# Carbon Neutral City achieved by Next-generation Photovoltaics

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# Toward climate neutrality

## Paris Agreement（2015）stipulating clear long-term goal for decarbonization

- Holding the increase in the global average temperature to well below 2 ℃ and pursuing efforts to limit the temperature increase to 1.5 ℃ above pre-industrial levels (Art. 2.1 (a))
- “Net zero emission” “De-carbonization” in the second half of this century (Art. 4.1)

## Japan's pledge: reduce GHG emission to net zero by 2050

- “Japan pledges to, by 2050, reduce GHG emission in Japan to net zero, namely become carbon neutral and achieve a decarbonized society”.
- The pledge is now legalized under the 1998 Law to promote measures to cope with global warming.

## More than 150 countries and EU have now pledge to reduce emission to net zero

- All G7 countries, Brazil, South Korea, Viet Nam etc.: net zero by 2050 at the latest
- China, Russia, Saudi Arabia etc.: net zero by 2060 at the latest
- India: net zero by 2070
- Many countries update their 2030 climate target upward in line with net zero by 2050.

## COP26："resolves to pursue efforts to limit the temperature increase to 1.5 °C"

- **"recognizes that this requires accelerated action in this critical decade, on the basis of the best available scientific knowledge and equity"**
- **Repeated endorsement by COP27, G7, G20**

# 2019 Top 10 Global Economic Loss Events

| Date (s) | Event | Location | Deaths | Economic Loss（USD billions） | Insured Loss（USD billions） |
|---|---|---|---|---|---|
| October 6-12 | Typhoon Hagibis (No. 19) | Japan | 99 | 15.0 | 9.0 |
| June - August | Monsoon Floods | China | 300 | 15.0 | 0.7 |
| September 7-9 | Typhoon Faxai（No. 15） | Japan | 3 | 10.0 | 6.0 |
| May - July | Mississippi Basin Floods | United States | 0 | 10.0 | 4.0 |
| August 25 – Sep 7 | Hurricane Dorian | Bahamas, Caribbean, US, Canada | 83 | 10.0 | 3.5 |
| March 12-31 | Missouri Basin Floods | United States | 10 | 10.0 | 2.5 |
| June - October | Monsoon Floods | India | 1750 | 10.0 | 0.2 |
| August 6-13 | Typhoon Lekima | China, Philippines, Japan | 101 | 9.5 | 0.8 |
| March - April | Flooding | Iran | 77 | 8.3 | 0.2 |
| May 2-5 | Cyclone Fani | India, Bangladesh | 81 | 8.1 | 0.5 |
| | | All Other Events | | 126 billion | 44 billion |
| | | Totals | | 232 billion | 71 billion |

Source：AON, 2020

# 2022 Top 10 Human fatality events

| | | | Deaths | Economic loss ($ billion) |
|---|---|---|---|---|
| 10-20 July | Heatwave | Western, Southern and Central Europe | 15450 | N/A |
| 13 – 19 June | Heatwave | Western, Southern and Central Europe | 3750 | N/A |
| 17 May -31 October | India Seasonal Floods | India | 2135 | 4.2 |
| 14 June -30 October | Pakistan Seasonal Floods | Pakistan | 1739 | 15.0 |
| 22 June | Earthquake | Afghanistan, Pakistan | 1163 | 0.1 |
| 1 July -31 October | Nigeria Seasonal Floods | Nigeria | 660 | 2.3 |
| 21 November | Cianjur Earthquakes | Indonesia | 603 | 0.4 |
| 8 -15 April | KwaZulu-Natal Floods | South Africa | 455 | 3.6 |
| 15-16 February | Rio de Janeiro Floods | Brazil | 232 | ＜0.1 |
| 8-13 April | Tropical Storm Megi | Philippines | 214 | ＜0.1 |
| | All other events | | 4900 | 287.0 |
| | | Totals | 31300 | 313 billion |

Source： AON, 2023

# Projected changes in extremes are larger in frequency and intensity

| 1850-1900 | | Present 1℃ | 1.5℃ | 2℃ | 4℃ |
|---|---|---|---|---|---|
| Hot temperature extremes over land: 10-year event | Intensity increase | 1.2℃ hotter | 1.9℃ hotter | 2.6℃ hotter | 5.1℃ hotter |
| | Frequency per 10 years | 2.8 times | 4.1 times | 5.6 times | 9.4 times |
| Hot temperature extremes over land: 50-year event | Intensity increase | 1.2℃ hotter | 2.0℃ hotter | 2.7℃ hotter | 5.3℃ hotter |
| | Frequency per 50 years | 4.8 times | 8.6 times | 13.9 times | 39.2 times |
| Heavy precipitation over land: 10-year event | Intensity increase | 6.7% wetter | 10.5% wetter | 14.0% wetter | 30.2% wetter |
| | Frequency per 10 years | 1.3 times | 1.5 times | 1.7 times | 2.7 times |
| Agricultural & ecological droughts in drying regions: 10 year event | Frequency per 10 years | 1.7 times | 2.0 times | 2.4 times | 4.1times |

Source: IPCC AR6, 2021

# The most recent science tells us

## IPCC Sixth Assessment Report Synthesis Report （March 2023）

- Critical decade/decisive decade
  - Climate change as imminent risk. Global climate related economic loss has inreased.
  - Every increment of global warming will intensify multiple and concurrent hazards. "Limits to adaptation"
  - 1.5℃ and 2℃ goals involve rapid and deep, immediate GHG emissions reductions in all sectors this decade. Global net zero CO2 emissions are reached in the early 2050s, and around the early 2070s, respectively.

| | | Reduction rate compared to emissions in 2019 | | | |
|---|---|---|---|---|---|
| | | 2030 | 2035 | 2040 | 2050 |
| 1.5℃ goal (>50%) | GHG | 43 [34 - 60] | 60 [49 - 77] | 69 [58 - 90] | 84 [73 - 98] |
| | CO2 | 48 [36 - 69] | 65 [50 - 96] | 80 [61 - 109] | 99 [79 - 119] |
| 2℃ goal (>67%) | GHG | 21 [1 - 42] | 35 [22 - 55] | 46 [34 - 63] | 64 [53 - 77] |
| | CO2 | 22 [1 - 44] | 37 [21 - 59] | 51 [36 - 70] | 73 [55 - 90] |

