



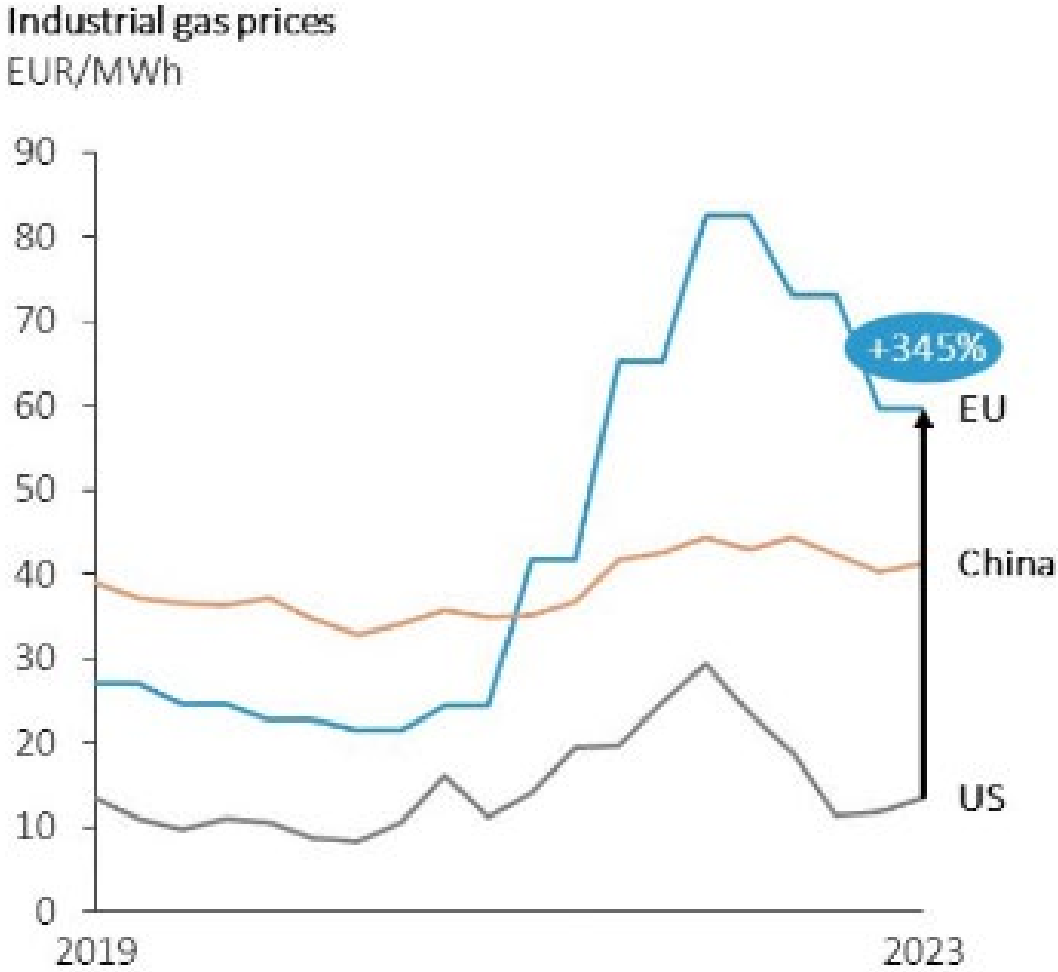
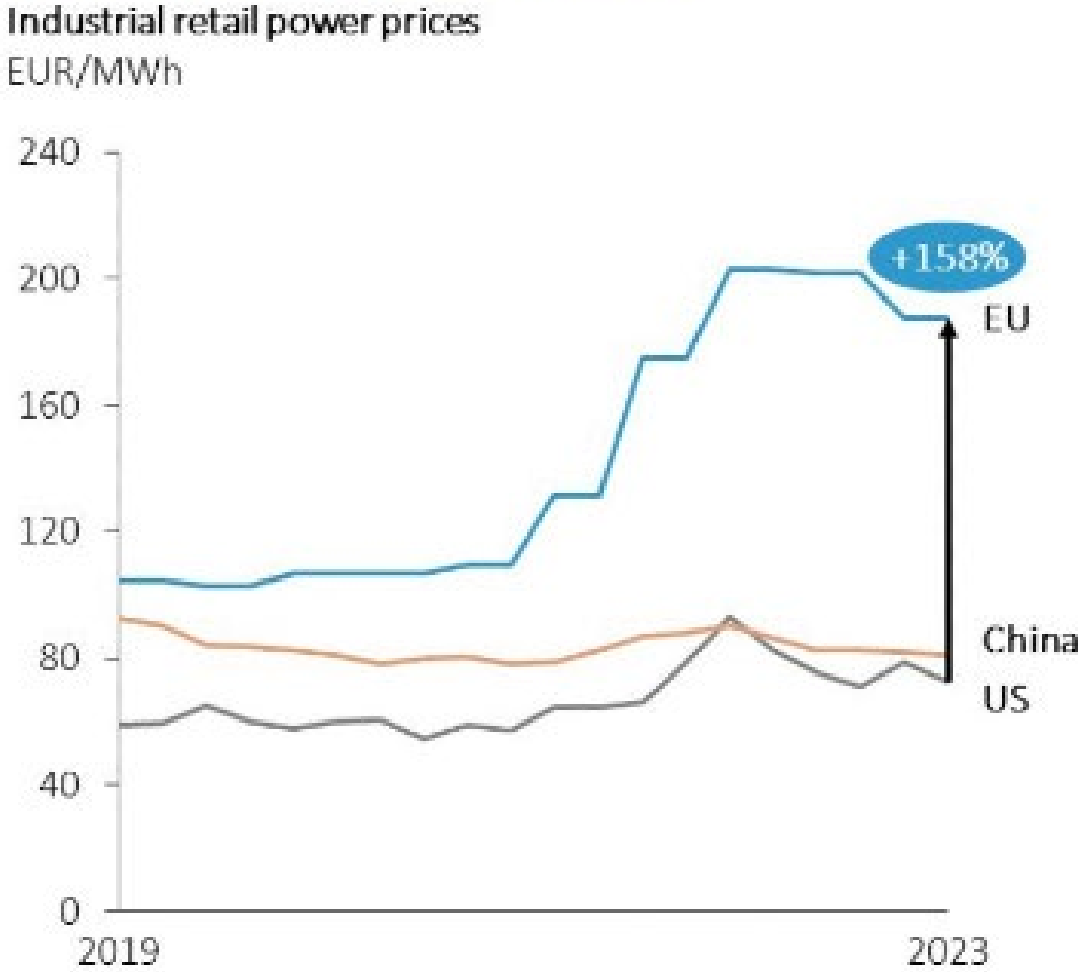
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RES, an outlook (oct 2024)

Livio de Santoli

Prorettore alla Sostenibilità, Sapienza Università di Roma_y

FIGURE 6
Gas and retail price gap for industry

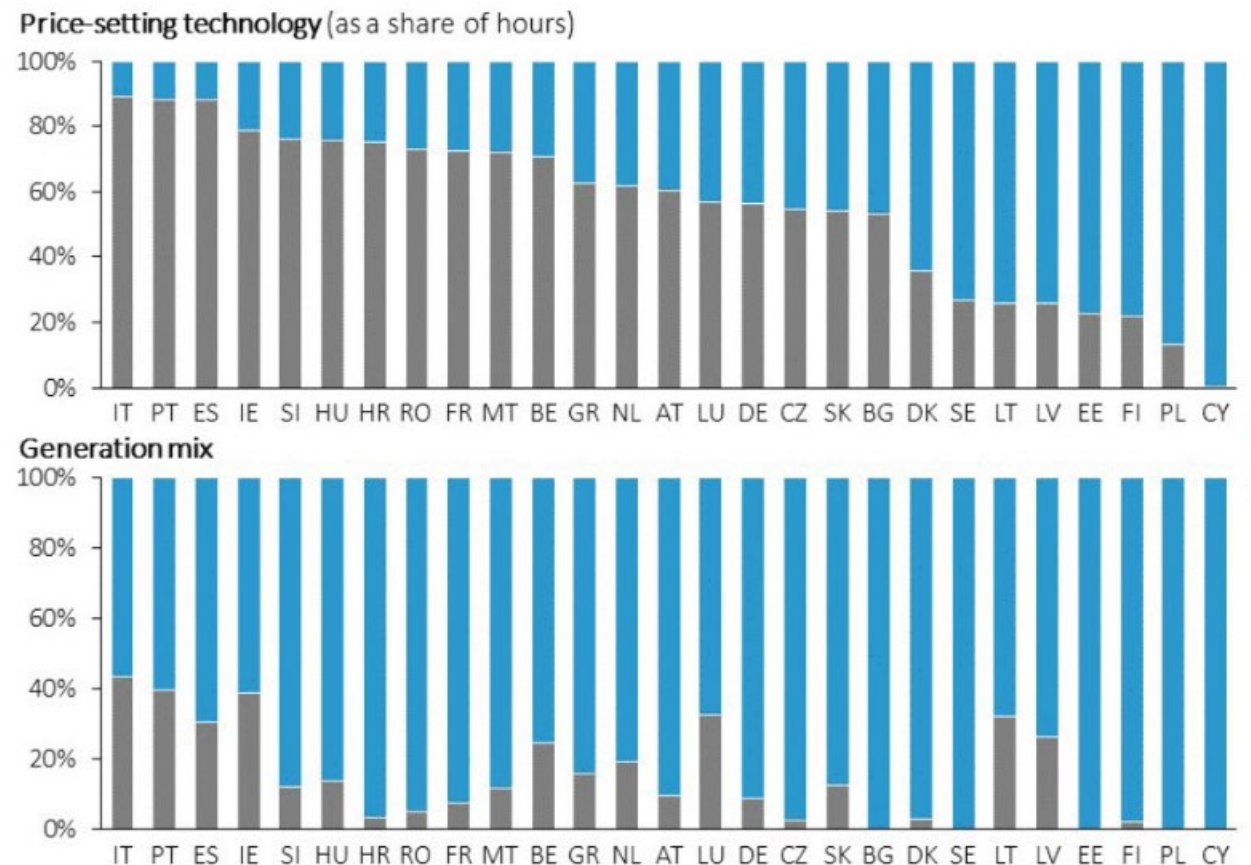


Source: European Commission, 2024. Based on Eurostat (EU), EIA (US) and CEIC (China), 2024.

