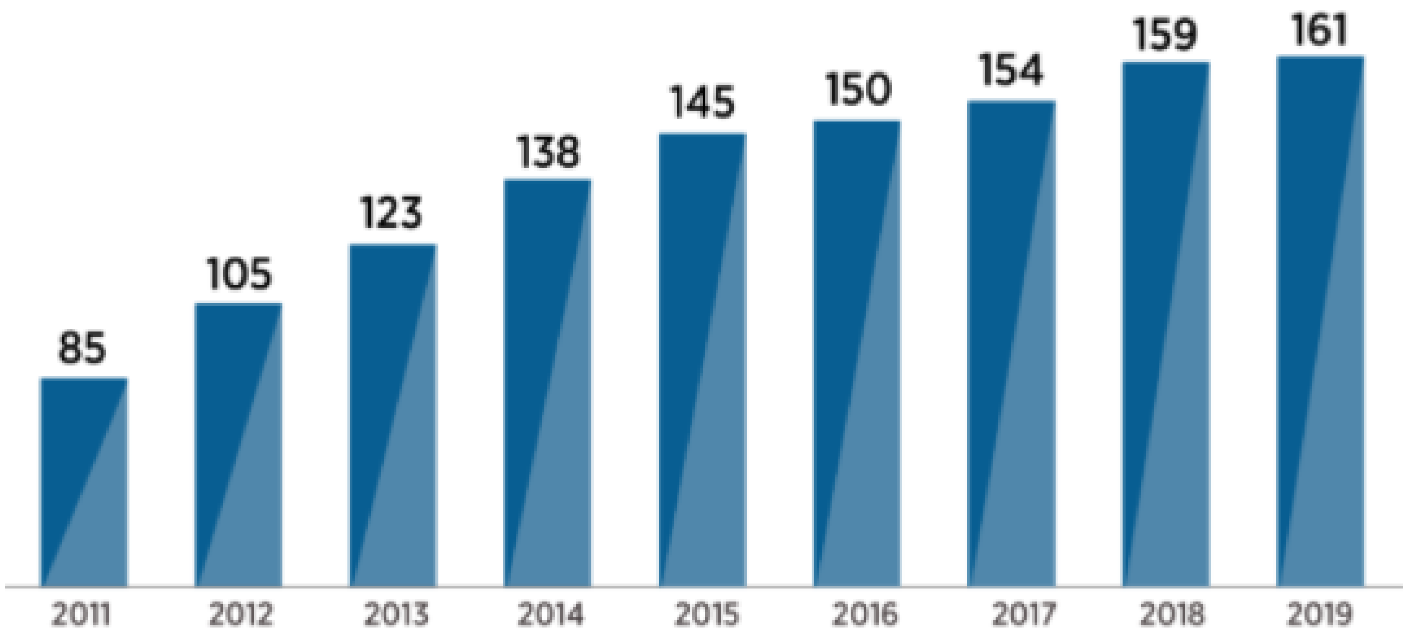
Mandate: to promote the **widespread adoption and sustainable use of all forms of renewable energy**

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

Growth in IRENA Membership



IRENA **Offices**

IRENA Headquarters
Masdar City

IRENA Innovation and Technology Center

IRENA - Office of the Permanent Observer to the United Nations

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.
- **6 global reports (‘14, ‘16, ‘17, ‘18, ‘19, ‘20)**