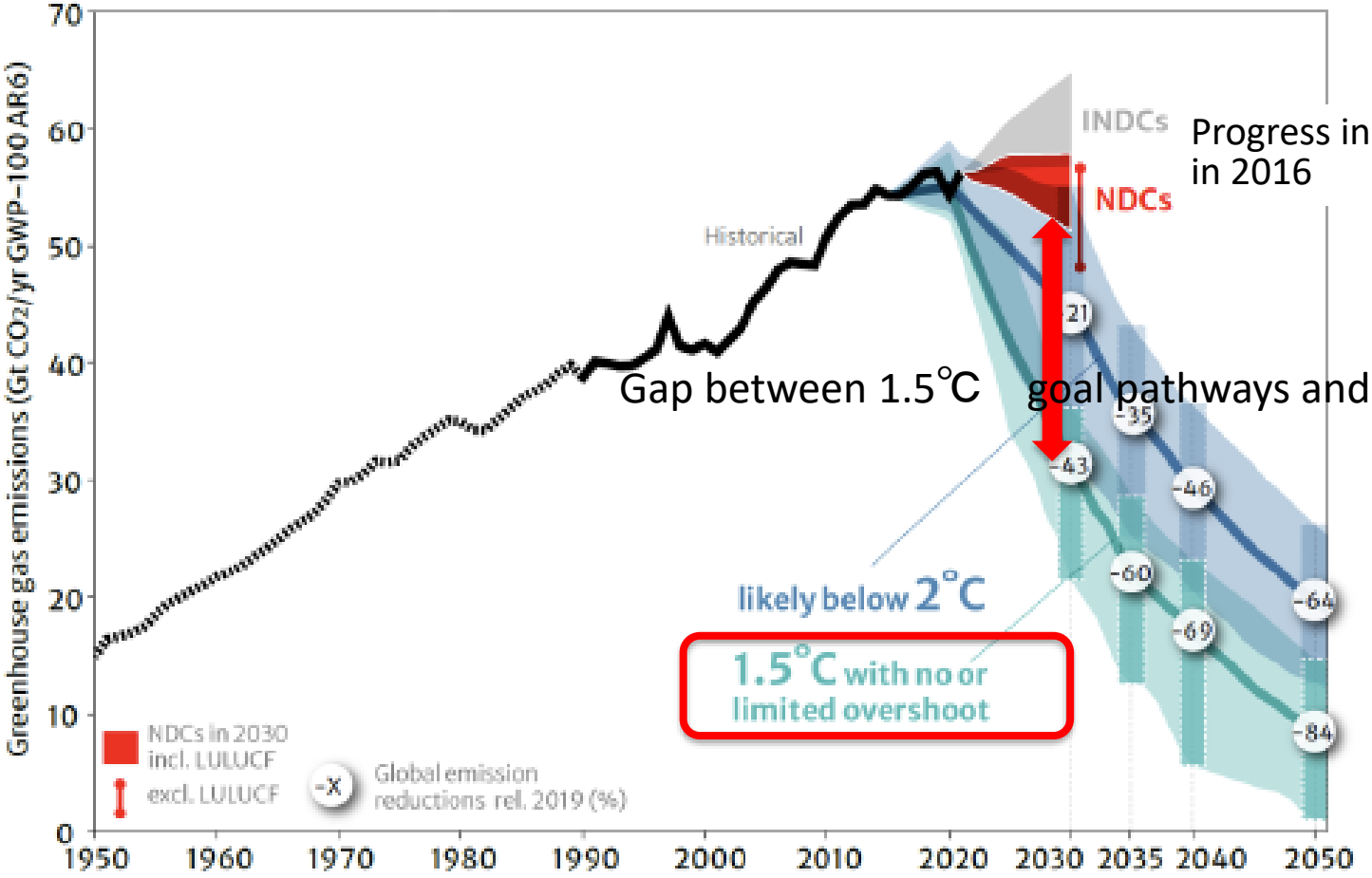
- From goals and policies to implementation and actions
- Extension of our present society will not lead to a sustainable society in future.

= need "systems transitions"

Source：IPCC, 2023, modified by Takamura

# Gap between pathways toward 1.5℃ goal and 2030 NDCs

Extension of our present society will not lead to a sustainable society in future.
= need "systems transitions"
Clear long term vision/goal for future society makes us identify and understand challenges.