FIGURE 5

Price-setting technology per Member State and their generation mix

%, 2022



Source: European Commission (JRC), 2023

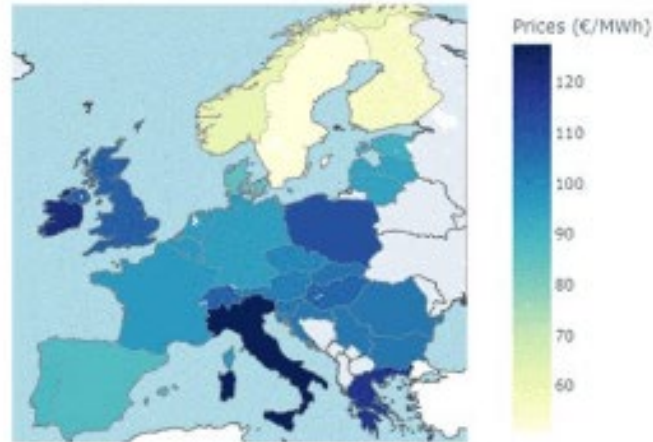
L'Italia è il Paese europeo più dipendente dal gas per produrre elettricità (qui circa per il 40%) e quello nel quale il gas ha il peso maggiore per determinare le tariffe elettriche (qui le fissa circa nel 90% dei casi).

FIGURE 6

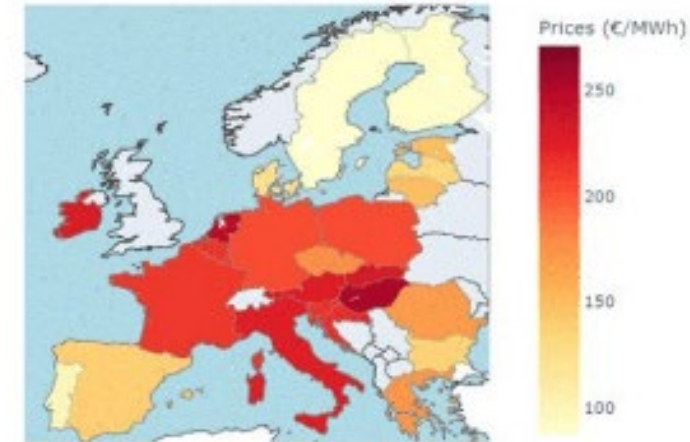
Electricity wholesale and retail prices across Member States for industry

EUR/MWh, 2023

Wholesale electricity prices



Retail electricity prices



Source: European Commission, 2024. Based on Eurostat, S&P Global, and ENTSO-E, 2024.

Nel 2023 l'Italia aveva i costi elettrici all'ingrosso più alti d'Europa – dunque del mondo – e i costi elettrici al dettaglio più alti di tutte le grandi economie europee.

Renewable energy highlights

11 July 2024

HEADLINE FIGURES

Electricity Generation

8 440 TWh

Renewables in 2022

29.1% | 7.2%

Renewables YoY Growth

11.7% | 18.2%

Variable YoY Growth

Renewables

Hydro **4 330 TWh**

Wind **2 098 TWh**

Solar **1 294 TWh**

Bioenergy **619 TWh**

Geothermal **97 TWh**

Marine **1 TWh**

Electricity capacity

3 865 GW

Renewables in 2023

43.0% | 14.0%

Renewables YoY Growth

27.1% | 23.4%

Variable YoY Growth

Renewables

Solar **1 418 GW**

Hydro **1 265 GW**

Wind **1 017 GW**

Bioenergy **149 GW**

Geothermal **15 GW**

Marine **1 GW**

11.17 TW target by 2030

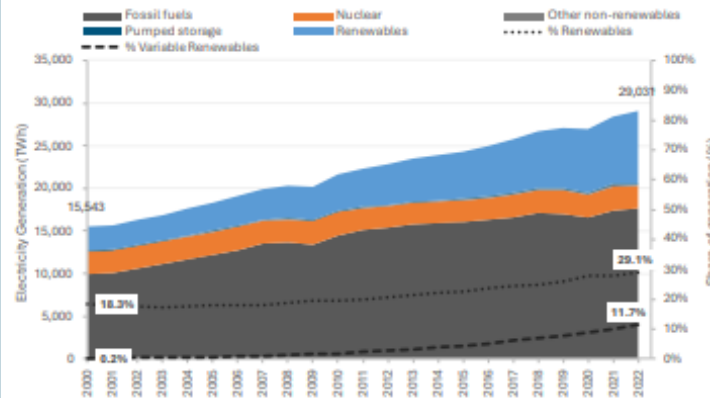
Progress To go

0.47 TW **7.31 TW**

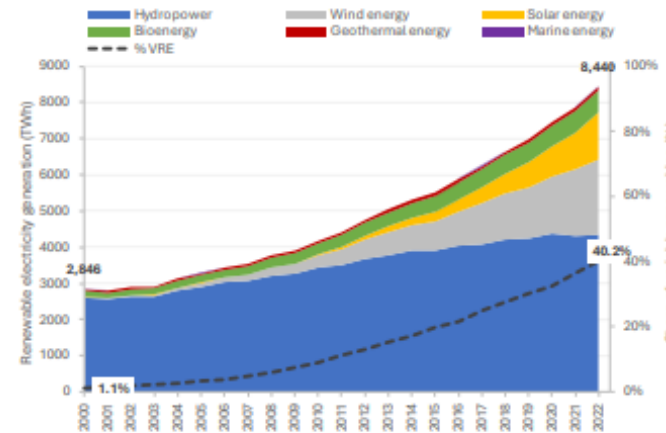
since 2022 to meet target

Electricity generation by energy source

Renewable energy sources accounted for 29.1% of electricity generation globally in 2022, totalling 8 440 TWh. The other 70.9% (20 591 TWh) corresponded to fossil fuels, nuclear energy, pumped storage and other non-renewables, bringing global electricity generation from all sources to 29 031 TWh in 2022.

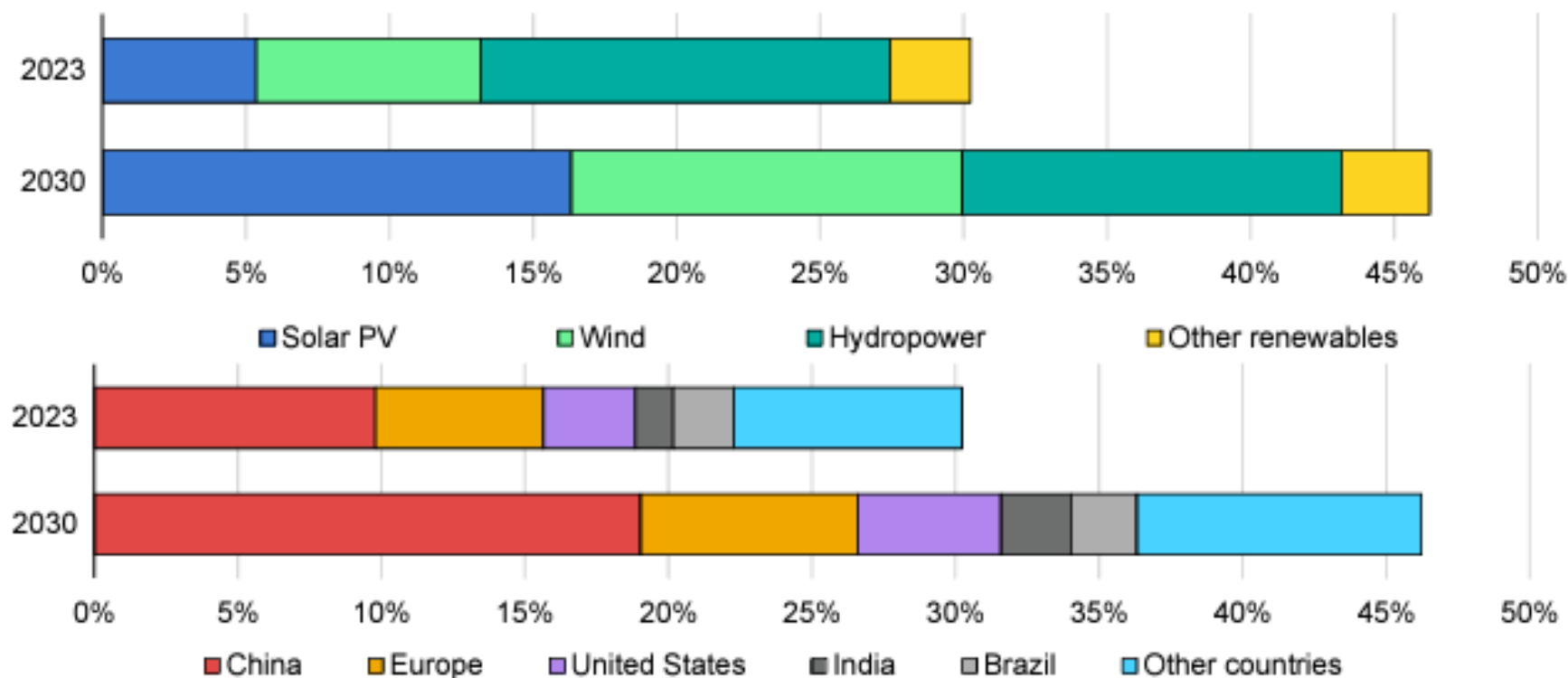


Total electricity generation increased by 2.4% annually since 2011. Renewables contributed at a rate of 6.1%, while non-renewables showed a 1.3% growth rate. In 2022 alone, renewable electricity grew by 7.2% over 2021. However, there have been similar and larger annual growth rates over the past decades. Since 2010, the largest growth in renewable electricity has been driven by solar and wind energy (variable renewables), which reached 11.7% of the global electricity mix in 2022 with a growth of 18.2% from 2021.