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**

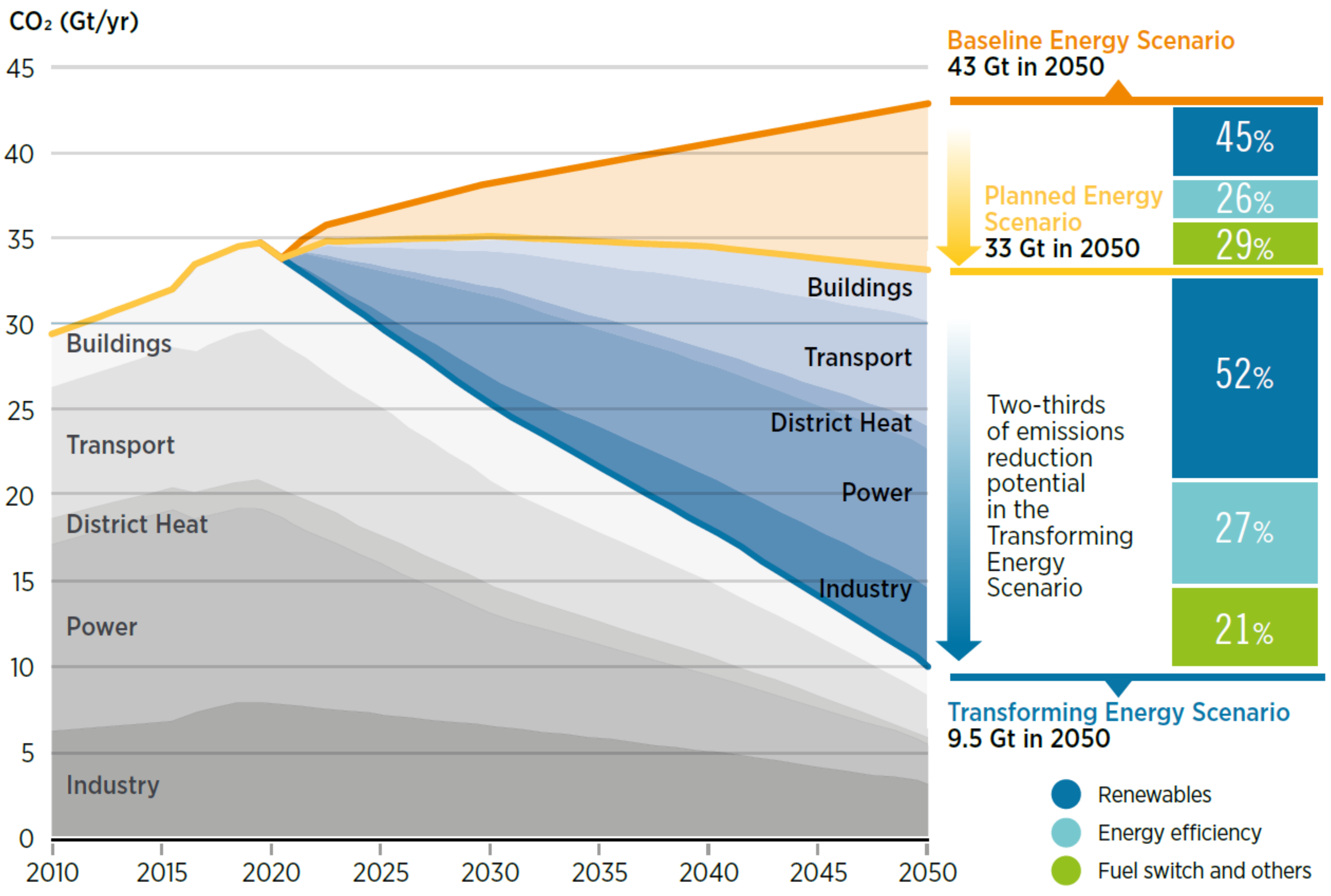
Thematic

- 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**

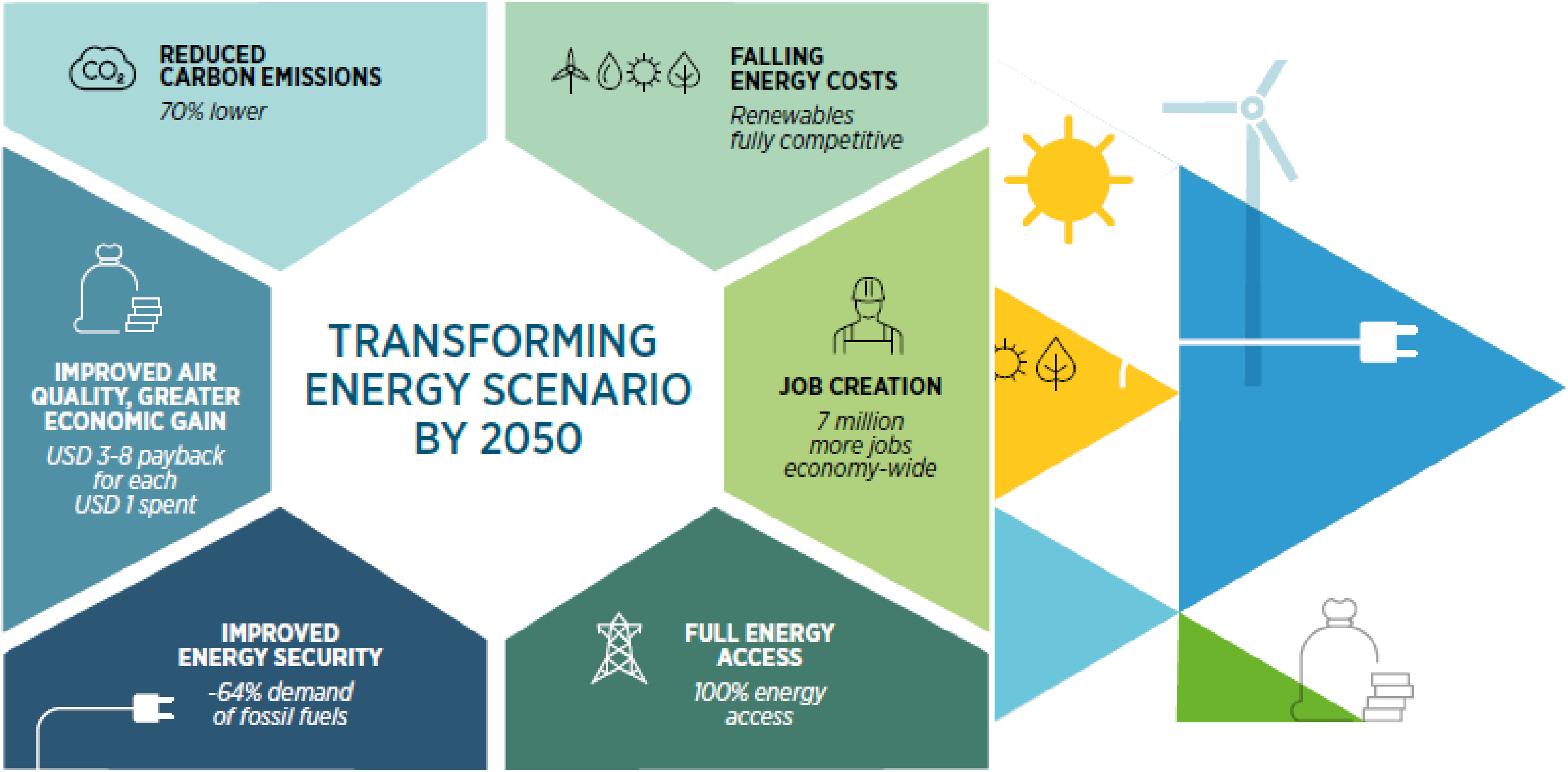
The bulk of emission reductions: renewable and efficiency

- To achieve the Transforming Energy Scenario, **energy-related CO_2 emissions need to fall** by 3.8% per year on average until 2050.
- Annual energy-related CO_2 emissions would need to **decline by 70% below today's level by 2050**.
- **Over half of the necessary reductions come from renewables and one quarter from energy efficiency measure**s.
- When including **direct and indirect electrification** (such as green hydrogen and technologies like EVs), the **total reductions increase to over 90%** of what is required.

Energy-related CO2 emissions, 2010-2050



Key drivers for the energy transformation



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

Indicator	Historical progress 2015-2018	Where we are heading (● PES / 2030 and 2050)	Where we need to be (● TES / 2030 and 2050)
Renewable energy share in TFEC (% modern)	9.5% (2015) → 10.5% (2018)	17% (2030); 25% (2050)	28% (2030); 66% (2050)
Energy intensity improvement rate (%/yr)	1.8% (2015-2018)	2.4% (2030); 2.6% (2050)	3.6% (2030); 3.2% (2050)

- **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.

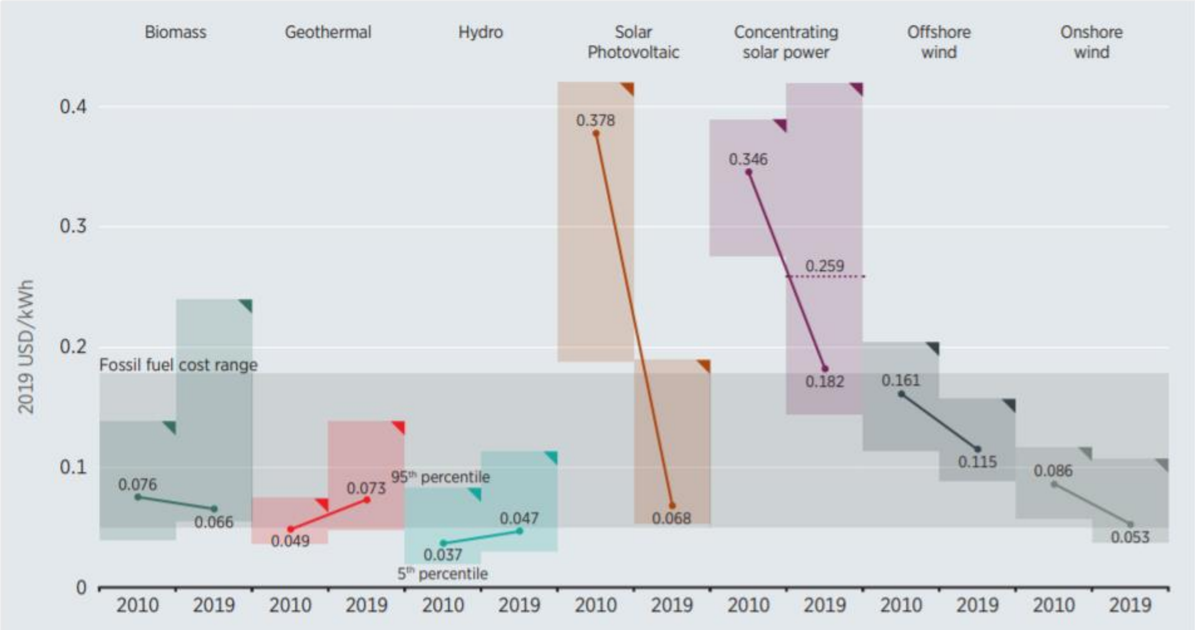
An increasingly electrified energy system