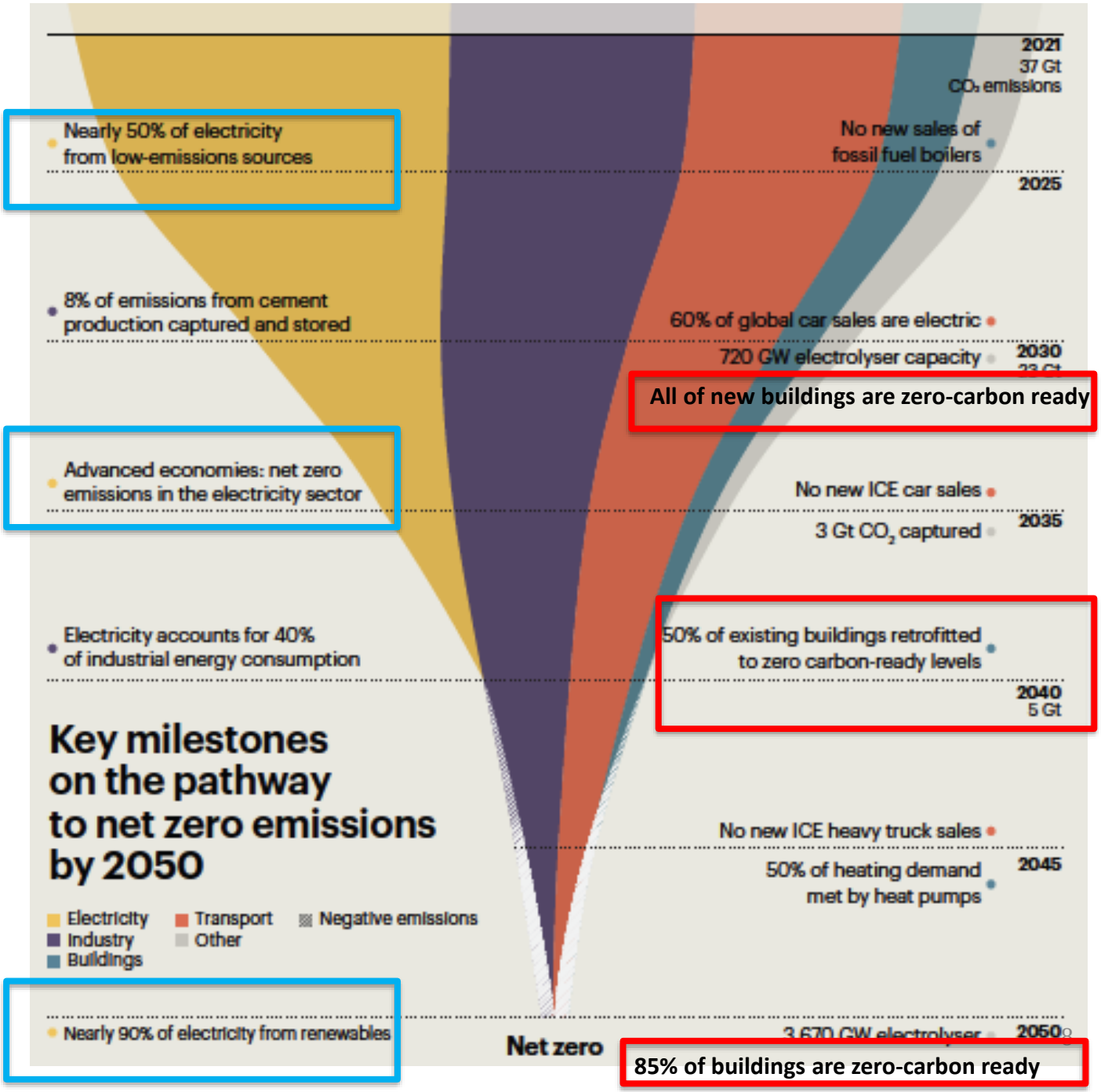



Progress in 2030 NDCs in 2016

Gap between 1.5℃ goal pathways and 2030 NDCs

Source： UNFCCC 2023

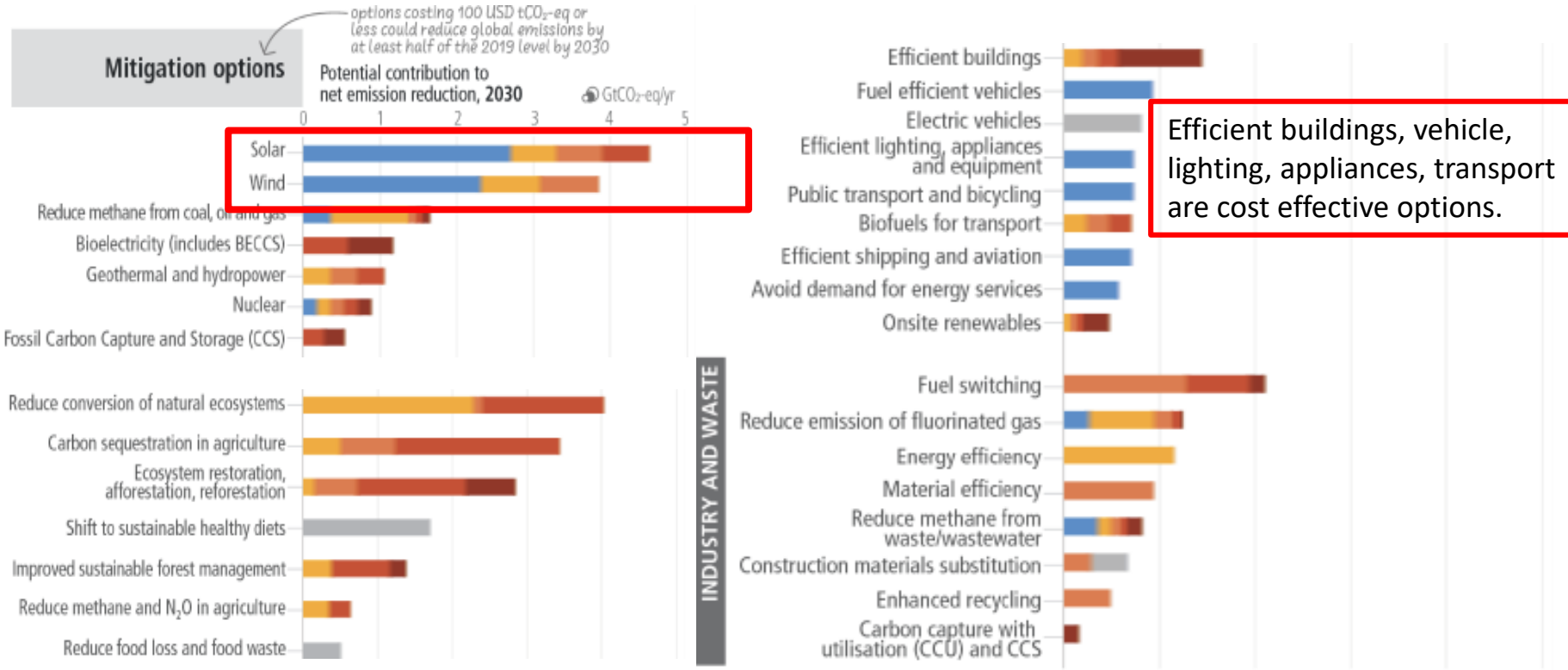
Source : IEA 2022



# Cost effective mitigation options are available

Energy Supply

Infrastructure

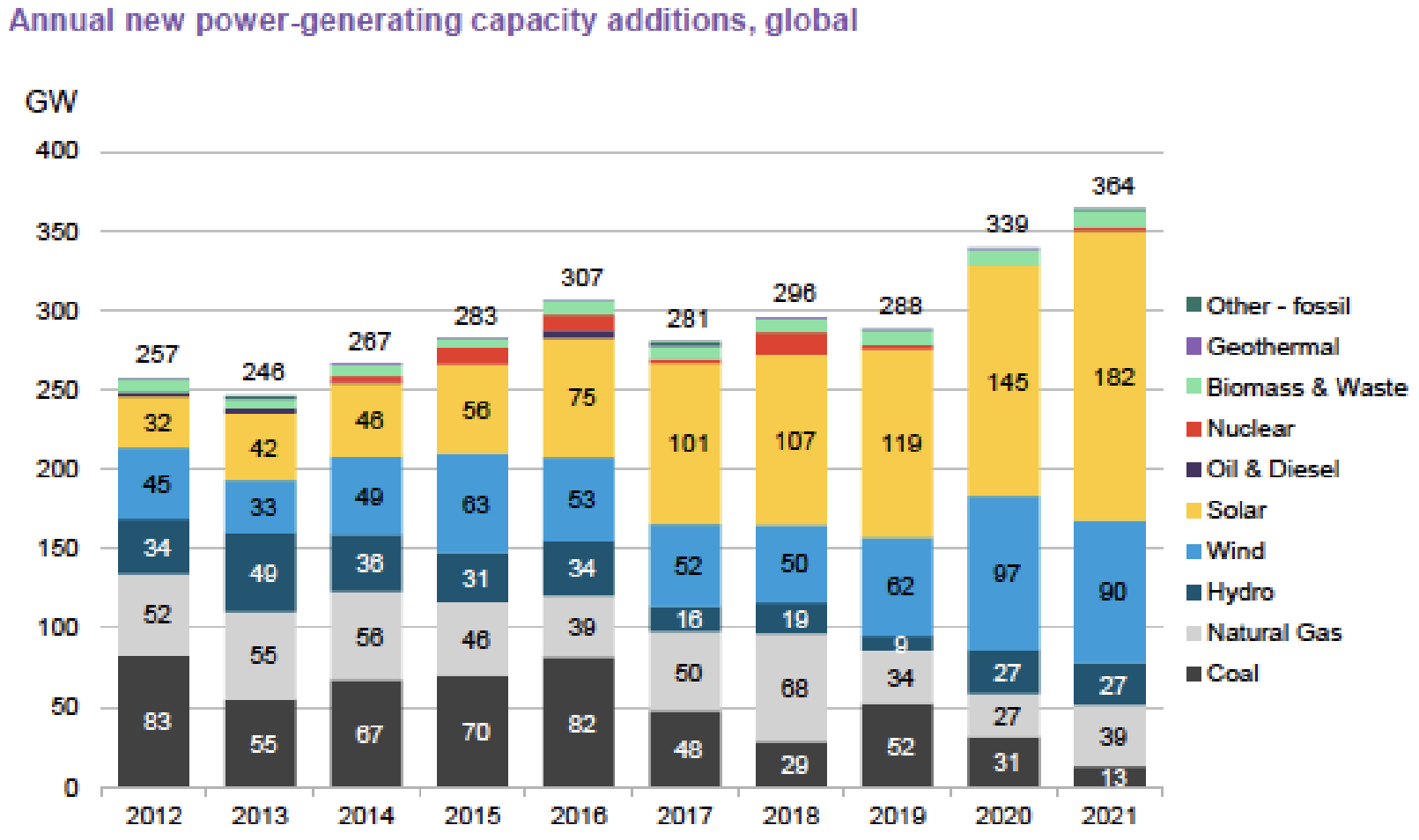



Efficient buildings, vehicle, lighting, appliances, transport are cost effective options.