Renewable Energy Statistics 2024, IRENA

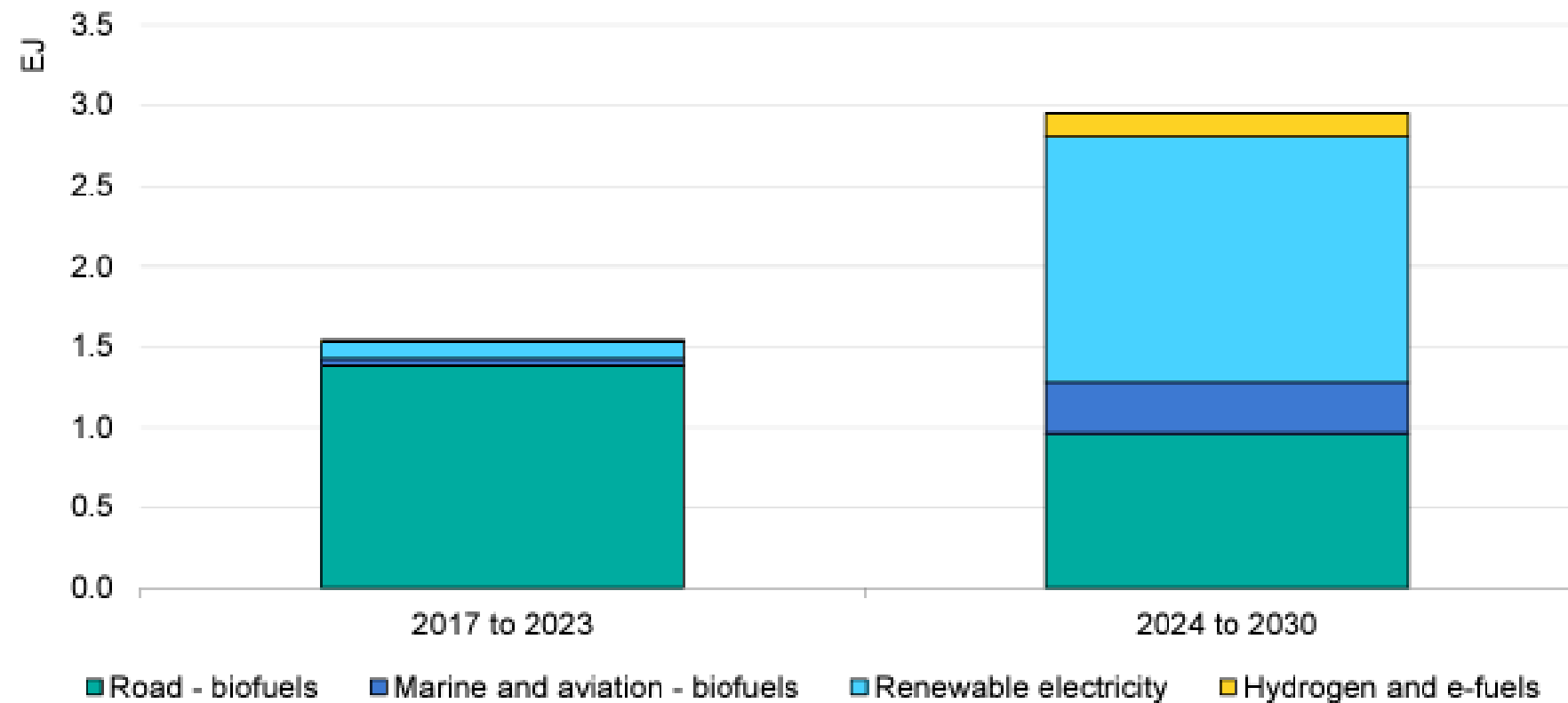
Global electricity generation by renewable energy technology and country/region, main case, 2023 and 2030



IEA. CC BY 4.0.

Notes: The electricity generation trajectories for wind and solar PV indicate potential generation, including current curtailment rates. However, they do not project future wind and solar PV curtailment, which may be significant in some countries by 2028. The "Increasing VRE Penetration Leads to Rising Curtailment" section in Chapter 2 discusses some recent trends.

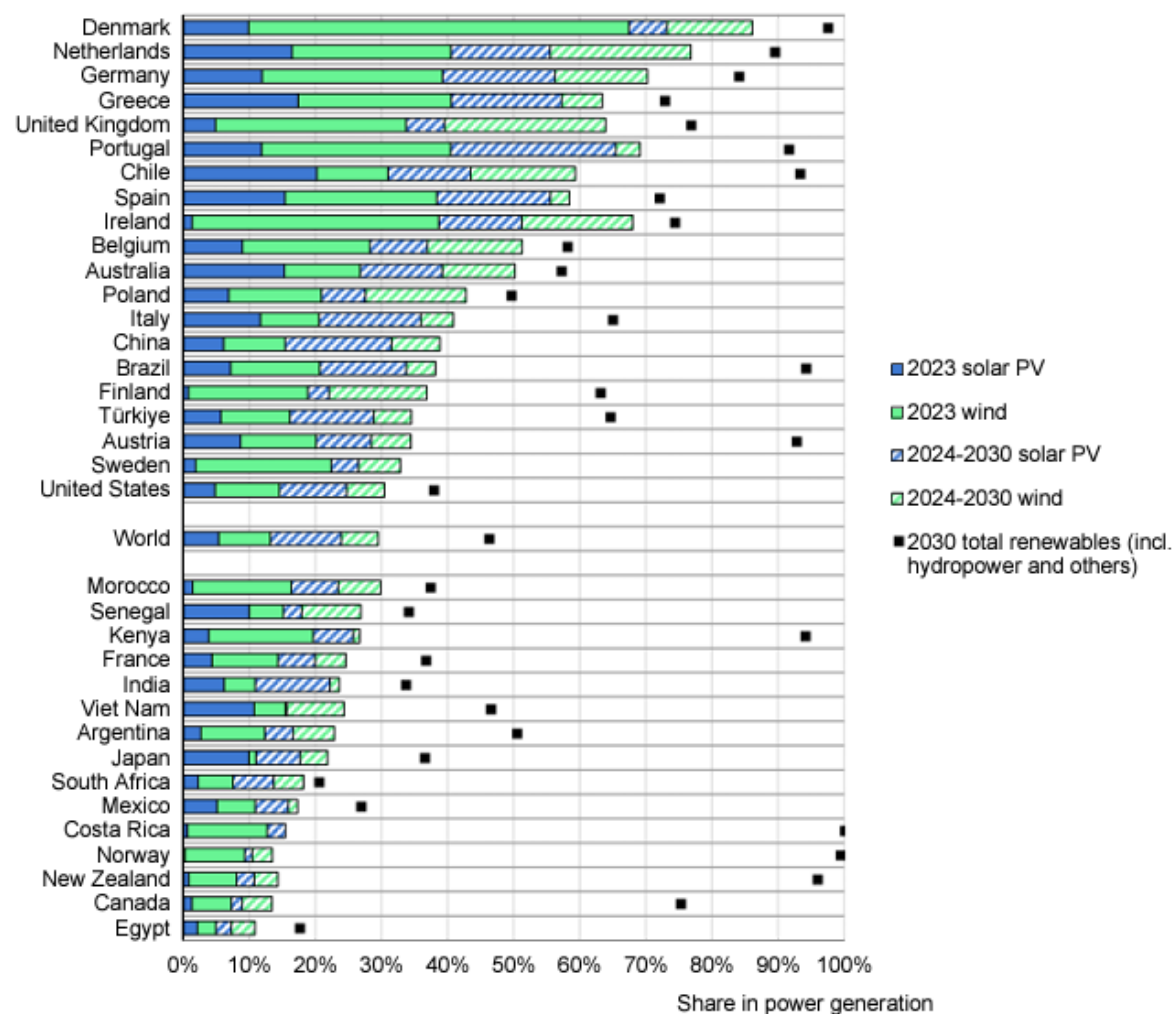
Transport sector renewable fuel growth by type, main case, 2016-2030



IEA. CC BY 4.0.

Sources: Electric vehicles consistent with IEA (2024), [Global EV Outlook 2024](#).

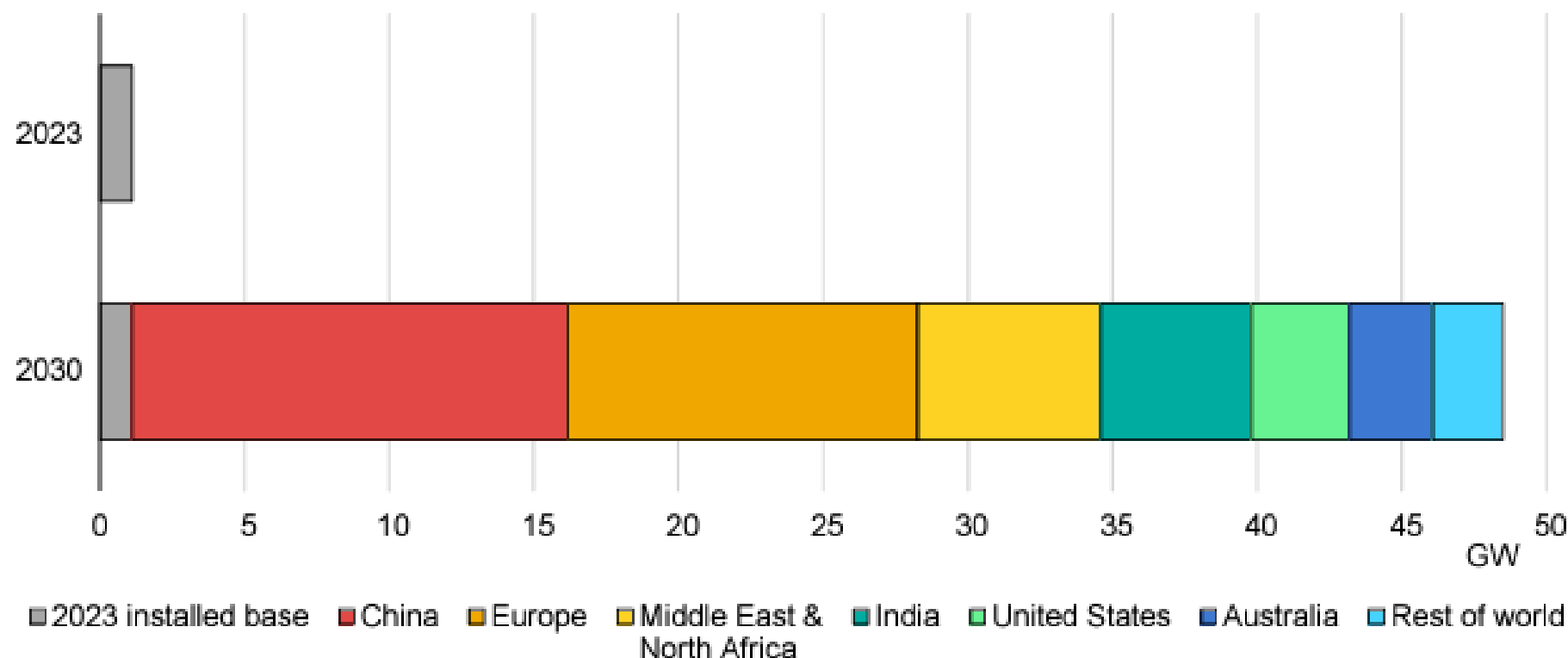
Selected country shares of variable and dispatchable renewable electricity generation, 2023-2030



IEA. CC BY 4.0.

