APEC Energy Demand and Supply Outlook
9th Edition
Japan Chapter

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January 23, 2026

Outline

1. Introduction to the Outlook
2. Macroeconomic and Demographic Trends
3. End-use Energy Demand by Sector
    1. Buildings
    2. Industry
    3. Transport
4. Electricity Generation
5. Generation Capacity and Grid Reliability
6. Primary Energy Supply and Import Dependence
7. Costs
8. CO_2 Emissions
9. Key Takeaways

Japan's energy future through two pathways

9th APEC Energy Outlook period:

- 2023-2060

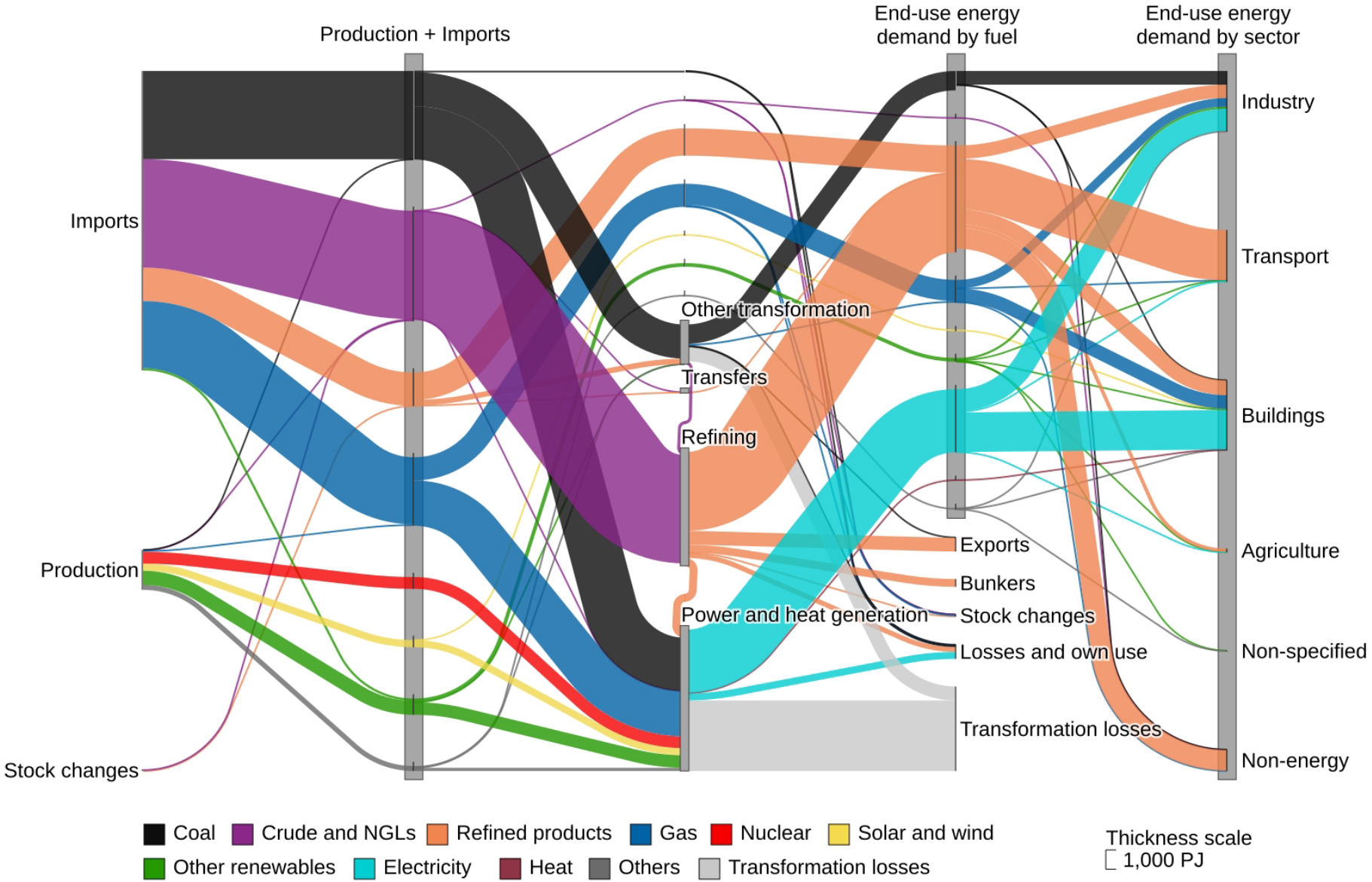
Scenarios:

- **Reference Scenario (REF):**
  - Projection based on historical trends and APERC's assumptions about the continuation of those trends, while acknowledging technical constraints.
- **Target Scenario (TGT):**
  - Explores a hypothetical pathway where Japan achieves its energy-related policy targets, assuming implementation regardless of cost-effectiveness.

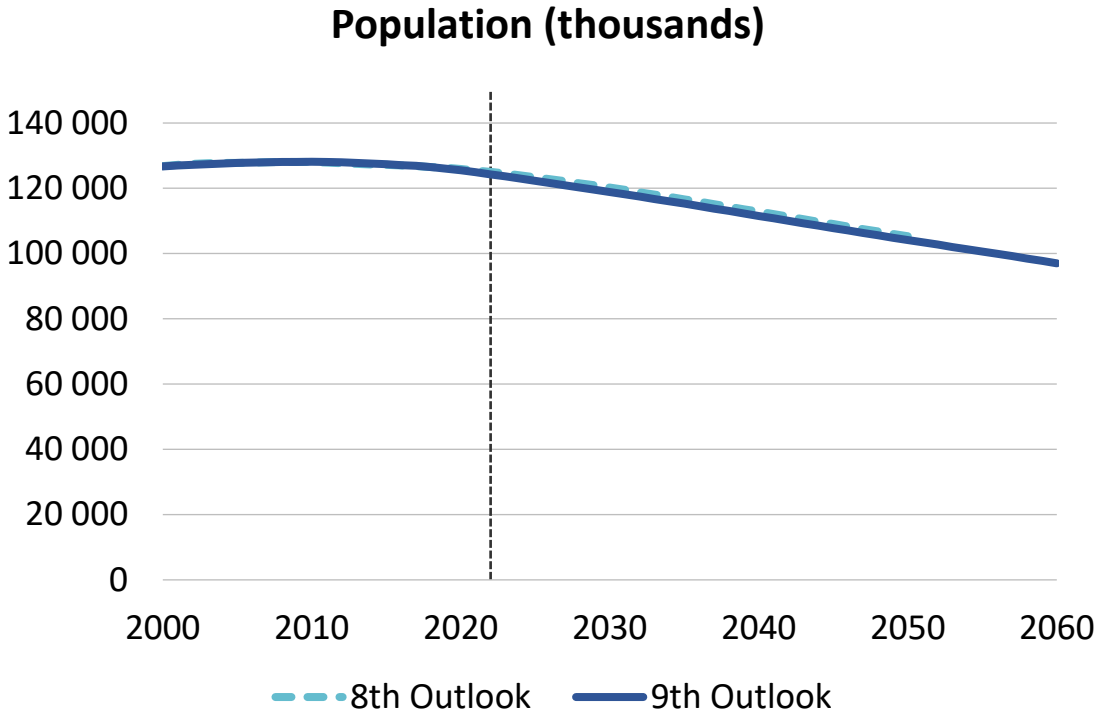
4 Key Takeaways:

- Emissions
- Energy Import Dependence
- Grid Reliability
- Cost

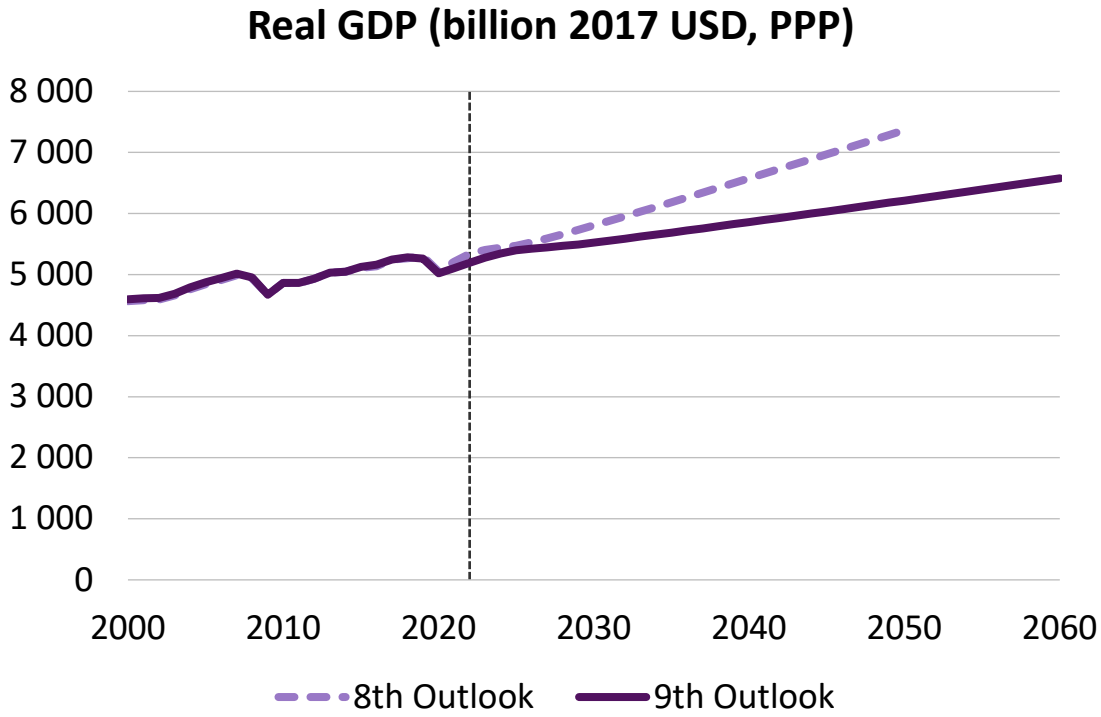
Japan’s Energy System in 2022



Higher living standards offset demographic decline



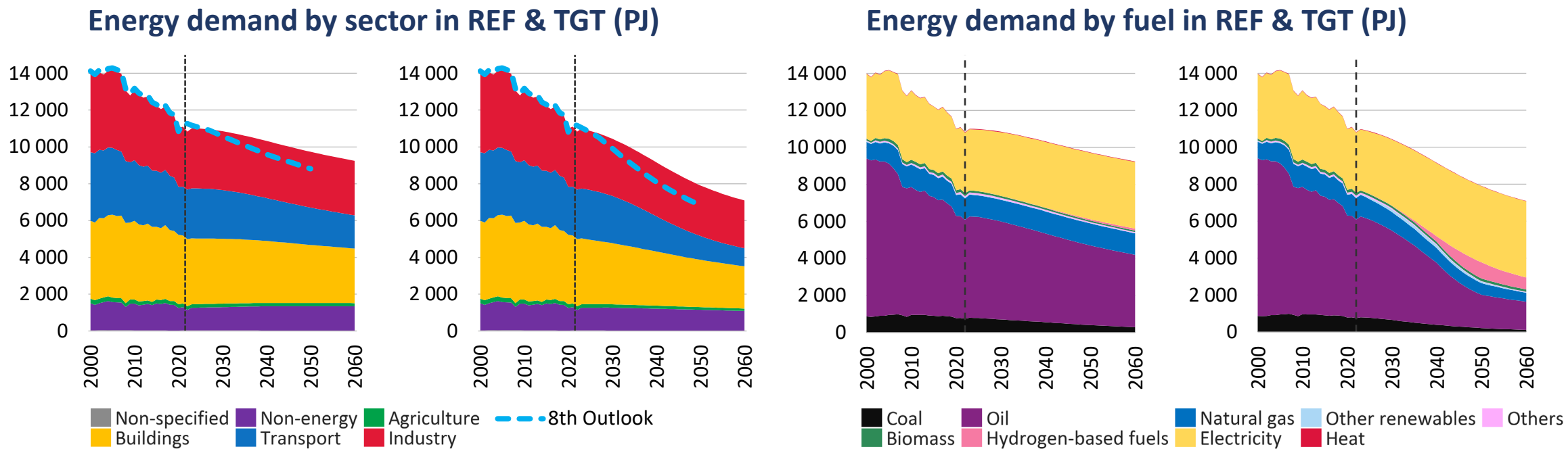
Note: Population projections are based on the UN DESA World Population Prospects (2022 revision, medium variant, to 2100).