Land, Water, Food

Source: IPCC AR6 Synthesis Report、2023

# Annual new power-generating capacity additions (global)




*Source: BloombergNEF. Note: GW is gigawatts.*

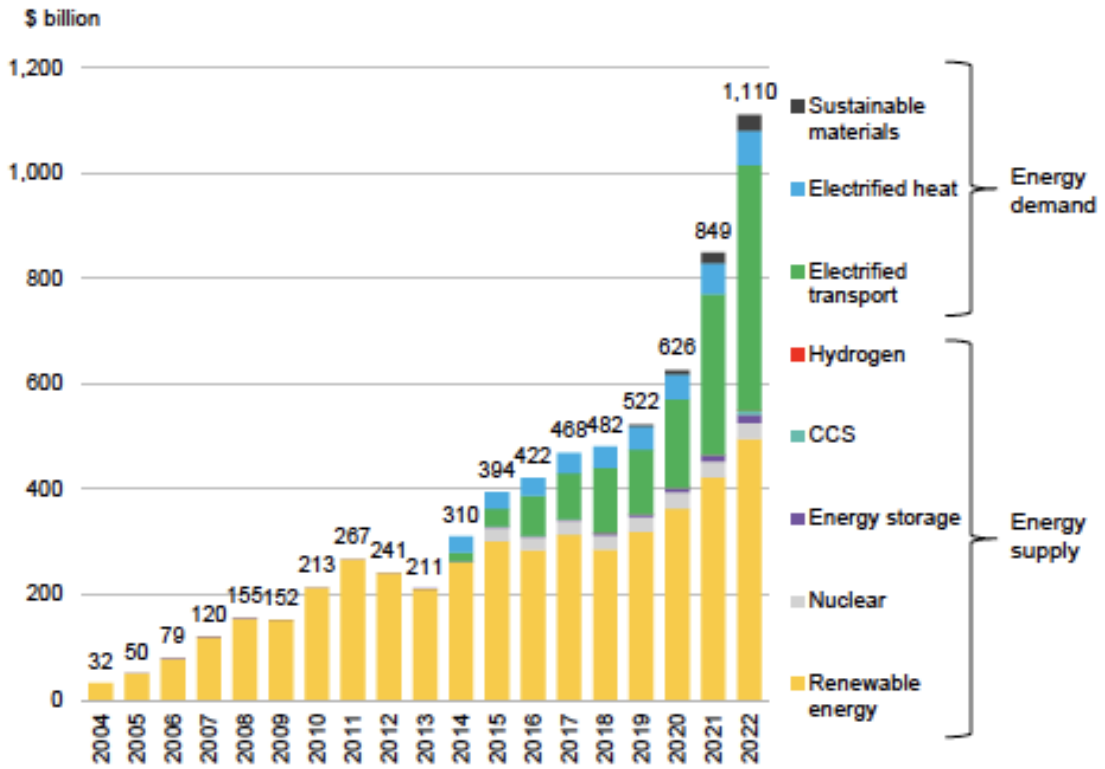
Source： BloombergNEF, 2022

# Global investment in energy transition

Energy transition investment surpassed USD 1 trillion in 2022, which increased by 31% from 2021.

Become triple from 2015, 35 times increase from 2004

Global investment in energy transition by sector




*Source: BloombergNEF. Note: start-years differ by sector but all sectors are present from 2019 onwards; see Appendix for more detail. Nuclear figures start in 2015.*

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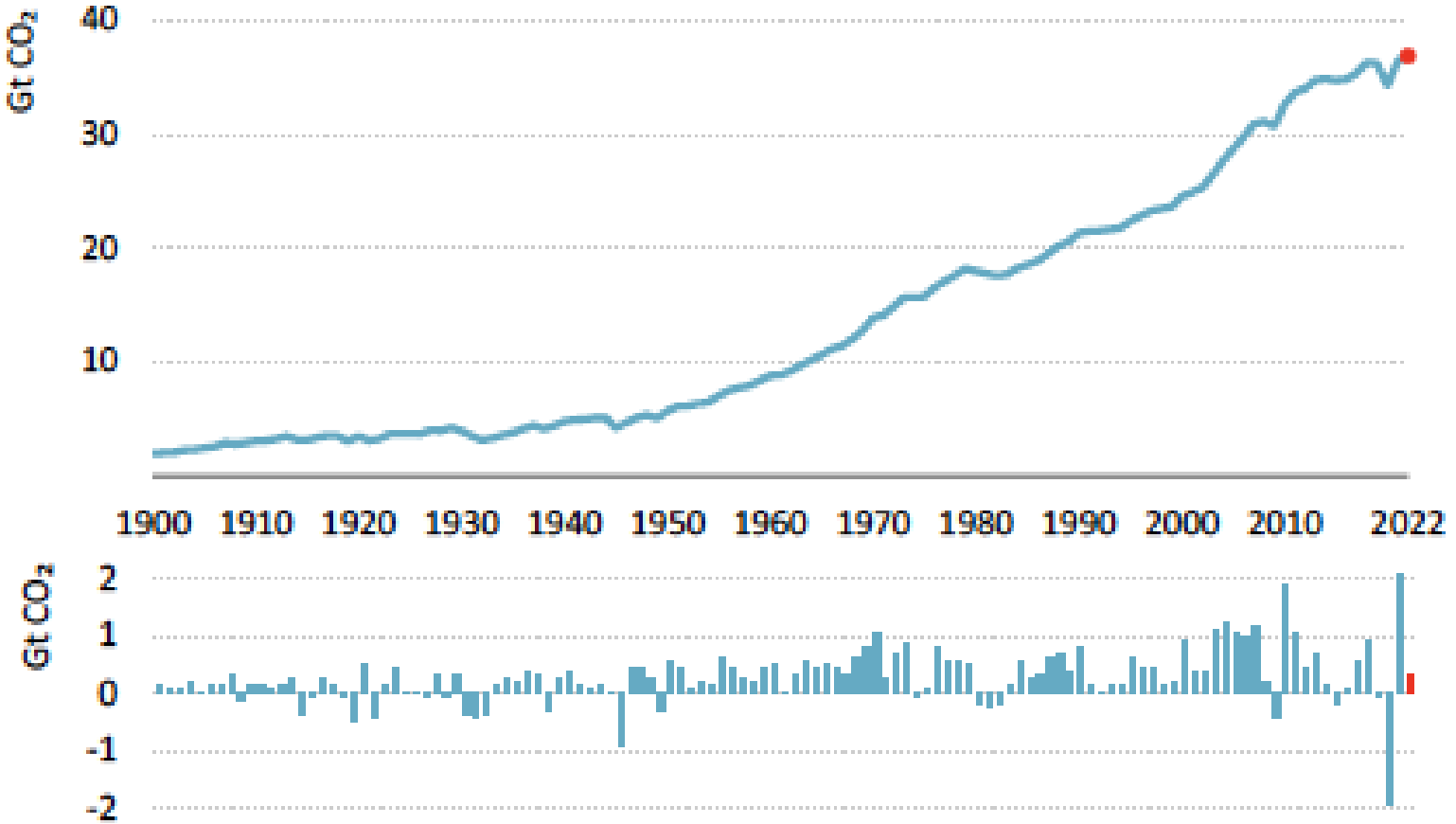
出典: BloombergNEF, 2023