Notes: 2024-2030 values are based on the main-case capacity forecast. "Others" include bioenergy, concentrated solar power, and geothermal and ocean energy. Electricity generation from wind and solar PV indicates potential generation under current curtailment rates, but does not project future curtailment, which may change notably in some countries by 2030. The curtailment section below (Increasing VRE Penetration Leads to Rising Curtailment) discusses curtailment trends for several countries.

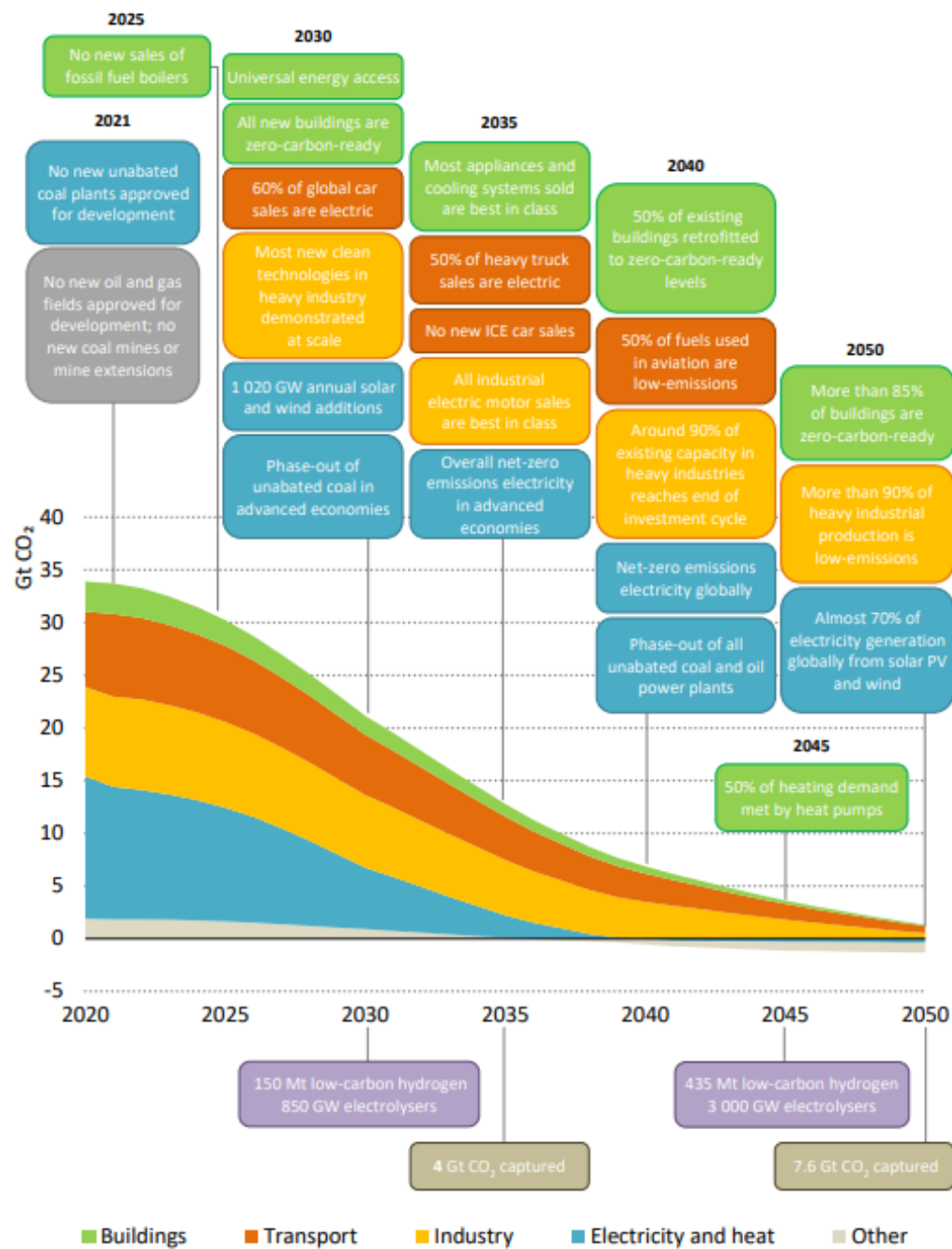
Installed electrolyser capacity and hydrogen production in 2023 and 2030



IEA. CC BY 4.0.

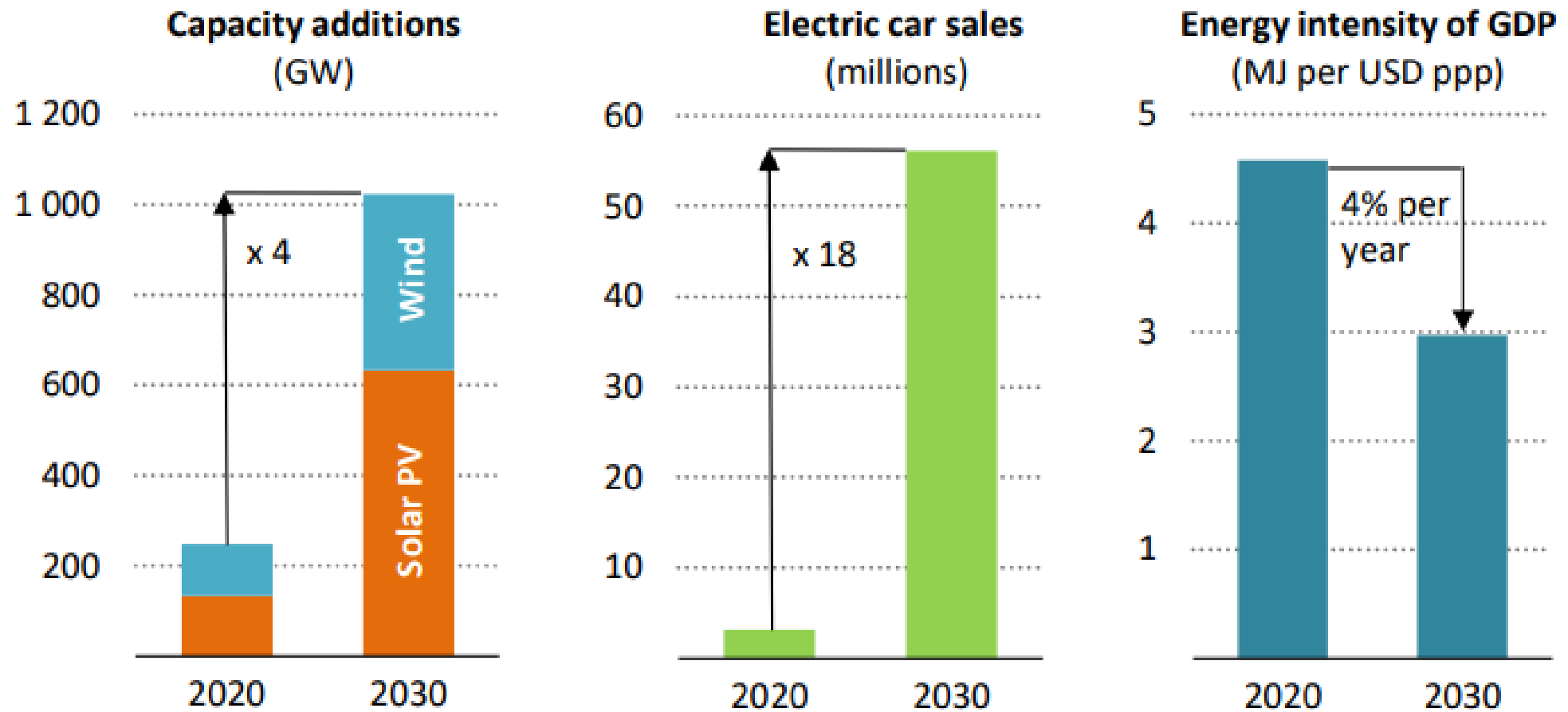
Sources: The 2030 electrolyser forecast is based on bottom-up project assessments and top-down policy and market evaluations. The main source is the [IEA's Global Hydrogen Database](#). Selected projects from this database were included in the forecast based on their status and an assessment of their ability to commission before 2030. The project pipeline also includes additional projects from other sources such as developer announcements, auction winners, and databases on electrolyser orders. Top-down estimates reflect anticipated demand driven by policies and regulations, not tied to specific projects.

Key milestones in the pathway to net zero



https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

Key clean technologies ramp up by 2030 in the net zero pathway



Note: MJ = megajoules; GDP = gross domestic product in purchasing power parity.