Indicator	Historical progress 2015-2018/2019	Where we are heading (● PES/2030 and 2050)	Where we need to be (● TES/2030 and 2050)
Renewable share in electricity generation (%)	23% (2015) → 26% (2018)	38% (2030), 55% (2050)	57% (2030), 86% (2050)
Electrification share of final energy (%)	19% (2015) → 20% (2017)	24% (2030), 30% (2050)	29% (2030), 49% (2050)
Technologies			
Electric cars (mln units)	1.2 mln (2015) → 7.9 mln (2019e)	269 mln (2030), 627 mln (2050)	379 mln (2030), 1 109 mln (2050)
Heat pumps (mln units)	20 mln (2017) → 38 mln (2019e)	63 mln (2030), 119 mln (2050)	155 mln (2030), 334 mln (2050)

- **Renewable power generation technologies are setting records for low costs and new capacity** despite falling renewable energy subsidies and slowing global GDP growth.
- **Gross generation of electricity needs to increase from around 26,000 TWh today, to over 55,000 TWh by 2050**
- **The electrification of end uses will drive increased power demand to be met with renewables**

Renewable power costs continue to decline

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

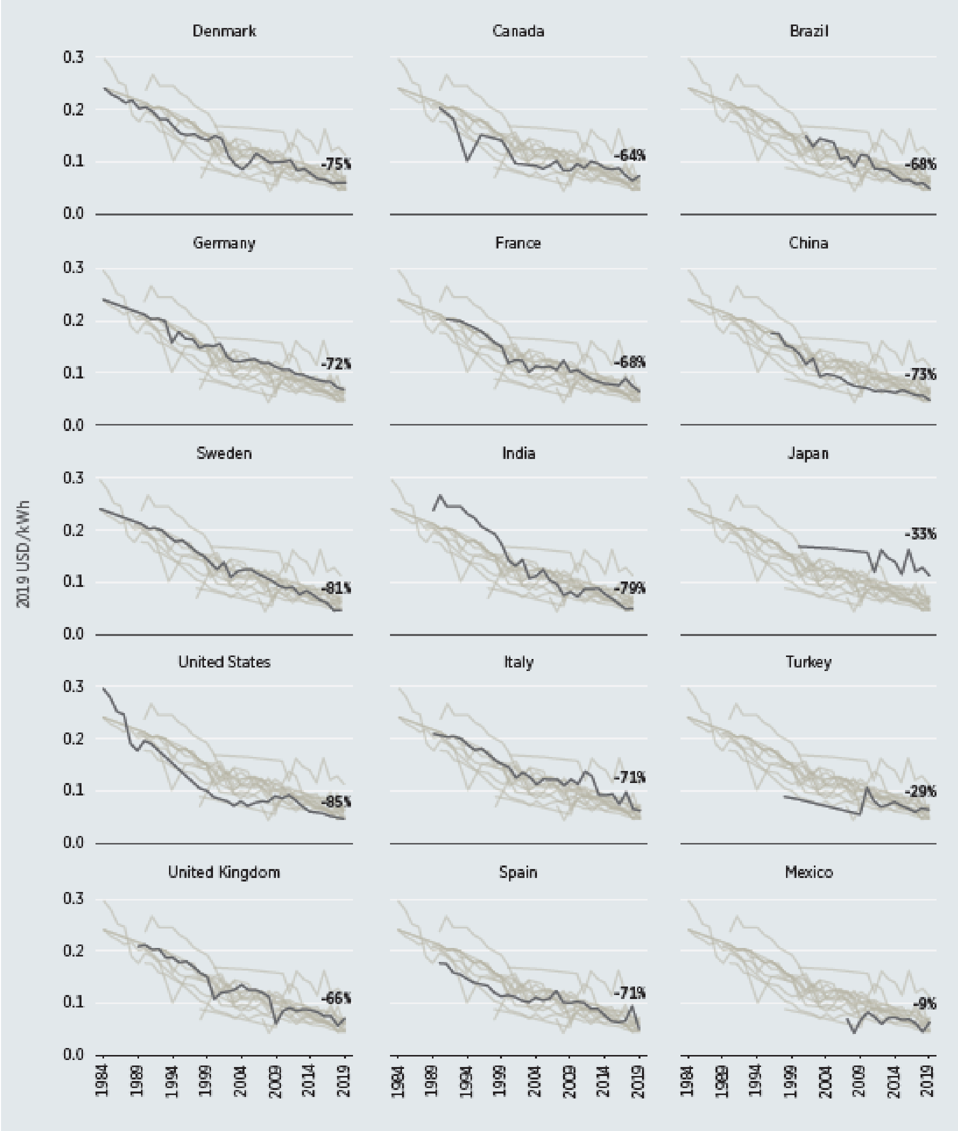


Note: For CSP, the dashed bar in 2019 shows the weighted average value including projects in Israel.

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.

Globally by technology (above) and across all regions (right) e.g. for wind

Figure 2.9 The weighted average LCOE of commissioned onshore wind projects in 15 countries, 1984–2019



Source: IRENA Renewable Cost Database.