# CO2 emissions from energy combustion and industrial process and change compared to the previous year（1900 – 2022）

Emissions in 2020 decreased by more than 5% compared to in 2019.
Emissions in 2021 increased by more than 6% compared to in 2022.
Emission in 2022 increased by 0.9% (historic record) while global GDP increased by 3.2%.
=decoupling between CO2 emissions and economic growth.

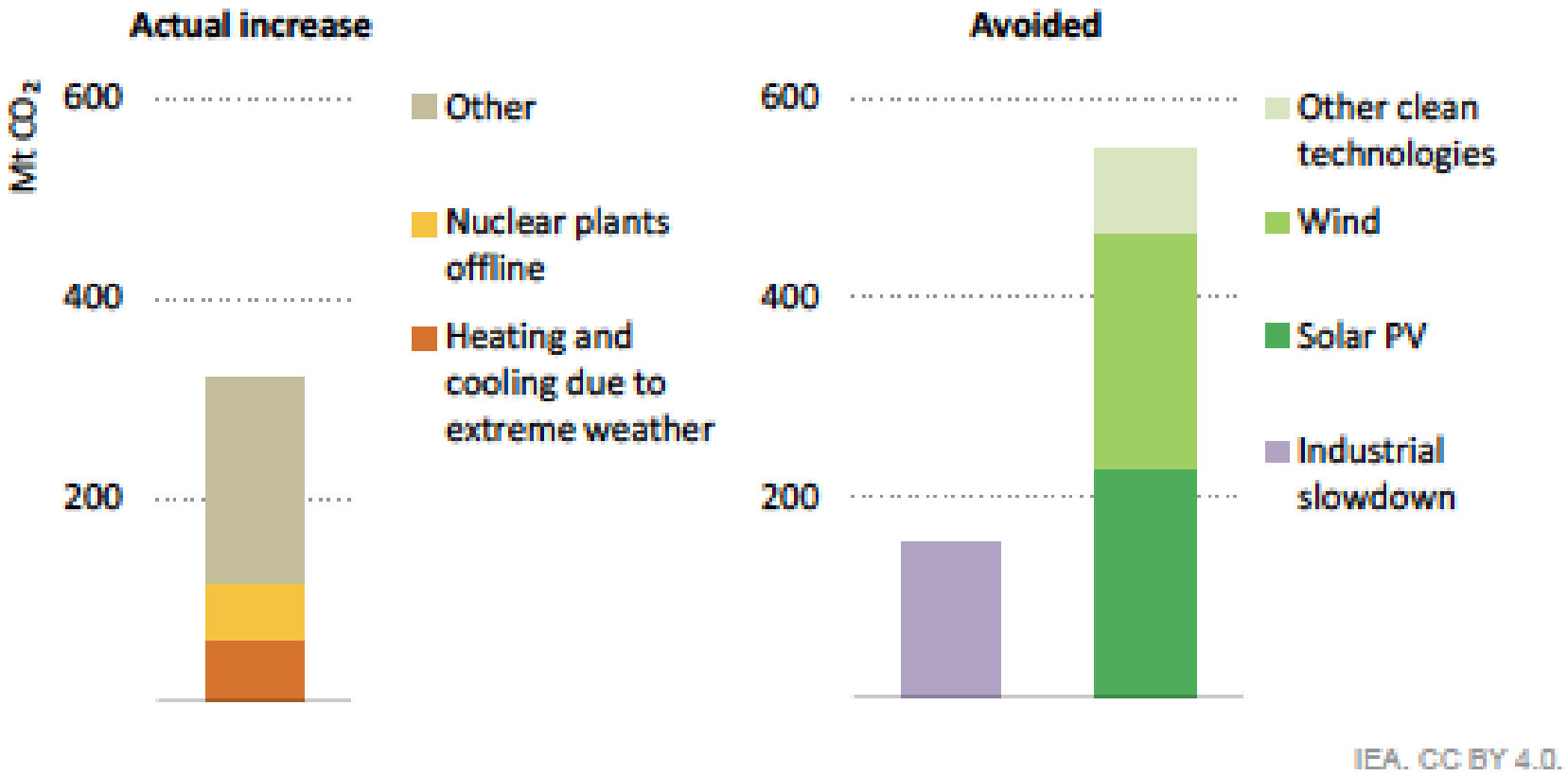



IEA. CC BY 4.0.

Source: IEA 2023

# Drivers for change in global emissions (2021-2022)

Solar and wind expansion offset increase in emission of power sector.
Without expansion of clean energy technologies, increase in 2022 emissions would have tripled.




Notes: Solar PV and wind refer to the annual growth in generation. Other clean technologies is the annual growth in use of other renewables, electric vehicles, and heat pumps. In this figure, Industry includes iron and steel, chemicals, non-metallic minerals, and non-ferrous metals.