Table B.1 ► Electricity generation technology costs by selected region in the NZE

| | Financing rate (%) | Capital costs (\$/kW) | | | Capacity factor (%) | | | Fuel, CO ₂ and O&M (\$/MWh) | | | LCOE (\$/MWh) | | |
|-----------------------|--------------------|-----------------------|-------|-------|---------------------|-------------|-------------|--|------|------|---------------|-------------|-------------|
| | All | 2020 | 2030 | 2050 | 2020 | 2030 | 2050 | 2020 | 2030 | 2050 | 2020 | 2030 | 2050 |
| United States | | | | | | | | | | | | | |
| Nuclear | 8.0 | 5 000 | 4 800 | 4 500 | 90 | 80 | 75 | 30 | 30 | 30 | 105 | 110 | 110 |
| Coal | 8.0 | 2 100 | 2 100 | 2 100 | 20 | <i>n.a.</i> | <i>n.a.</i> | 90 | 170 | 235 | 220 | <i>n.a.</i> | <i>n.a.</i> |
| Gas CCGT | 8.0 | 1 000 | 1 000 | 1 000 | 55 | 25 | <i>n.a.</i> | 50 | 80 | 105 | 70 | 125 | <i>n.a.</i> |
| Solar PV | 3.7 | 1 140 | 620 | 420 | 21 | 22 | 23 | 10 | 10 | 10 | 50 | 30 | 20 |
| Wind onshore | 3.7 | 1 540 | 1 420 | 1 320 | 42 | 43 | 44 | 10 | 10 | 10 | 35 | 35 | 30 |
| Wind offshore | 4.5 | 4 040 | 2 080 | 1 480 | 42 | 46 | 48 | 35 | 20 | 15 | 115 | 60 | 40 |
| European Union | | | | | | | | | | | | | |
| Nuclear | 8.0 | 6 600 | 5 100 | 4 500 | 75 | 75 | 70 | 35 | 35 | 35 | 150 | 120 | 115 |
| Coal | 8.0 | 2 000 | 2 000 | 2 000 | 20 | <i>n.a.</i> | <i>n.a.</i> | 120 | 205 | 275 | 250 | <i>n.a.</i> | <i>n.a.</i> |
| Gas CCGT | 8.0 | 1 000 | 1 000 | 1 000 | 40 | 20 | <i>n.a.</i> | 65 | 95 | 120 | 100 | 150 | <i>n.a.</i> |
| Solar PV | 3.2 | 790 | 460 | 340 | 13 | 14 | 14 | 10 | 10 | 10 | 55 | 35 | 25 |
| Wind onshore | 3.2 | 1 540 | 1 420 | 1 300 | 29 | 30 | 31 | 15 | 15 | 15 | 55 | 45 | 40 |
| Wind offshore | 4.0 | 3 600 | 2 020 | 1 420 | 51 | 56 | 59 | 15 | 10 | 5 | 75 | 40 | 25 |
| China | | | | | | | | | | | | | |
| Nuclear | 7.0 | 2 800 | 2 800 | 2 500 | 80 | 80 | 80 | 25 | 25 | 25 | 65 | 65 | 60 |
| Coal | 7.0 | 800 | 800 | 800 | 60 | <i>n.a.</i> | <i>n.a.</i> | 75 | 135 | 195 | 90 | <i>n.a.</i> | <i>n.a.</i> |
| Gas CCGT | 7.0 | 560 | 560 | 560 | 45 | 35 | <i>n.a.</i> | 75 | 100 | 120 | 90 | 115 | <i>n.a.</i> |
| Solar PV | 3.5 | 750 | 400 | 280 | 17 | 18 | 19 | 10 | 5 | 5 | 40 | 25 | 15 |
| Wind onshore | 3.5 | 1 220 | 1 120 | 1 040 | 26 | 27 | 27 | 15 | 10 | 10 | 45 | 40 | 40 |
| Wind offshore | 4.3 | 2 840 | 1 560 | 1 000 | 34 | 41 | 43 | 25 | 15 | 10 | 95 | 45 | 30 |
| India | | | | | | | | | | | | | |
| Nuclear | 7.0 | 2 800 | 2 800 | 2 800 | 70 | 70 | 70 | 30 | 30 | 30 | 75 | 75 | 75 |
| Coal | 7.0 | 1 200 | 1 200 | 1 200 | 50 | <i>n.a.</i> | <i>n.a.</i> | 35 | 50 | 75 | 65 | <i>n.a.</i> | <i>n.a.</i> |
| Gas CCGT | 7.0 | 700 | 700 | 700 | 55 | 50 | <i>n.a.</i> | 45 | 45 | 50 | 55 | 60 | <i>n.a.</i> |
| Solar PV | 5.8 | 580 | 310 | 220 | 20 | 21 | 21 | 5 | 5 | 5 | 35 | 20 | 15 |
| Wind onshore | 5.8 | 1 040 | 980 | 940 | 26 | 28 | 29 | 10 | 10 | 10 | 50 | 45 | 40 |
| Wind offshore | 6.6 | 2 980 | 1 680 | 1 180 | 32 | 37 | 38 | 25 | 15 | 10 | 130 | 70 | 45 |

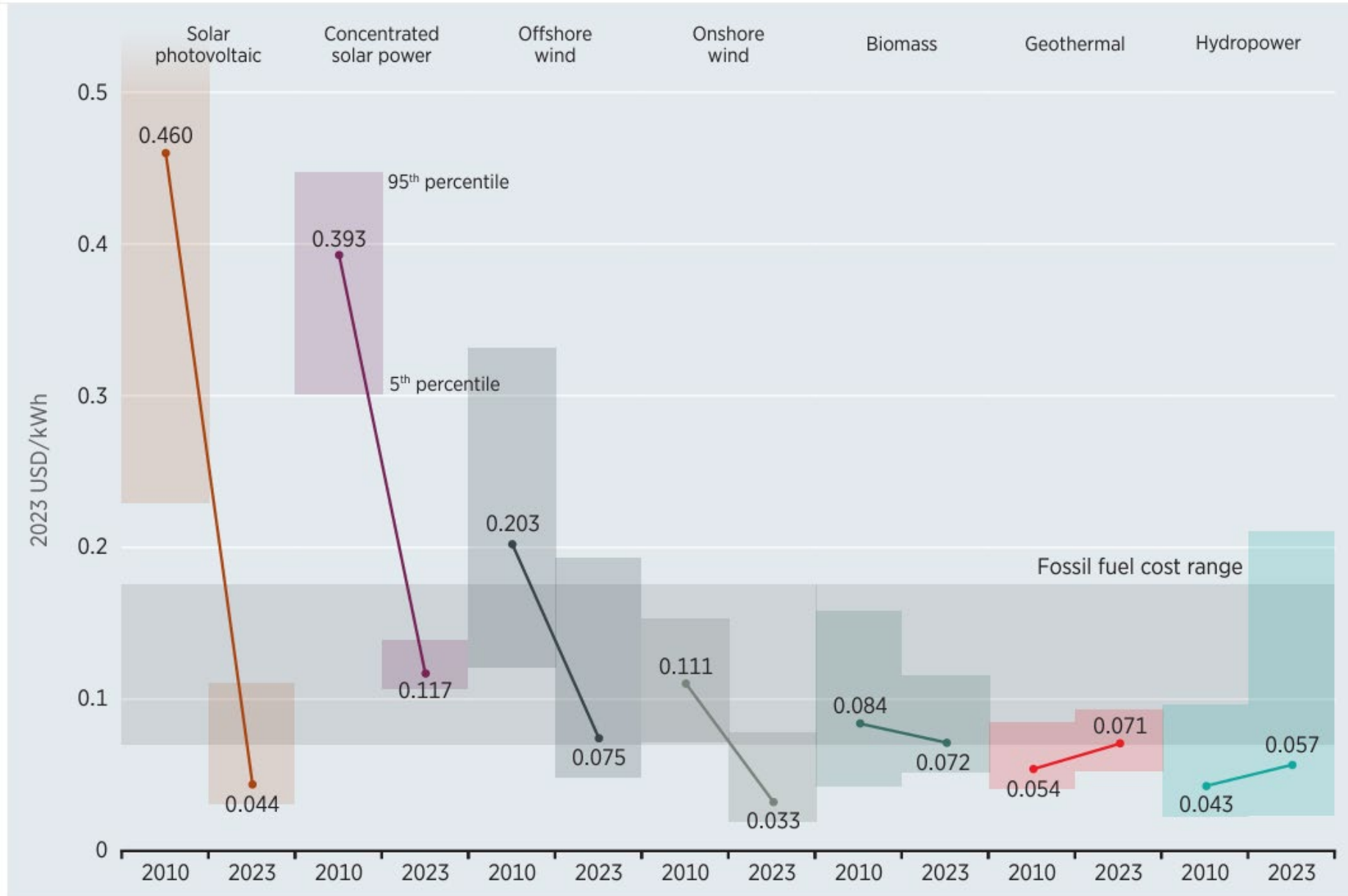
Notes: O&M = operation and maintenance; LCOE = levelised cost of electricity; kW = kilowatt; MWh = megawatt-hour; CCGT = combined-cycle gas turbine; *n.a.* = not applicable. Cost components and LCOE figures are rounded.

Sources: IEA analysis; IRENA Renewable Costing Alliance; IRENA (2020).