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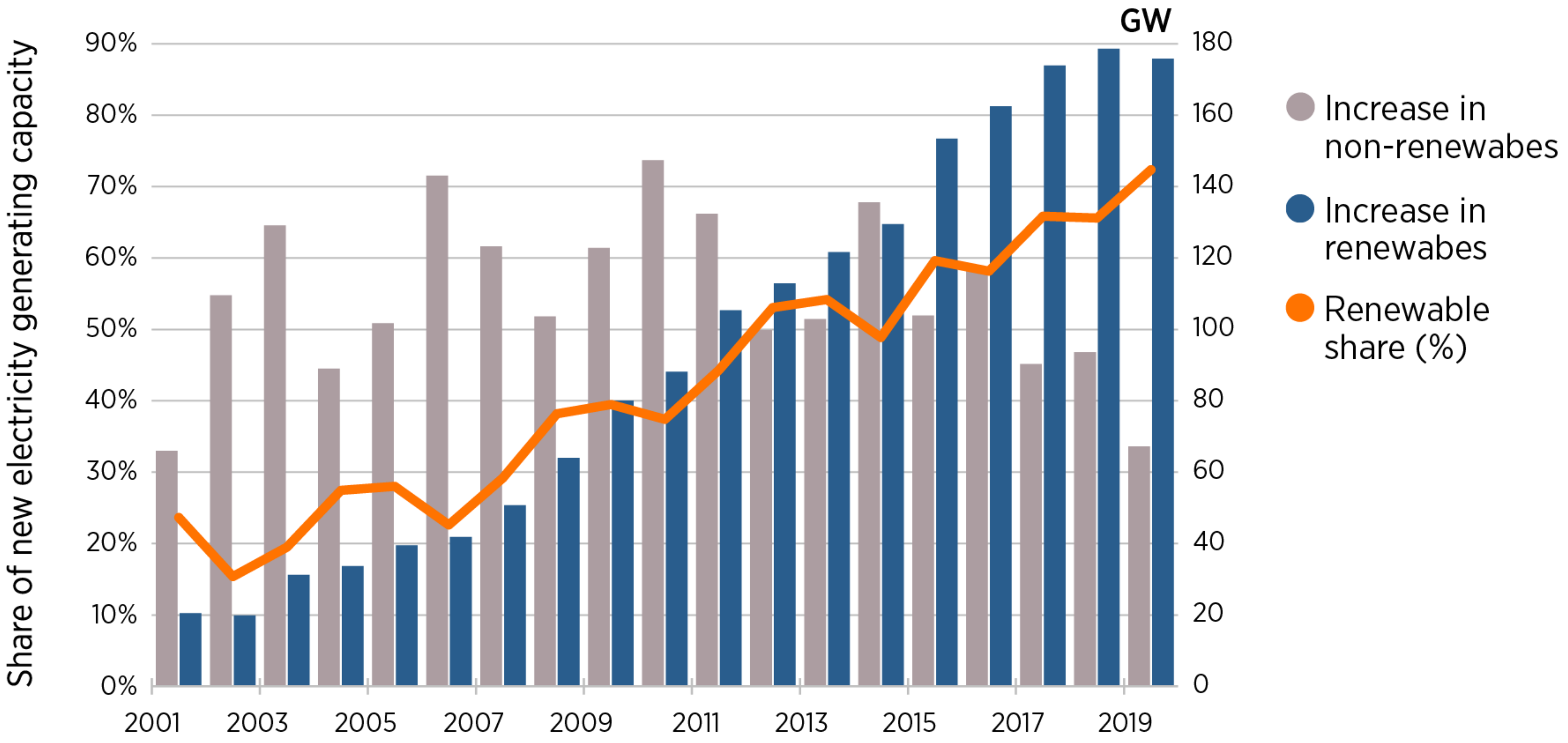
Renewables continue to dominate new capacity expansion



Renewables now account for one third of global power capacity today

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 flexibilit**y.

Indicator		Historical progress 2015-2018/2019		Where we are heading (PES/2030 and 2050)		Where we need to be (TES/2030 and 2050)	
VRE share in generation (%)		4.5% (2015)	10% (2018)	19% (2030)	36% (2050)	35% (2030)	61% (2050)
GW of VRE (GW)	Solar	222 GW (2015)	582 GW (2019e)	2 037 GW (2030)	4 474 GW (2050)	3 227 GW (2030)	8 828 GW (2050)
	Wind	416 GW (2015)	624 GW (2019e)	1 455 GW (2030)	2434 GW (2050)	2526 GW (2030)	6 044 GW (2050)
Enabling Technologies							
Storage stationary (GWh)		30 GWh (2019e)		370 GWh (2030)	3 400 GWh (2050)	745 GWh (2030)	9 000 GWh (2050)
Storage EVs (GWh)		200 GWh (2019e)		3 294 GWh (2030)	7 546 GWh (2050)	5 056 GWh (2030)	14 145 GWh (2050)

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Hydrogen: A key part of future energy systems

Indicator	Historical progress 2015-2018	Where we are heading (PES / 2030 and 2050)		Where we need to be (TES / 2030 and 2050)	
		2030	2050	2030	2050
Blue H_2 (Mt and EJ)	0.6 Mt / 0.08 EJ (2015 - 2018)	10 Mt 1.25 EJ	40 Mt / 5 EJ	30 Mt 3.75 EJ	80 Mt / 10 EJ
Green H_2 (Mt and EJ)	1.2 Mt / 0.16 EJ (2015 - 2018)	9 Mt 1.1 EJ	25 Mt / 3 EJ	25 Mt / 3 EJ	160 Mt / 19 EJ
Green H_2 production costs (USD/kg)	4.0 - 8.0 USD/kg (2015 - 2018)	2.5 - 5.0 USD/kg	1.6 - 3.3 USD/kg	1.8 - 3.2 USD/kg	0.9 - 2.0 USD/kg
Electrolysers (GW)	0.04 GW (2016)	100 GW	270 GW	270 GW	1 700 GW
Electricity demand to produce H_2 from renewables (GW)	0.26 TWh (2016)	450 TWh	1 200 TWh	1 200 TWh	7 500 TWh

- **Hydrogen can offer a solution** for types of energy demand that are hard to directly electrify.
- **Green hydrogen will become cost competitive with "blue" hydrogen in the next few years** in locations with favourable low-cost renewable electricity.
- **Hydrogen can be processed further into hydrocarbons or ammonia**, which can then help reduce emissions in shipping and aviation.

Note: Hydrogen produced from fossil fuels without CCS is called grey hydrogen, with CCS is called blue hydrogen, and if made from renewable power through electrolysis it is called green hydrogen. RE = Renewable Energy

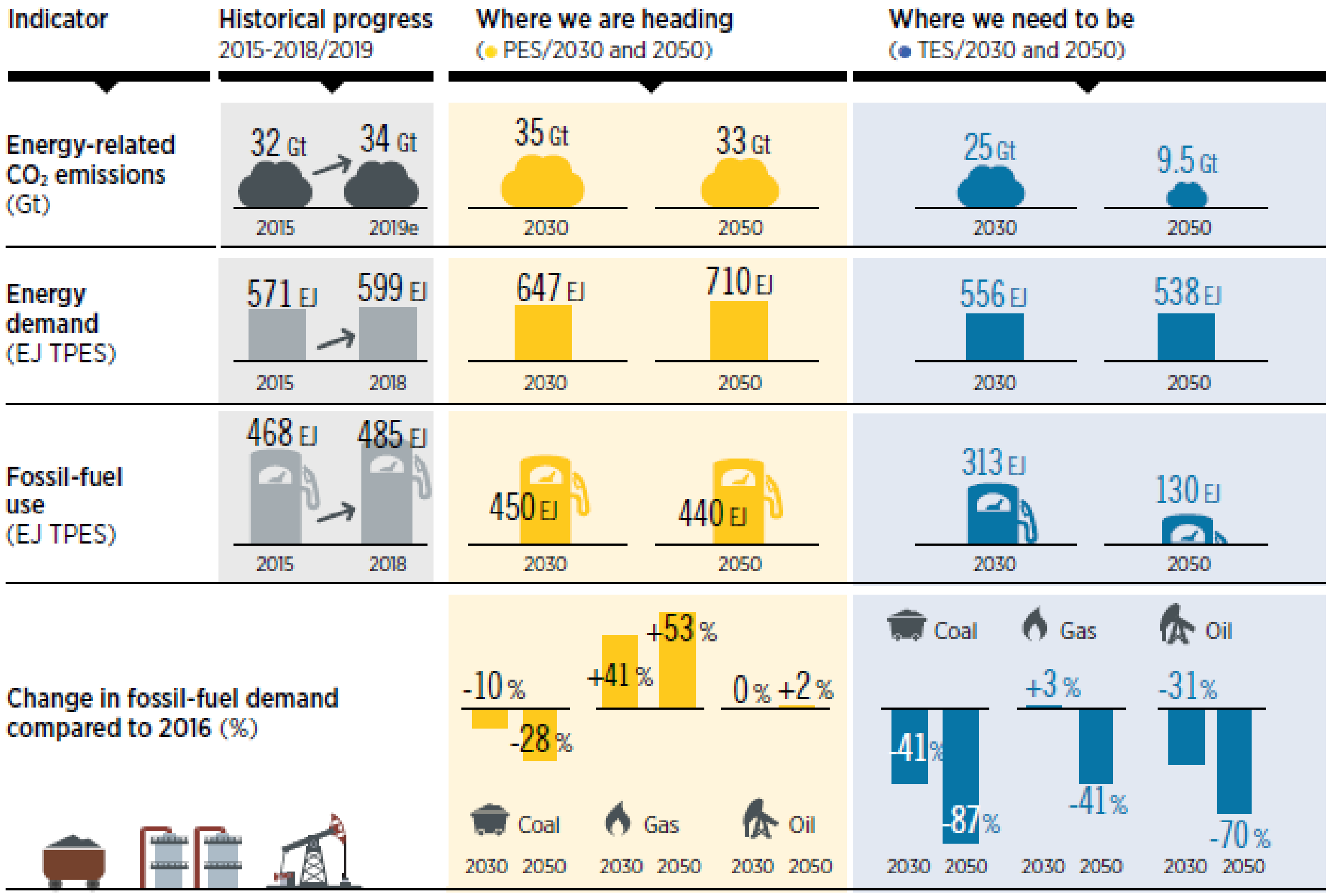
Vital to any future energy system: Hydropower and bioenergy