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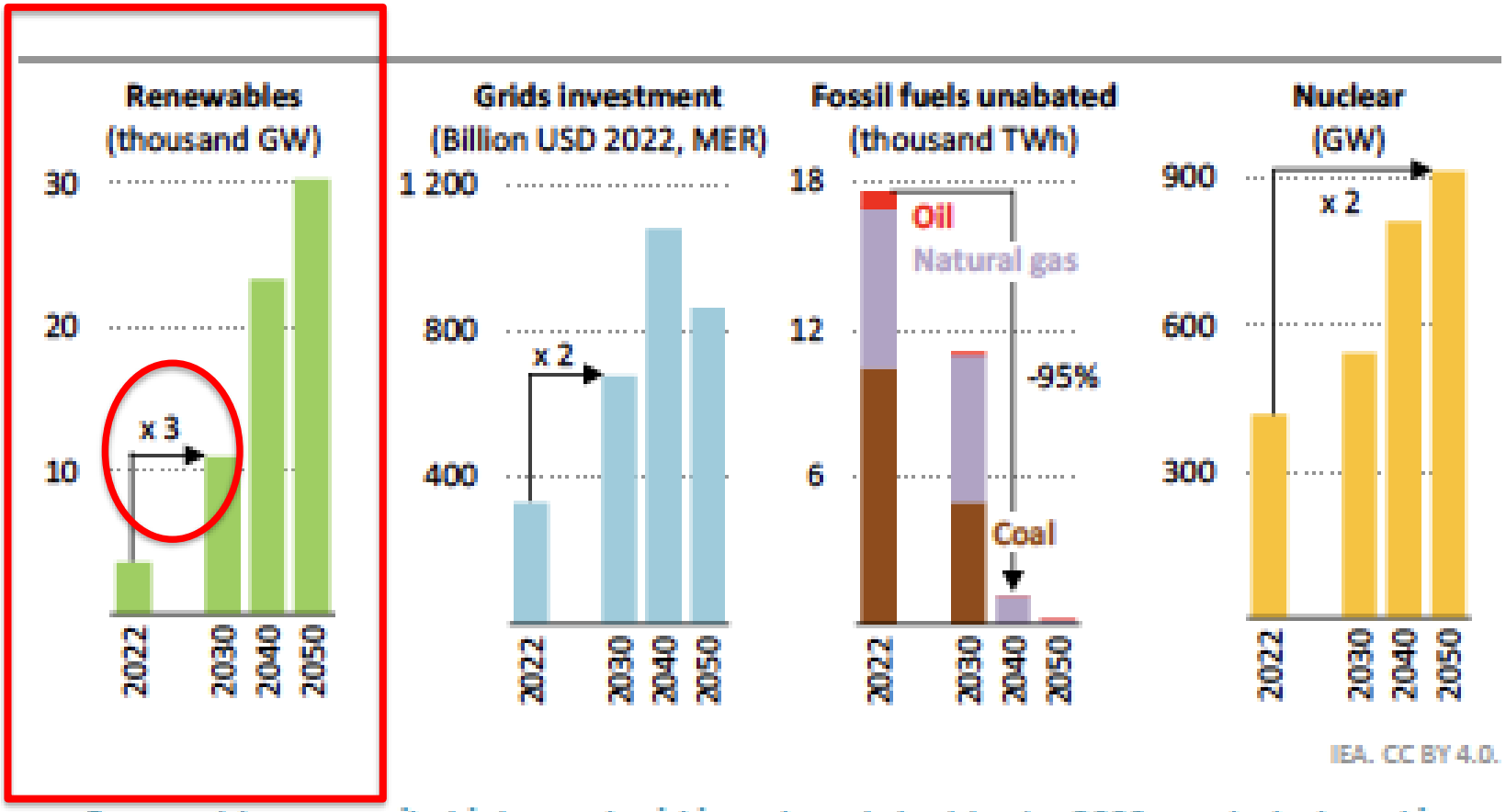
出典: IEA 2023

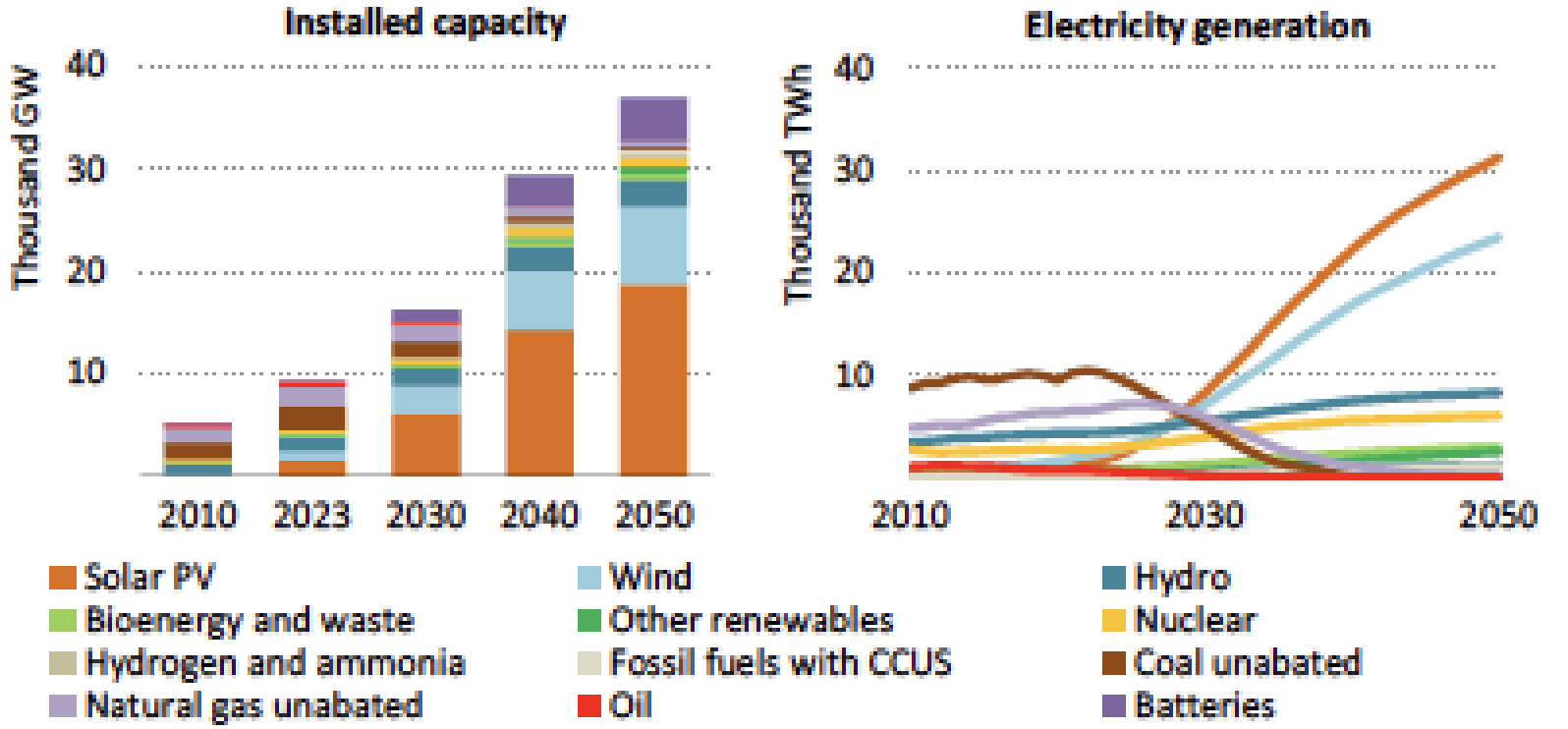
# Key milestones for the electricity sector in the NZE Scenario, 2022-2050




*Renewables capacity triples and grid investment doubles by 2030, unabated coal is phased out by 2040 in the NZE Scenario and nuclear capacity more than doubles by 2050*

Source: IEA, 2023

# Total installed capacity and electricity generation in the NZE Scenario, 2010-2050




*Solar PV and wind lead decarbonisation of the electricity sector, becoming the largest sources of electricity by 2030, complemented by nuclear and other low-emissions sources*