Table S1 Total installed cost, capacity factor and LCOE trends by technology, 2010 and 2023

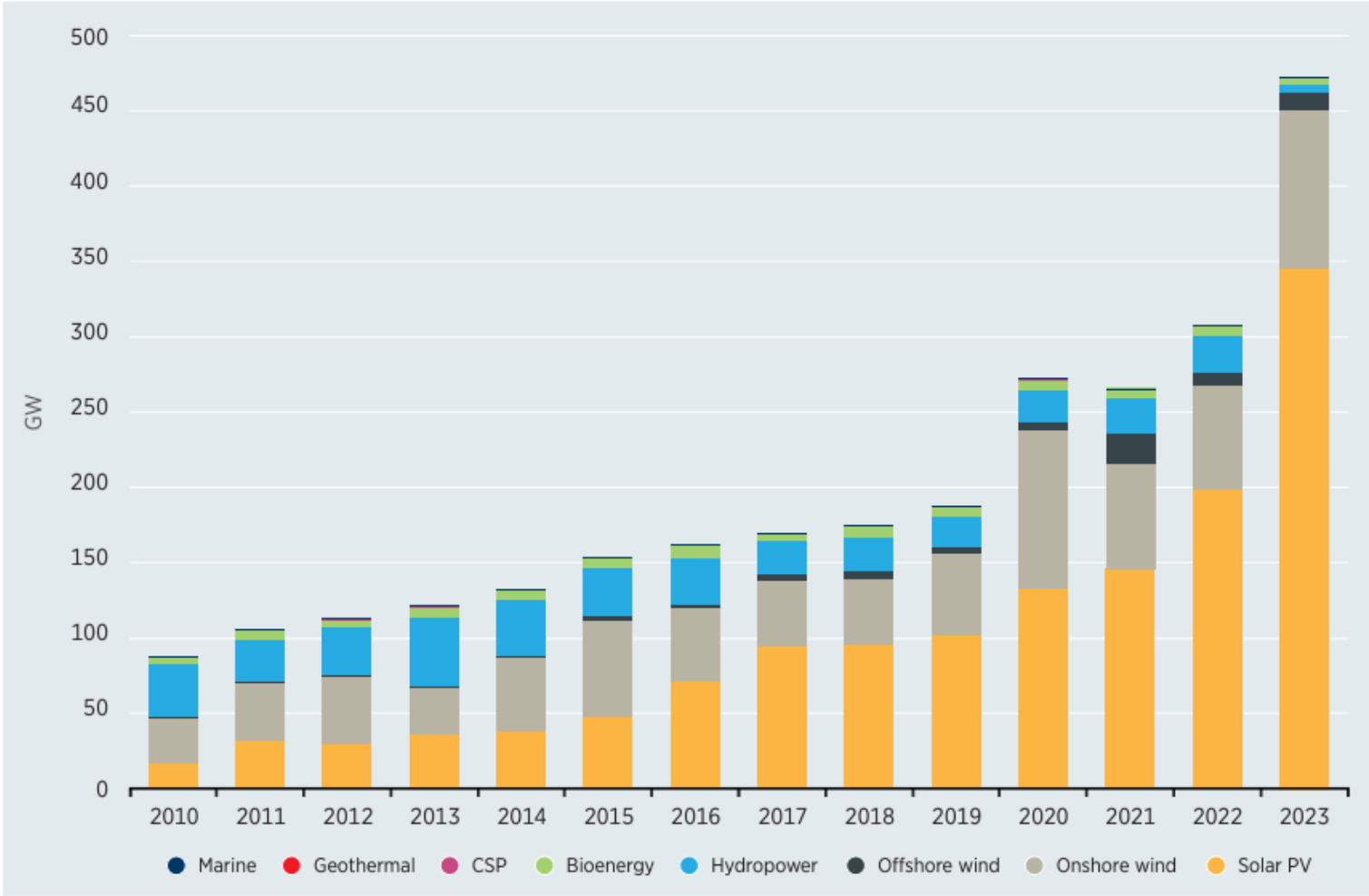
| | Total installed costs | | | Capacity factor | | | Levelised cost of electricity | | |
|---------------|-----------------------|-------|----------------|-----------------|------|----------------|-------------------------------|-------|----------------|
| | (2023 USD/kW) | | | (%) | | | (2023 USD/kWh) | | |
| | 2010 | 2023 | Percent change | 2010 | 2023 | Percent change | 2010 | 2023 | Percent change |
| Bioenergy | 3 010 | 2 730 | -9% | 72 | 72 | 0% | 0.084 | 0.072 | -14% |
| Geothermal | 3 011 | 4 589 | 52% | 87 | 82 | -6% | 0.054 | 0.071 | 31% |
| Hydropower | 1 459 | 2 806 | 92% | 44 | 53 | 20% | 0.043 | 0.057 | 33% |
| Solar PV | 5 310 | 758 | -86% | 14 | 16 | 14% | 0.460 | 0.044 | -90% |
| CSP | 10 453 | 6 589 | -37% | 30 | 55 | 83% | 0.393 | 0.117 | -70% |
| Onshore wind | 2 272 | 1 160 | -49% | 27 | 36 | 33% | 0.111 | 0.033 | -70% |
| Offshore wind | 5 409 | 2 800 | -48% | 38 | 41 | 8% | 0.203 | 0.075 | -63% |

Notes: CSP = concentrated solar power; kW = kilowatt.



Note: These data are 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 LCOE is calculated with project-specific installed costs and capacity factors, while the other assumptions, including weighted average cost of capital (WACC), are detailed in Annex I. The grey band represents the fossil fuel-fired power generation cost in 2023, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

Figure 1.2 Global annual new capacity additions of renewable power, 2010-2023



Source: IRENA (2024a).

Notes: CSP = concentrated solar power; PV = photovoltaic.

Tabella 7: Produzione lorda di energia elettrica da fonti rinnovabili in Italia - TWh

| Fonte | 2018 | 2019 | 2020 | 2021 | 2022 | 2023* |
|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Idraulica | 48,8 | 46,3 | 47,6 | 45,4 | 28,4 | 40,4 |
| Eolica | 17,7 | 20,2 | 18,8 | 20,9 | 20,5 | 23,3 |
| Solare | 22,7 | 23,7 | 24,9 | 25,0 | 28,1 | 30,7 |
| Geotermica | 6,1 | 6,1 | 6,0 | 5,9 | 5,8 | 5,7 |
| Bioenergie (**) | 19,2 | 19,6 | 19,6 | 19,1 | 17,6 | 16,0 |
| Totale FER | 114,4 | 115,8 | 116,9 | 116,3 | 100,5 | 116,2 |
| CIL - Consumo Interno Lordo (***) | 331,9 | 330,1 | 310,8 | 329,7 | 325,1 | 313,9 |
| FER/CIL | 34,5% | 35,1% | 37,6% | 35,3% | 30,9% | 37,0% |

(*) Dati provvisori

(**) Biomasse solide, bioliquidi, biogas e frazione rinnovabile dei rifiuti

(***) Il CIL è pari alla produzione lorda di energia elettrica più il saldo scambi con l'estero ed è qui considerato al netto degli apporti da pompaggio. Per l'energia elettrica, tale grandezza corrisponde alla disponibilità lorda.

Tabella 8: Energia termica da fonti rinnovabili in Italia (TJ)

| Fonte | 2021 | 2022 | 2023* |
|---|----------------|----------------|----------------|
| Solare | 10.333 | 11.019 | 11.363 |
| - di cui consumi diretti | 10.323 | 11.010 | 11.353 |
| - di cui produzione di calore derivato | 10 | 9 | 9 |
| Geotermica | 5.887 | 5.665 | 5.776 |
| - di cui consumi diretti | 4.815 | 4.591 | 4.703 |
| - di cui produzione di calore derivato | 1.072 | 1.074 | 1.073 |
| Bioenergie (**) | 327.578 | 300.388 | 293.583 |
| - di cui consumi diretti | 313.045 | 285.841 | 279.501 |
| - di cui produzione di calore derivato | 14.532 | 14.546 | 14.082 |
| Energia ambiente da pompe di calore (***) | 119.285 | 127.802 | 130.714 |
| - di cui consumi diretti | 119.285 | 127.802 | 130.714 |
| - di cui produzione di calore derivato | 0 | 0 | 0 |
| Totale FER-H | 463.083 | 444.873 | 441.436 |
| - di cui consumi diretti | 447.468 | 429.243 | 426.271 |
| - di cui produzione di calore derivato | 15.615 | 15.629 | 15.165 |

(*) Stime preliminari

(**) Biomasse solide, bioliquidi, biogas e frazione rinnovabile dei rifiuti

(***) Impianti per riscaldamento e raffrescamento alimentati da fonte aerotermica, geotermica o idrotermica.

Fonte: GSE

Tabella 10: Consumi finali lordi di energia in Italia, da FER e complessivi (Mtep)

| | 2021 | 2022 | 2023* |
|---|---------------|---------------|---------------|
| <i>Metodologia/direttiva di riferimento</i> | <i>RED II</i> | <i>RED II</i> | <i>RED II</i> |
| CFL FER – Settore Elettrico | 10,2 | 10,4 | 10,5 |
| CFL FER – Settore Termico | 11,1 | 10,6 | 10,5 |
| CFL FER – Settore Trasporti | 1,6 | 1,6 | 1,7 |
| Consumi finali lordi di energia da FER | 22,8 | 22,6 | 22,8 |
| Consumi finali lordi di energia (CFL) | 120,8 | 118,0 | 115,1 |
| Quota dei CFL coperta da FER | 18,9% | 19,1% | 19,8% |

(*) Stime preliminari

Fonte: GSE

Overview of energy decarbonisation measures

Heating

- Energy saving measures
- DH expansion and waste heat recovery
- HP for individual demand

Transport

- Electrification of 90% of light-duty vehicles (cars and vans)
- E-fuels, hydrogen and biofuels for the remaining light-duty transport and heavy-duty transport

Industry

- Energy saving measures
- Electrification of space heating and low-temperature process heating
- Conversion of current *grey hydrogen* demand in *green hydrogen*
- E-fuels, hydrogen and biofuels for the remaining fuel industry demand