Indicator	Historical progress 2015-2017/2018/2019		Where we are heading (PES/2030 and 2050)		Where we need to be (TES/2030 and 2050)	
	2015	2019	2030	2050	2030	2050
Hydropower (GW)	1 099 GW	1 189 GW	1 356 GW	1 626 GW	1 444 GW	1 822 GW
Pumped hydro storage (GW)	112 GW	121 GW	200 GW	300 GW	225 GW	325 GW
	2015	2018	2030	2050	2030	2050
Share of TPES provided by bioenergy (%) (total)	8.7 %	9.5 %	9 %	10 %	12 %	23 %
Share of TPES provided by bioenergy (%) (modern)	4.1 %	5.1 %	8 %	10 %	12 %	23 %
	2015	2017	2030	2050	2030	2050
Liquid biofuel production (bln litres)	129 bln ltr	136 bln ltr	285 bln ltr	393 bln ltr	378 bln ltr	652 bln ltr

Note: The total bioenergy share includes traditional uses of biofuels. In PES their use is reduced considerably by 2030, but not entirely phased out, whereas in PES their use is entirely phased out by 2030.

- **Hydropower can bring important synergies to the energy system of the future.** In the Transforming Energy Scenario, hydropower capacity would need to increase 25% by 2030, and 60% by 2050.
- **Bioenergy will become increasingly vital in end-use sectors.** In the Transforming Energy Scenario, it plays an important role, particularly in sectors that are hard to electrify, such as in shipping and aviation and in industry, both for process heat and use as a feedstock.

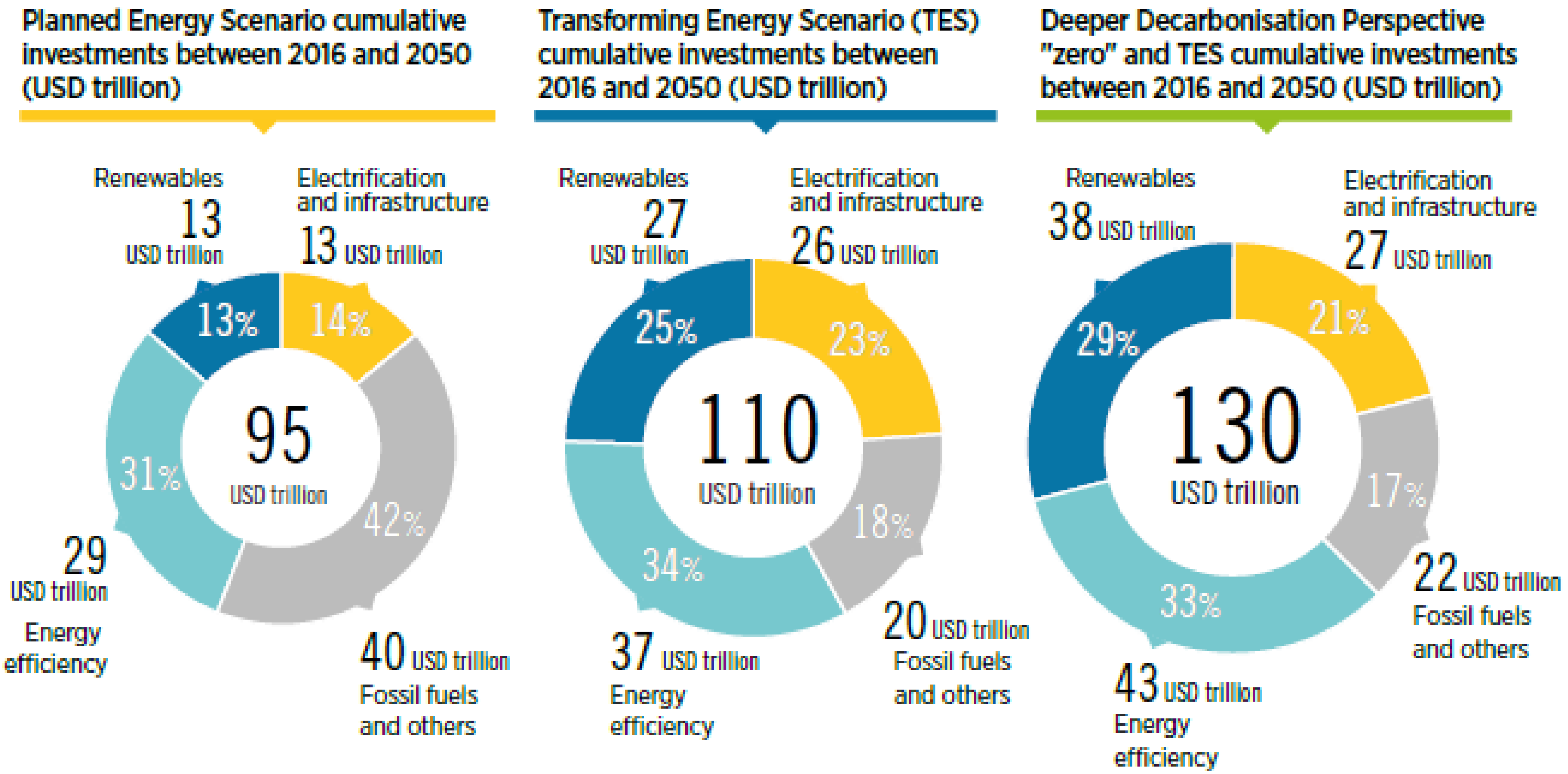
The changing nature of energy and fossil-fuel use



- Recent energy trends confirm the **need to accelerate a reduction in CO_2 emissions.**
- **Fossil fuels continue producing negative effects** in many parts of the world.
- The Transforming Energy Scenario would **cut fossil-fuel use by about 75%** by midcentury.