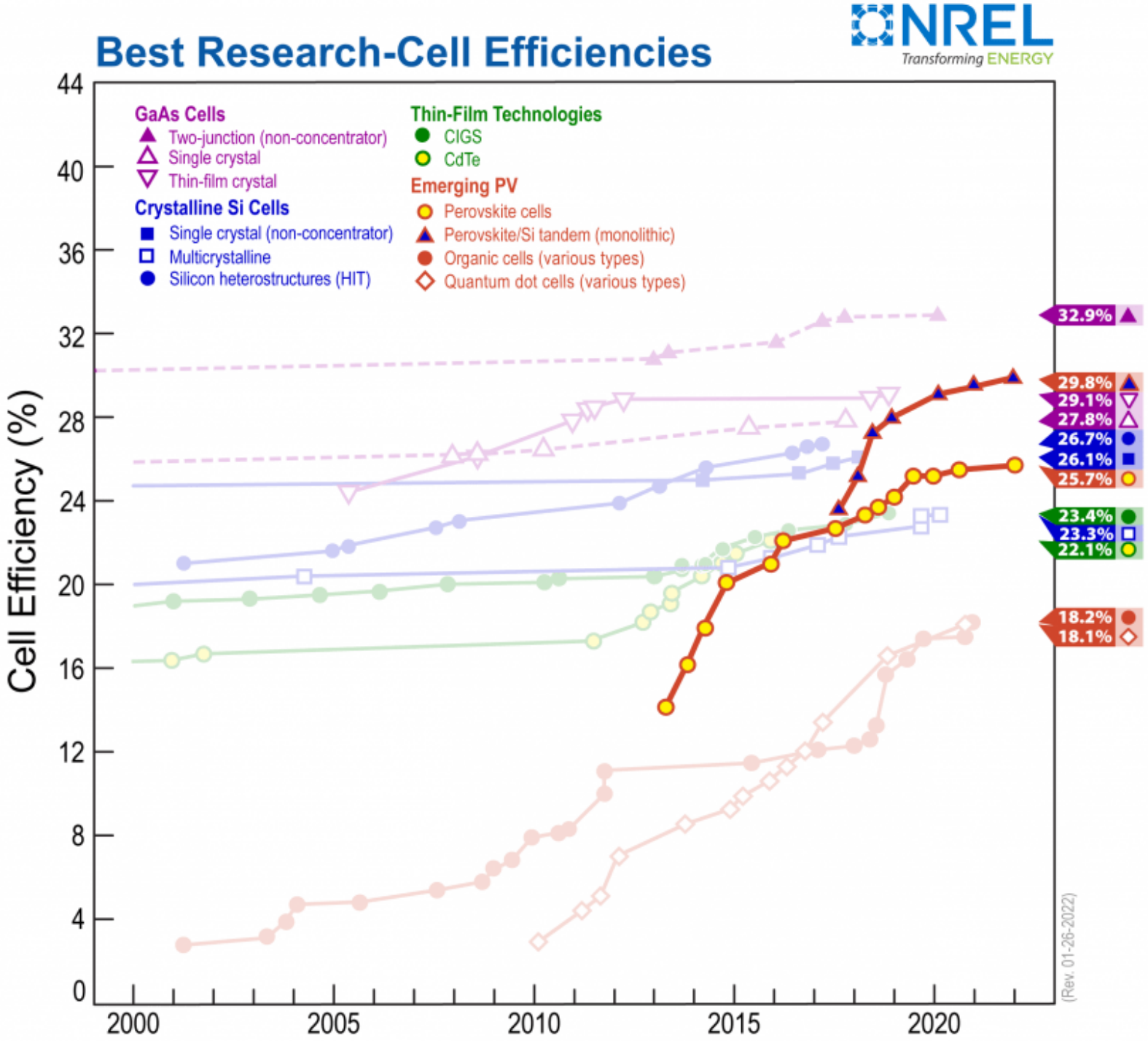
Source: IEA, 2023

# Perovskite Solar Cells

- Remarkable progress in recent years with rapid increases in efficiency, from about 3% in 2009 to over 25%.
- Possiblity of broader application, for instance, in urban areas, where large scale deployment of conventional cells could be difficult.

- Challenges（cf. Siegler et al., ACS Energy Lett. 2022）
  - Stability and durability: limited operational lifetimes.
  - improvement in efficiency in medium- and large-area modules
  - Scaling up perovskite manufacturing
  - Validation, performance verification and bankability

# Best Research-Cell Efficiencies



# Importance of actions by urban areas（IPCC AR6, 2022）

- The global share of emissions that can be attributed to urban areas is increasing. In 2015, urban emissions were estimated to be 25 GtCO2-eq (about 62% of the global share) and in 2020, 29 GtCO2-eq (67–72% of the global share).
- Urban areas can create opportunities to increase resource efficiency and significantly reduce GHG emissions through the systemic transition of infrastructure and urban form through low-emission development pathways towards net-zero emissions.
- Policy packages for buildings which combine ambitious sufficiency, efficiency, and renewable energy measures, are effectively implemented and barriers to decarbonisation are removed. Well-designed and effectively implemented mitigation interventions have significant potential to contribute to achieving SDGs . Benefits of transition: reducing energy bill, improving health, strengthening resilience…
- Cities can achieve net-zero emissions, but only if emissions are reduced within and outside of their administrative boundaries through supply chains, which will have beneficial cascading effects across other sectors.

# Expectations and challenges of the new-generation PV

- Role in the emerging new energy system toward decarbonization.
  - Towards energy system with more distributed and interlinked energy sources.
  - Energy system integration : How to integrate variable renewable into the grid? How to ensure and increase flexibility of power system, in a decarbonized and cost- effective ways?

- Technologies and policy interact: How to promote/accelerate transition, including development and diffusion of these technologies?
  - Policies and measures to raise demand for and to create market of lower carbon products and services. Policies and measures to make carbon (reduction) value clearly visible to users and consumers
  - Building infrastructure for new technologies, including institutional infrastructure enhancing innovation, such as new standards and QC scheme, regulatory measures
  - Promoting financial flow and investment for new technologies