Flexibility measures and energy storage systems

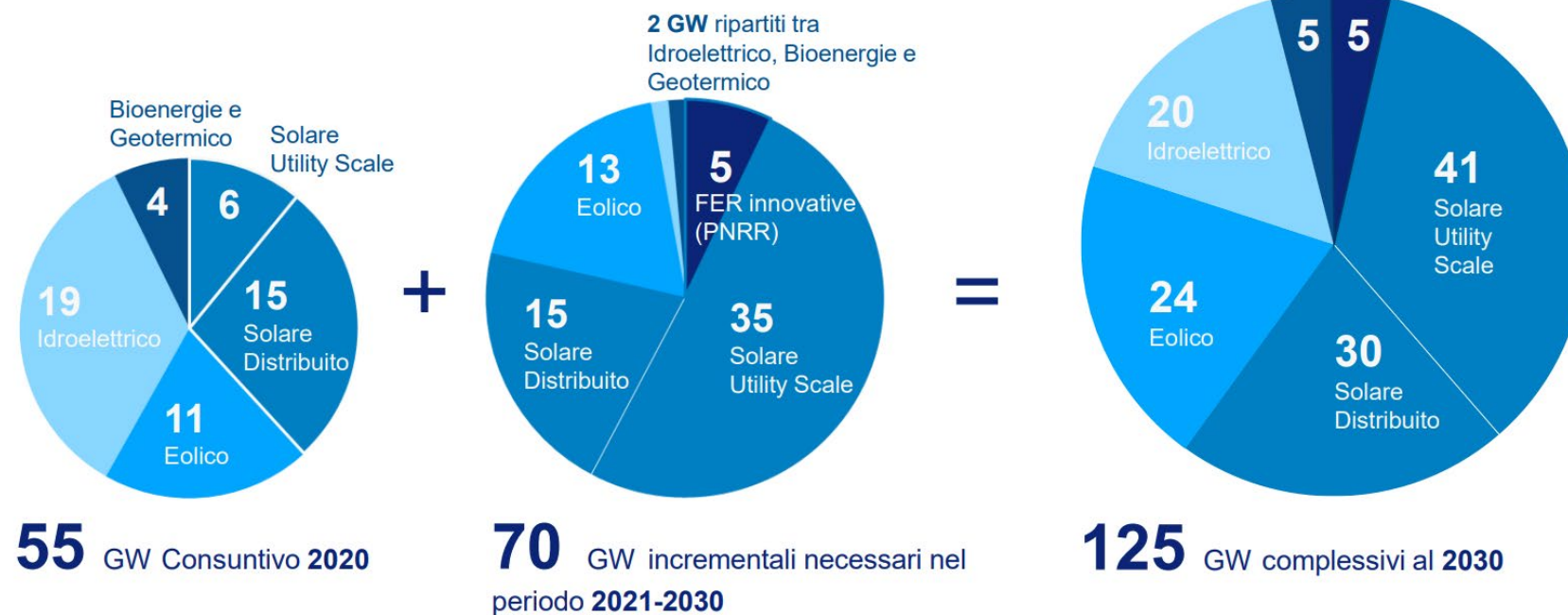
- Electrolysers and hydrogen storage
- Stationary storage systems (lithium-ion batteries)
- Smart charging of EVs, Vehicle-to-Grid, flexible electricity demand

Renewable energy sources

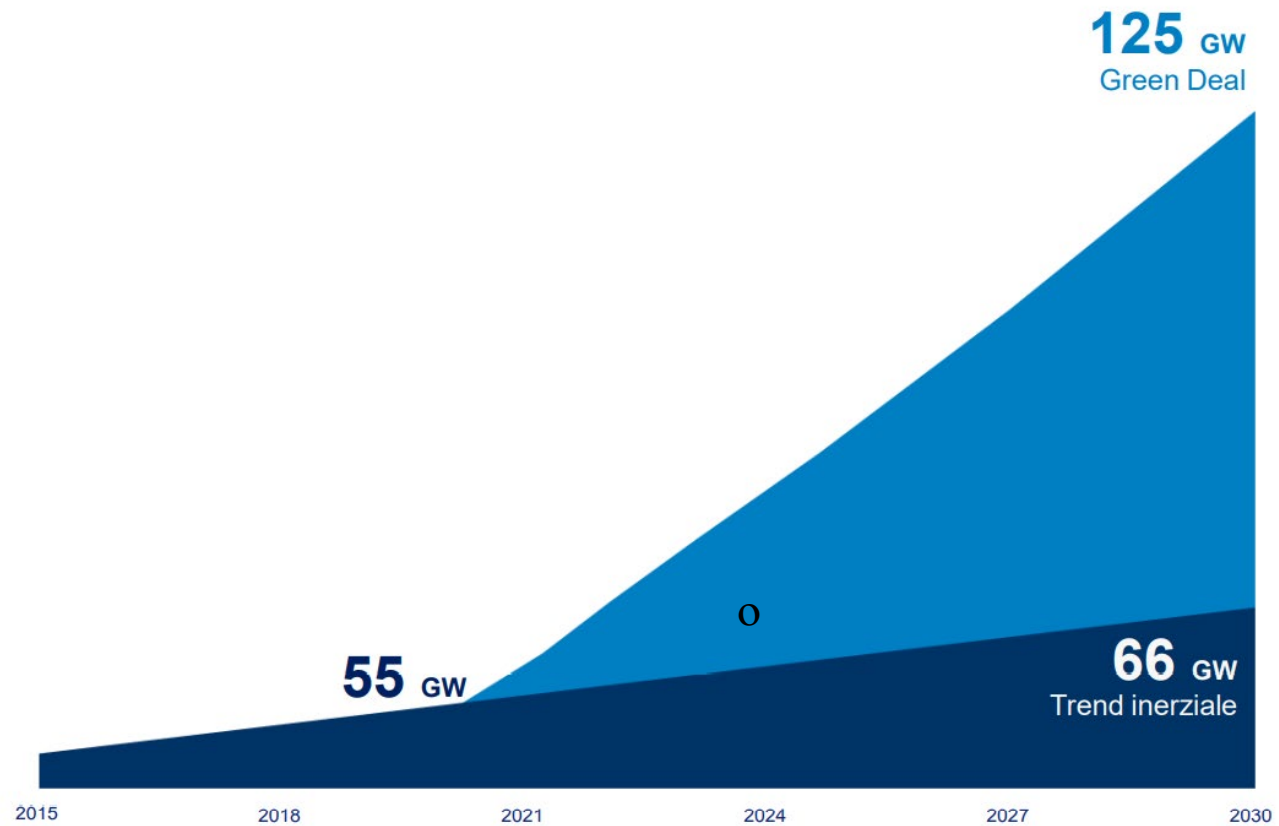
- PV, onshore and offshore Wind as main sources
- Hydro, geothermal and biomass as dispatchable electricity generation

Capacità rinnovabile per raggiungere i target 2030

La capacità incrementale necessaria per raggiungere i target Green Deal 2030 sarà 70 GW, che sommata ai 55 GW attuali, darà un totale di 125 GW al 2030.



+70 GW rinnovabile al 2030



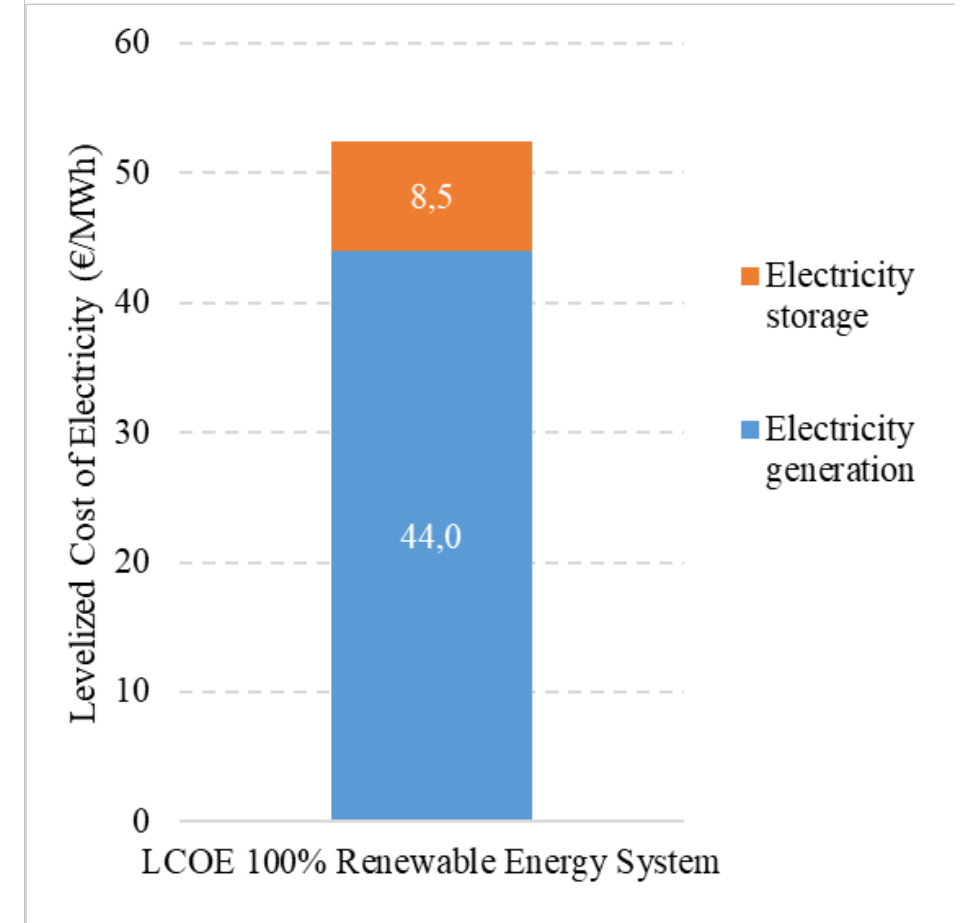
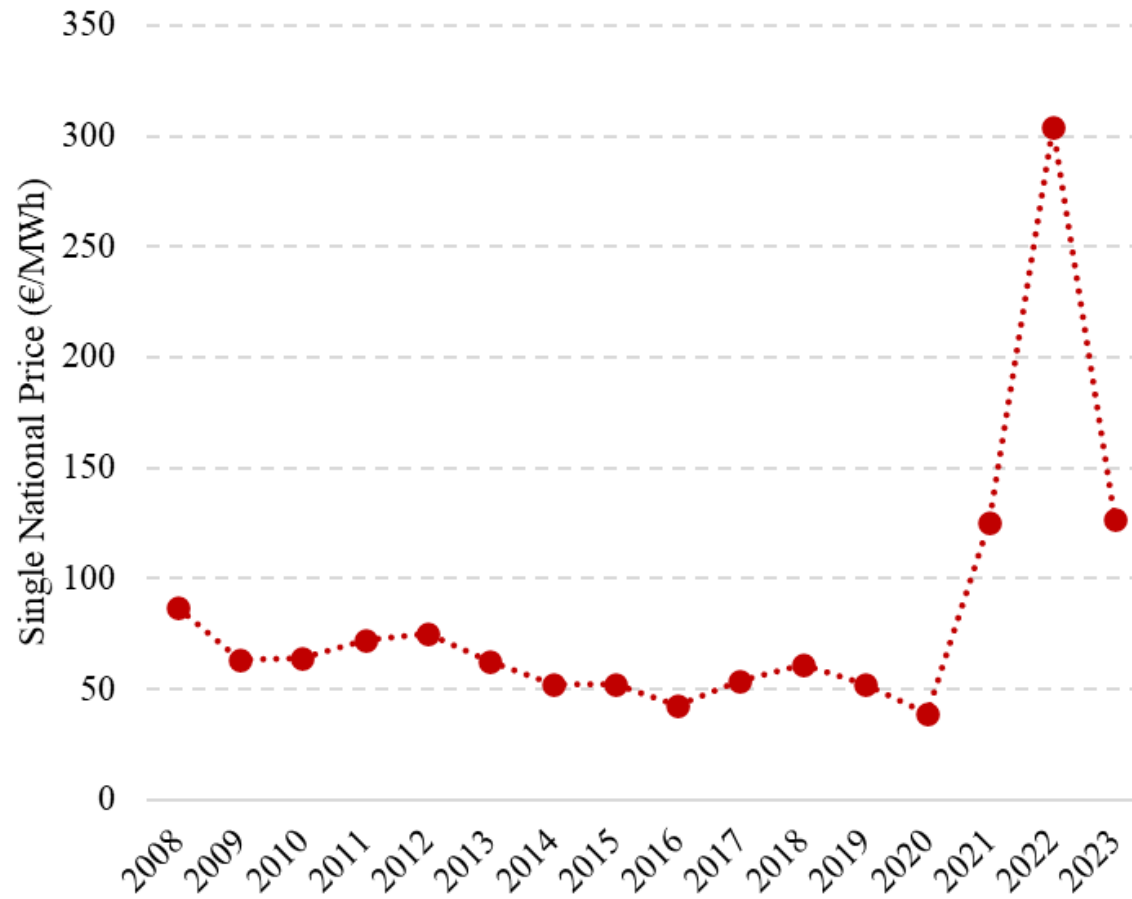
Rinnovabili in Italia (2023): +5 GW (2023), 70 GW (totali)