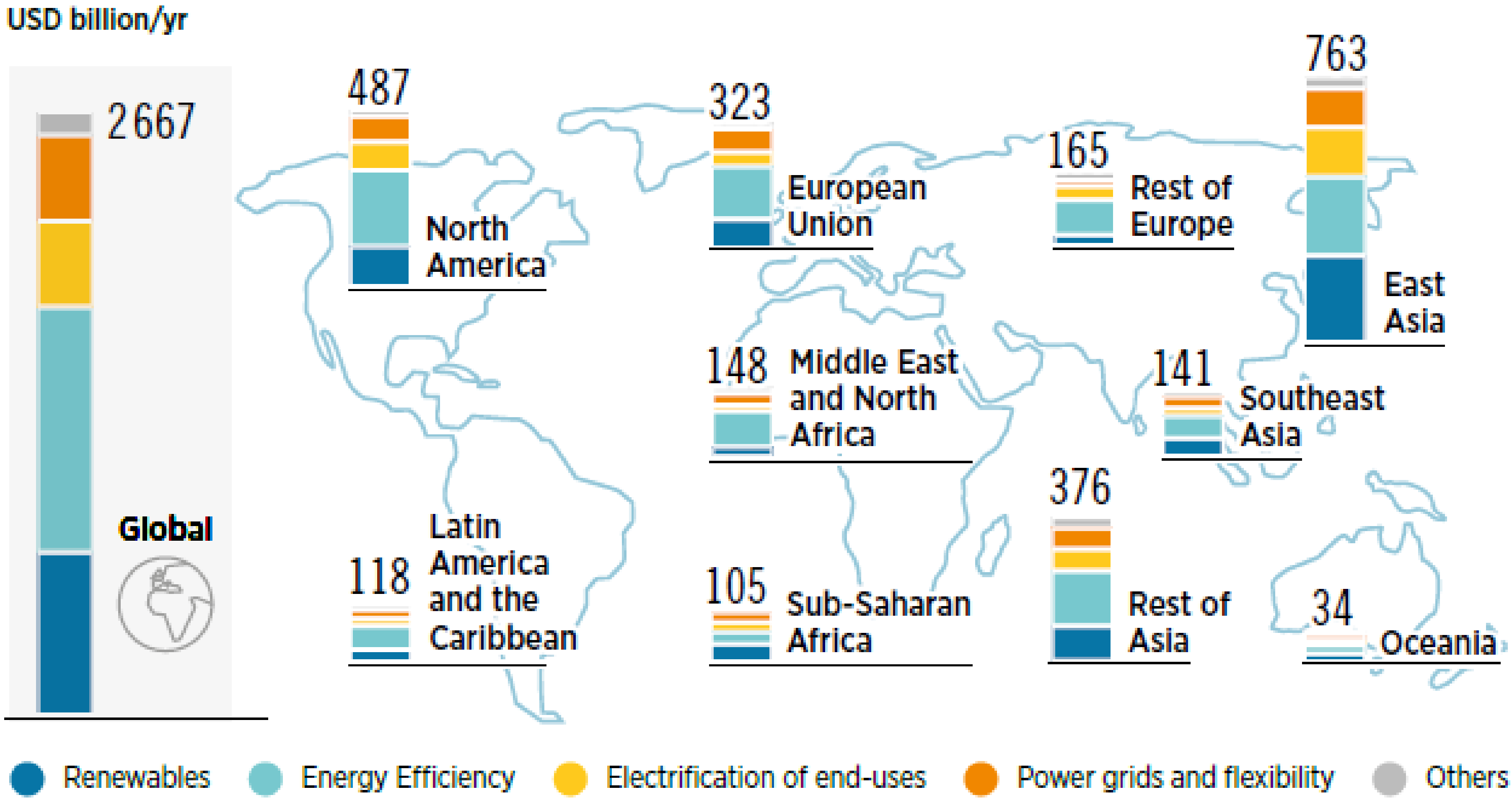
Note: TPES = total primary energy supply. e = estimate; Gt = gigatonnes; EJ = exajoules.

New investment priorities: renewables, efficiency and electrification



- **Total investment in the energy system in the Transforming Energy Scenario would reach USD 110 trillion** by 2050, or around **2% of average annual GDP over the period**. Of that total, over **80% needs to be invested in renewables, energy efficiency, end-use electrification, and power grids and flexibility.**
- **The Deeper Decarbonisation Perspective** would require an **additional investment of USD 20 trillion**.