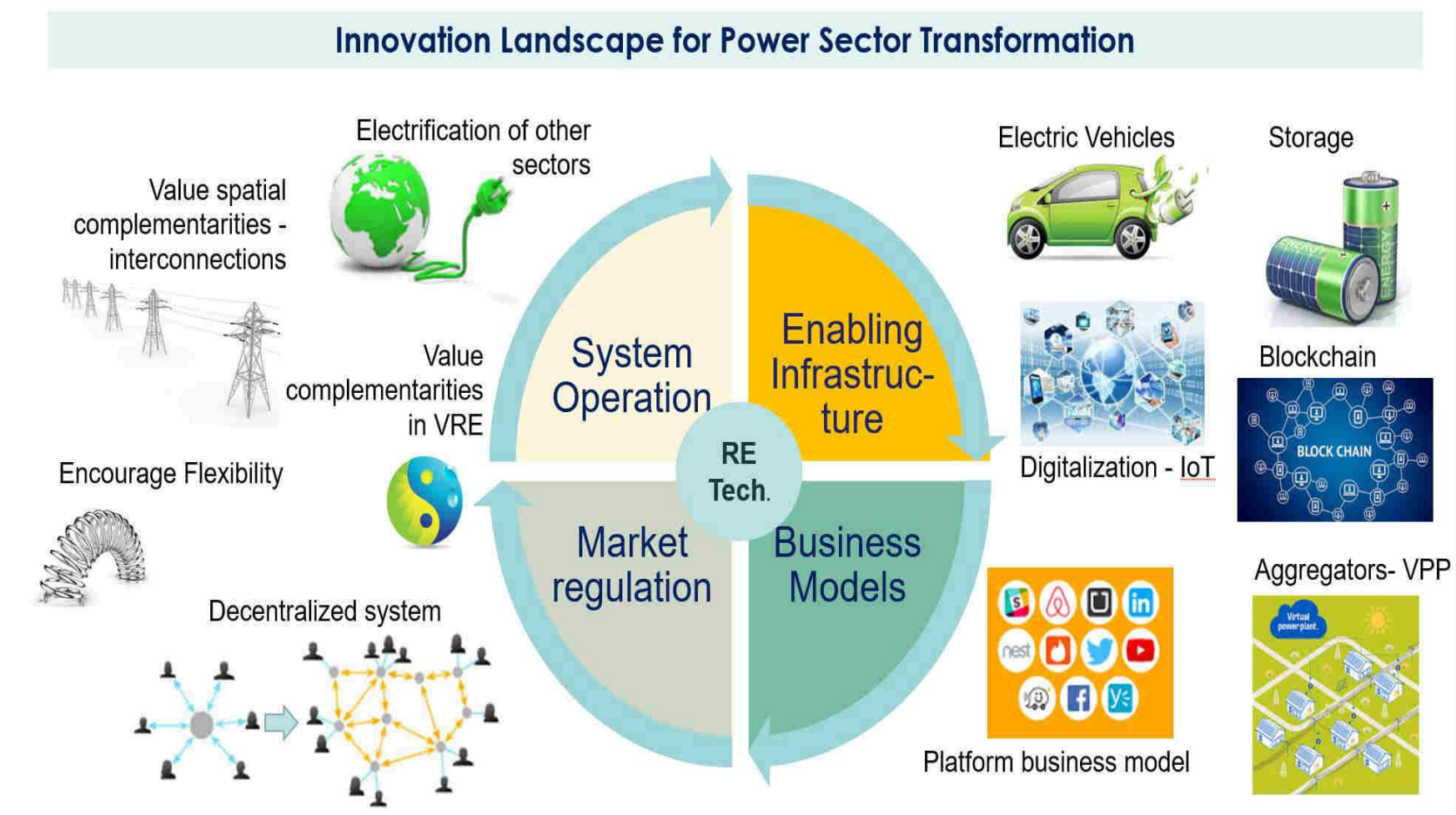
- Collaboration with a variety of technology areas and disciplines.

# 3D : Decarbonization, Decentralization and Digitalization

## Innovation progresses across the sectors (through sector coupling)

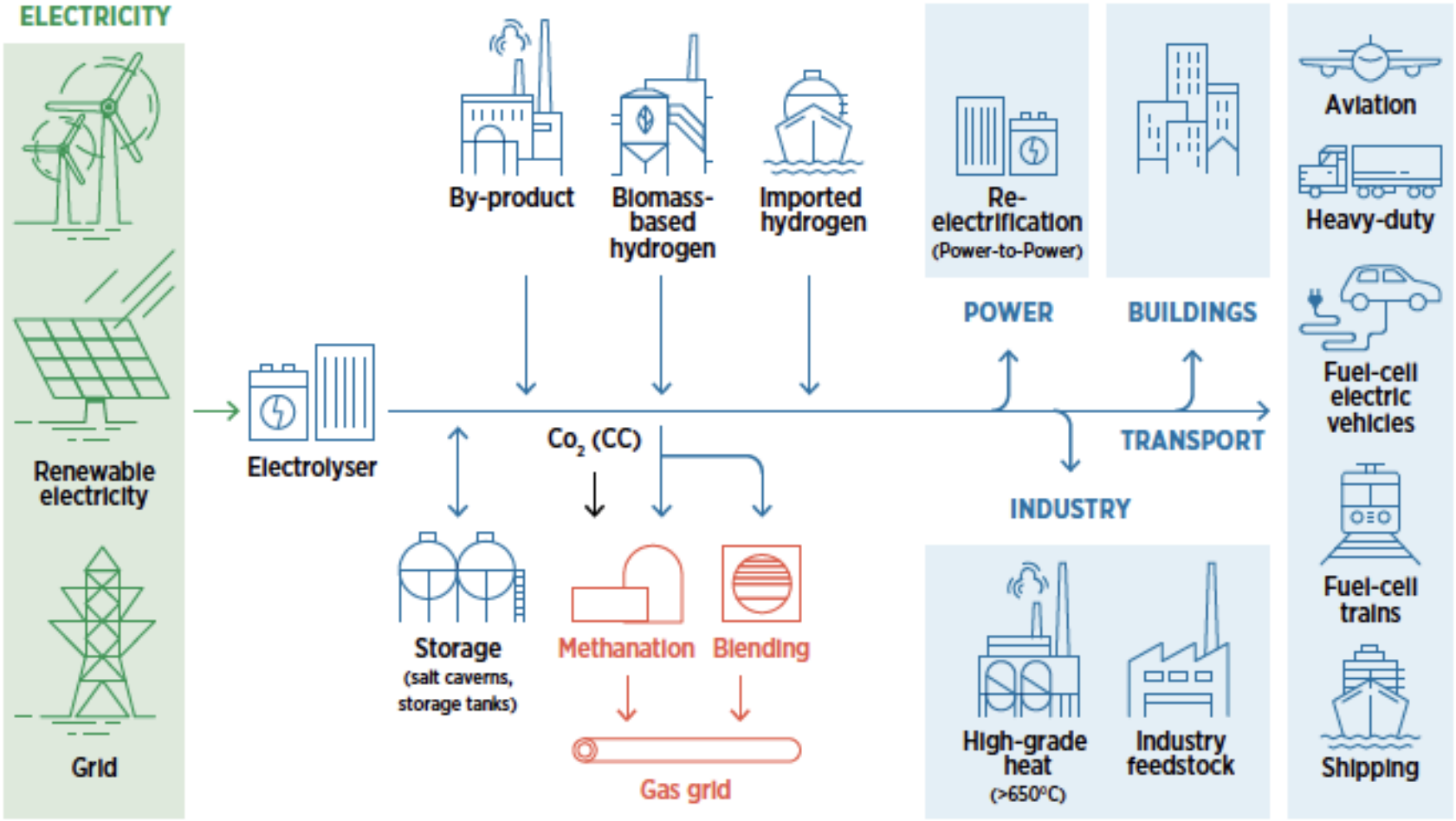
"Grid integrated efficient buildings" "Grid interactive efficient buildings"

Complementarity of technologies 技術の補完性




Source: IRENA, 2017

# Sector Coupling
# Power to X
# Energy System Integration




Source: IRENA, 2018

Thank you for your attention!

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