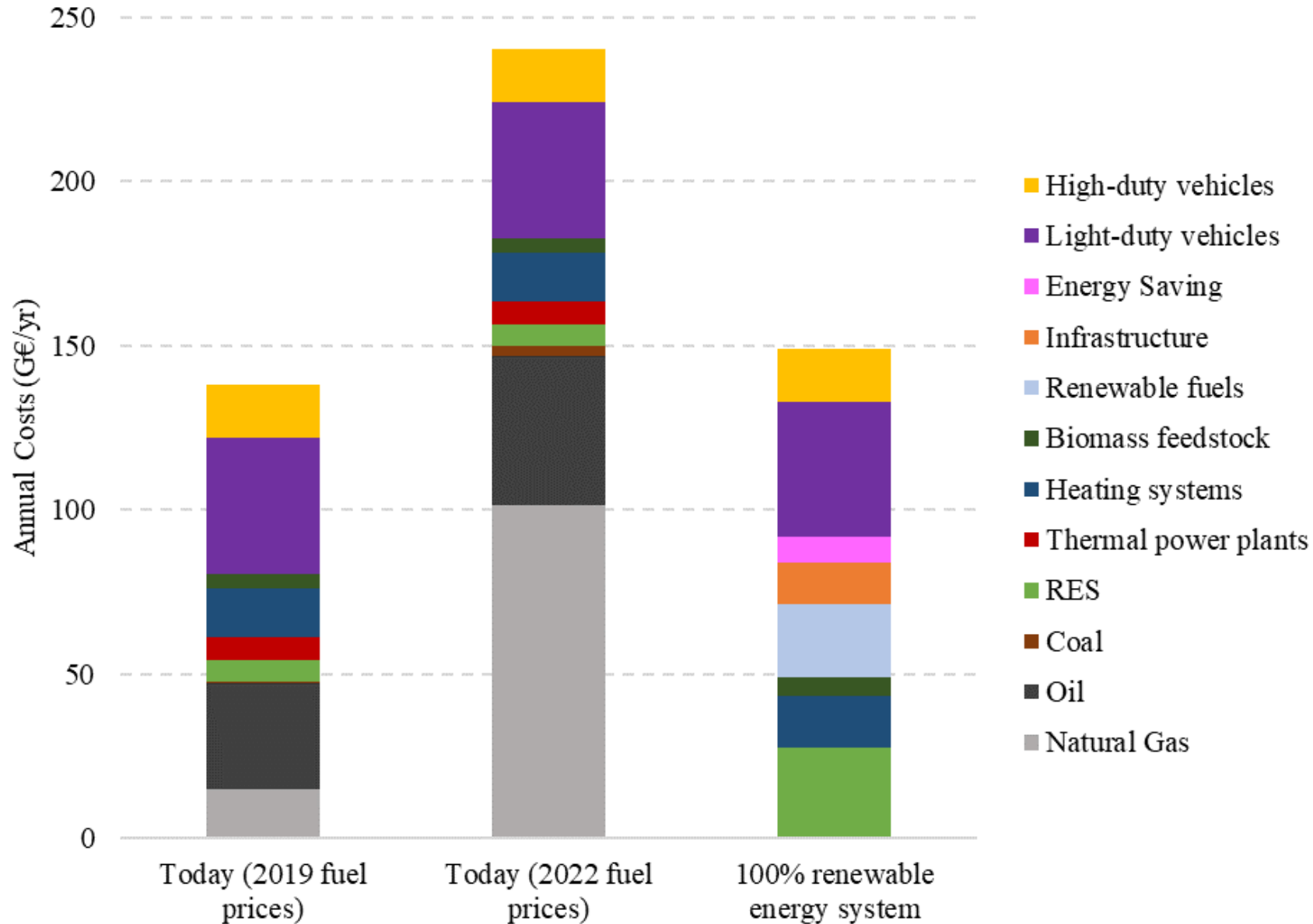
PNIEC 2023 è coerente con la decarbonizzazione?

- ❑ Al 2030 le **rinnovabili al 40%** dei consumi finali lordi di energia, con le **rinnovabili elettriche al 65%** dei corrispondenti consumi, con una capacità aggiuntiva di rinnovabili elettriche di 73,3 GW rispetto al 2021
- ❑ Un **ruolo importante per il gas naturale**, phase-out rimandato del carbone e 1,5 GW + 1,5 GW di termoelettrico per l'adeguatezza del sistema; nel 2030 è prevista una riduzione della domanda di gas pari soltanto a circa il 30% e al 2040 del 50%
- ❑ la decarbonizzazione richiesta sarà garantita dal CSS della CO2
- ❑ sviluppo di infrastrutture di interconnessione gas per la diversificazione degli approvvigionamenti, potenziamento rigassificazione e della fornitura di GNL
- ❑ non si rispettano gli intenti comunitari: **i consumi finali di energia** (indicati a 100 Mtep contro i 92-94 Mtep previsti) e **le emissioni nei settori non ETS** (35-37% di riduzione rispetto al 2005 contro il 44%):.
- ❑ L'elettrificazione dei consumi finali non coerente (nel PNIEC 2019 rinnovabili termiche per l'80% con **pompe di calore**, mentre ora 35% e **poca biomassa**)
- ❑ Ancora 6 milioni BEV e HEV per la mobilità elettrica, al 2035 all'interruzione della commercializzazione di auto a combustibili fossili

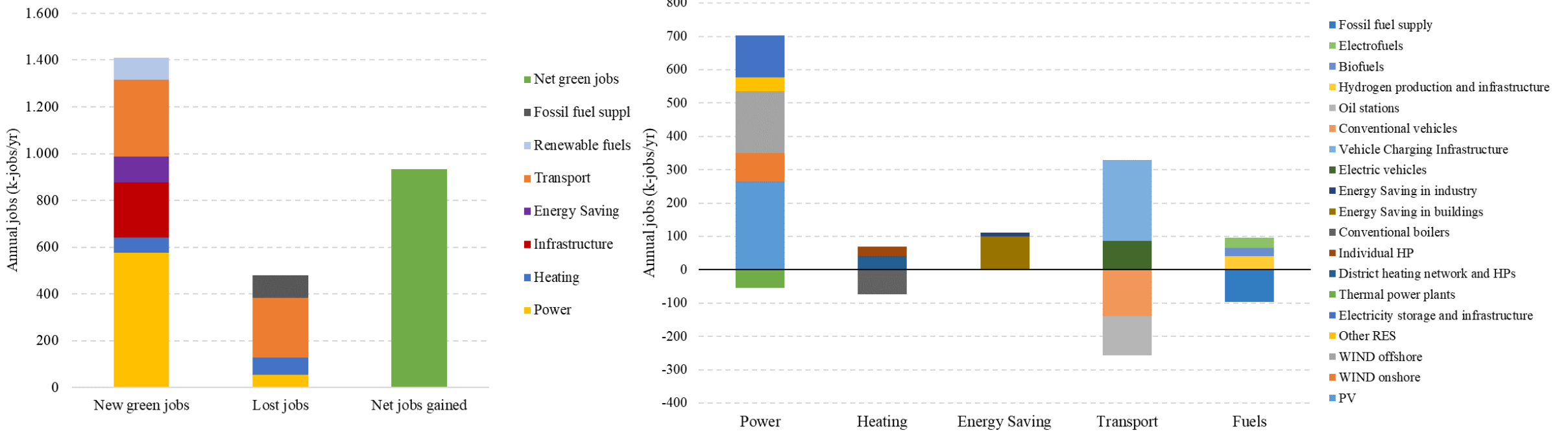
Aumenterà il costo dell'elettricità in un sistema decarbonizzato?



La transizione implicherà un aumento dei costi del sistema?



Green jobs: gli effetti della decarbonizzazione



Livio.desantoli@uniroma1.it