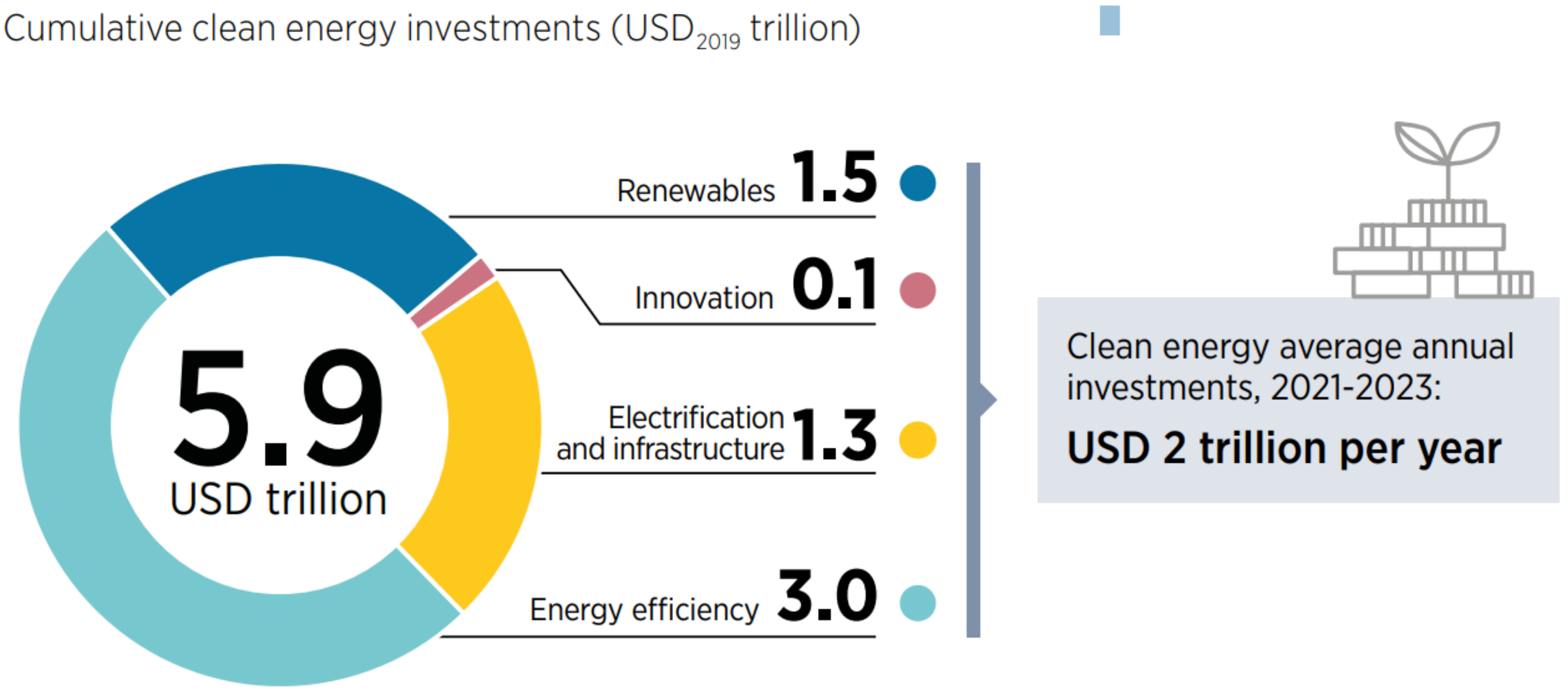
Investment needs by region to 2050



- Annual investments in energy transformation amount to **USD 2.7 trillion per year globally.**
- **East Asia will require the largest sum**, followed by North America, Rest of Asia, and the EU.

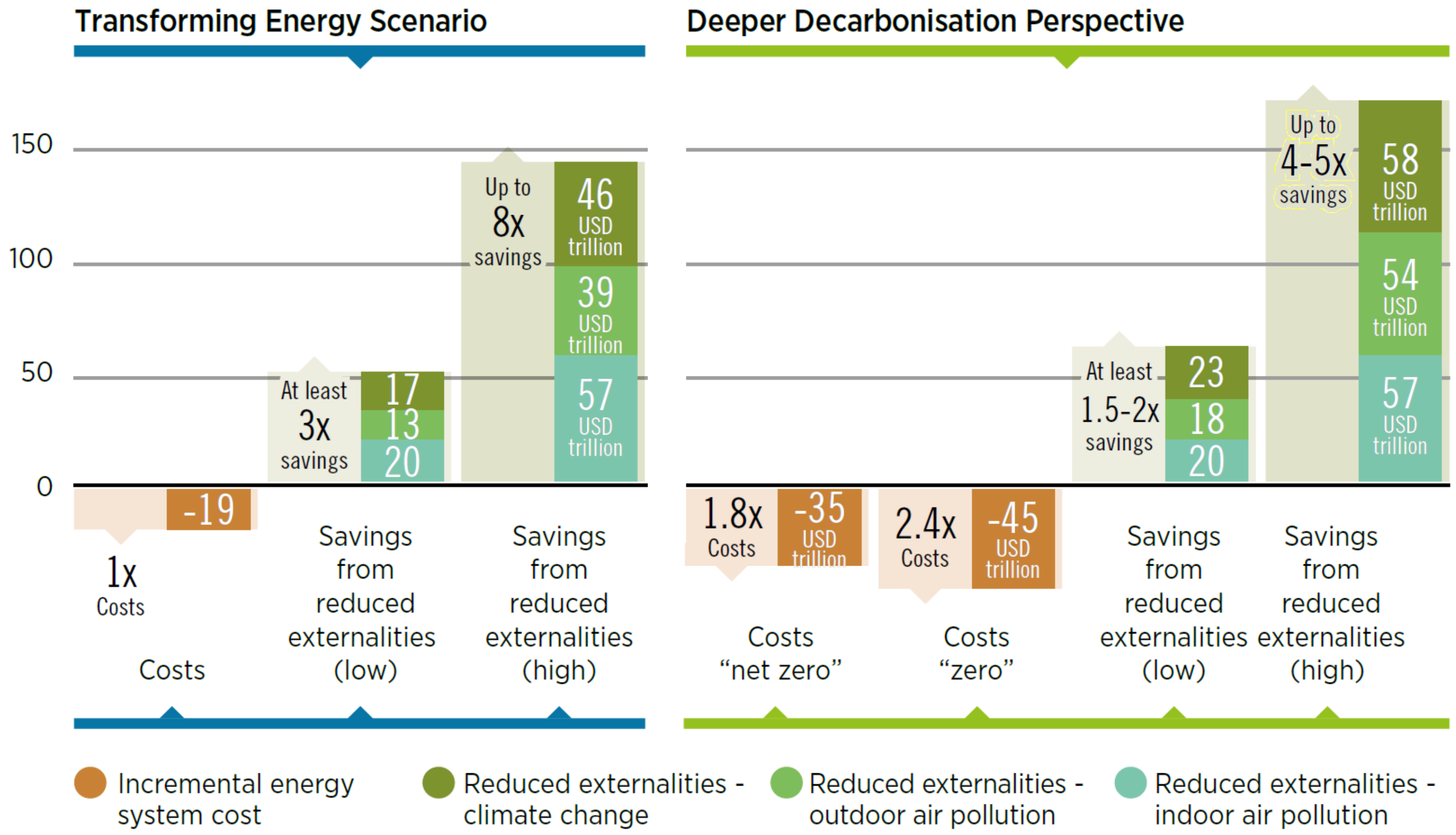
New investment priorities: renewables, efficiency and electrification

Figure ES.1 Energy transition investment under the Transforming Energy Scenario, 2021-2023



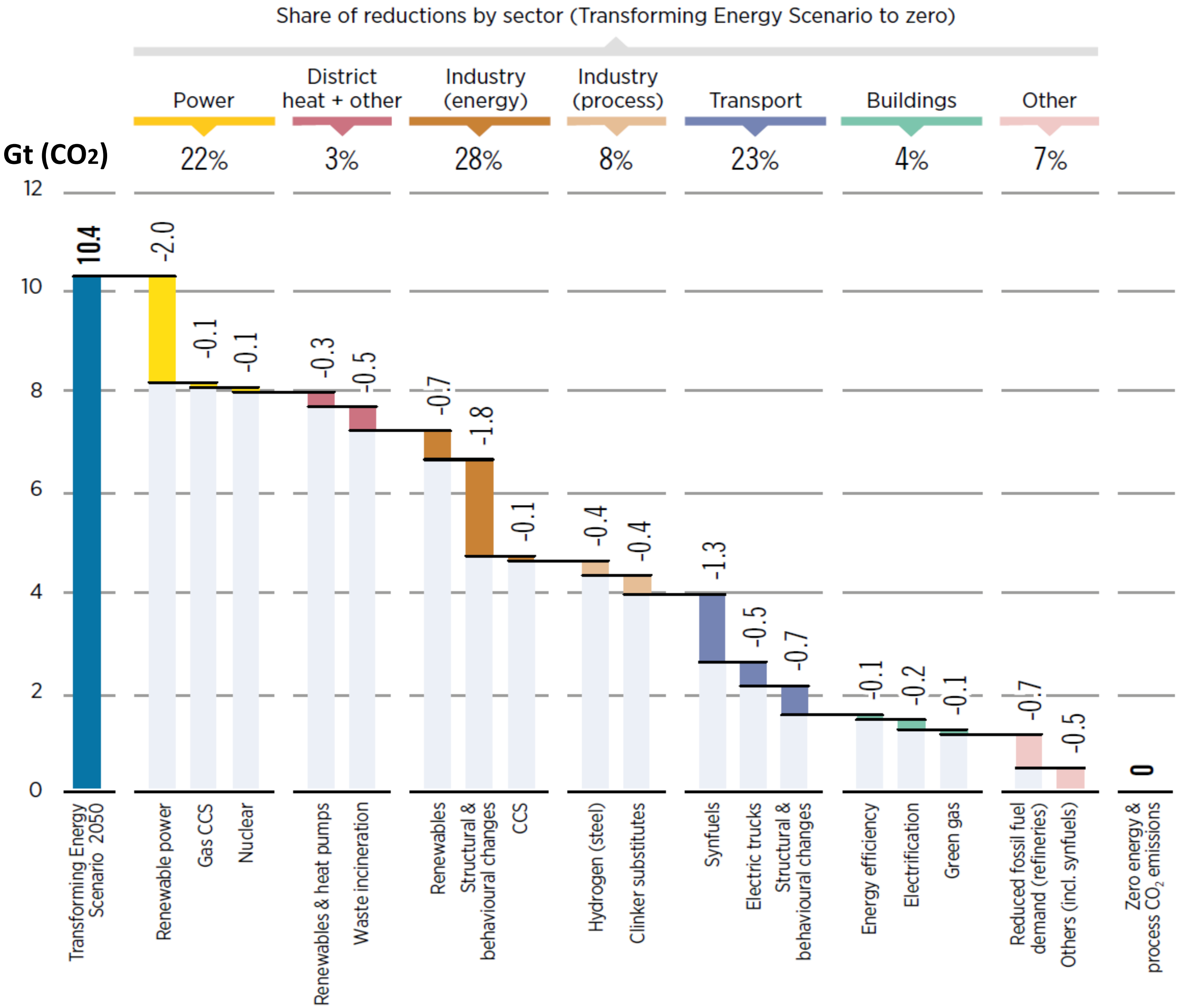
- **In the 2021-2023-recovery phase, investments should more than double to nearly USD 2 trillion and then continue to grow to an annual average of USD 4.5 trillion in the decade to 2030; this would result in over 4.4 million more jobs compared to not investing in transition technologies**

The energy transition: Benefits compared to costs



- **The payback for accelerating renewables deployment and efficiency measures is many times larger than the costs.** In the Transforming Energy Scenario, **every USD 1 spent** for the energy transition would bring a **payback of between USD 3 and USD 8.**

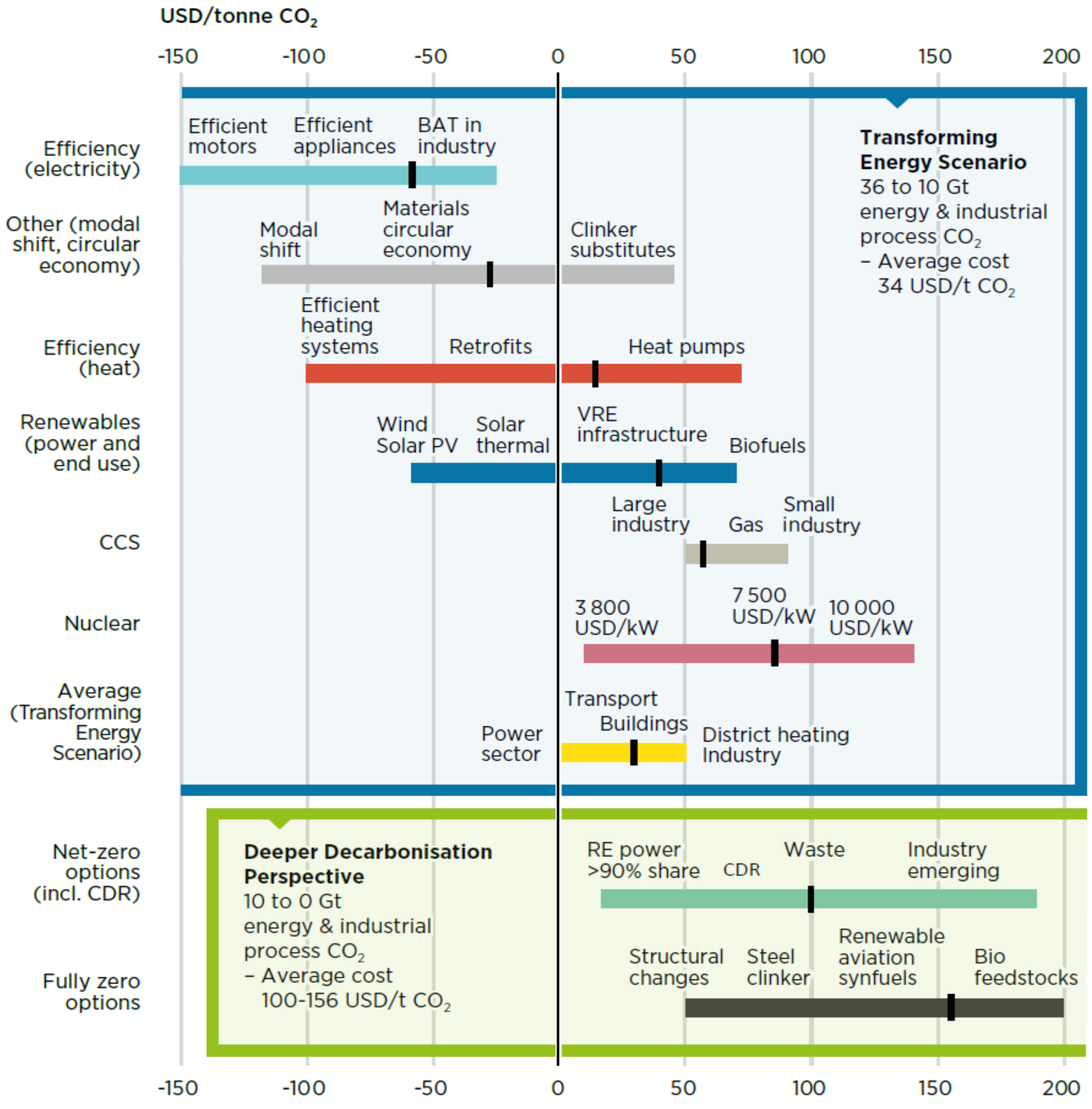
The Deeper Decarbonisation Perspective: Getting to "zero"



- With this approach, all energy and industrial processes are completely decarbonised so that **no CO2 is emitted at all**.

- The analysis assumes a policy objective to deliver the "zero" approach **in the decade following 2050**. It might be possible to shorten those time frames with sufficiently robust policy measurements, investment and improvements through innovation, but that is highly uncertain.

Mitigation costs for select technologies and groupings in 2050



- For **energy efficiency measures for electricity**, the mitigation costs fall in the USD -150/tonne to USD -20/tonne range.
- **Heating efficiency measures** range from USD -100/tonne to USD +70/tonne.
- The mitigation costs of most **renewables** are between USD -50/tonne and USD +50/tonne (even when including infrastructure costs).
- **All these technologies mentioned above are much cheaper than fossil fuel or nuclear alternatives.**

Thank you very much!

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More information at www.irena.org/remap