Note: Historical GDP is from the World Bank. Near-term GDP projections (2023–2027) are from the IMF, with longer-term GDP extended by APERC based on population trends. GDP is expressed in constant 2017 USD at purchasing power parity (PPP).

- **Japan's population declines steadily to 2060**, broadly in line with the previous Outlook.
- **Compared with the 8th Outlook, long-term GDP growth is more moderate**, reflecting stronger demographic and productivity headwinds after 2027.
- Even so, **GDP per capita continues to rise**, supporting **growing demand for energy services per person.**

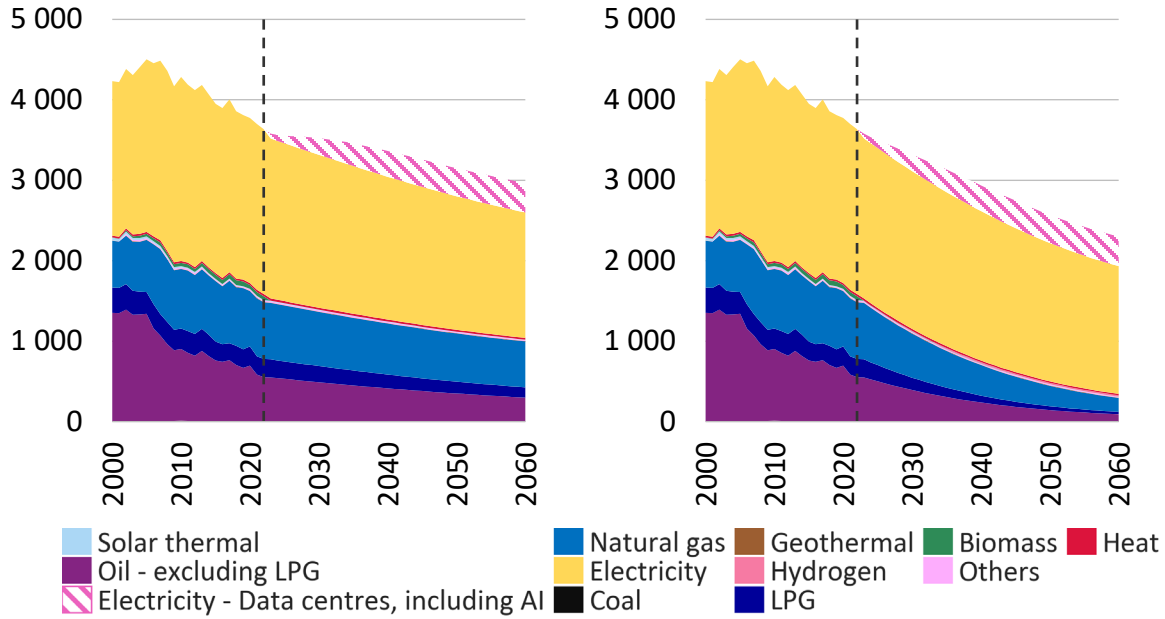
Japan's long-term demand decline shifts the focus to emissions and energy security



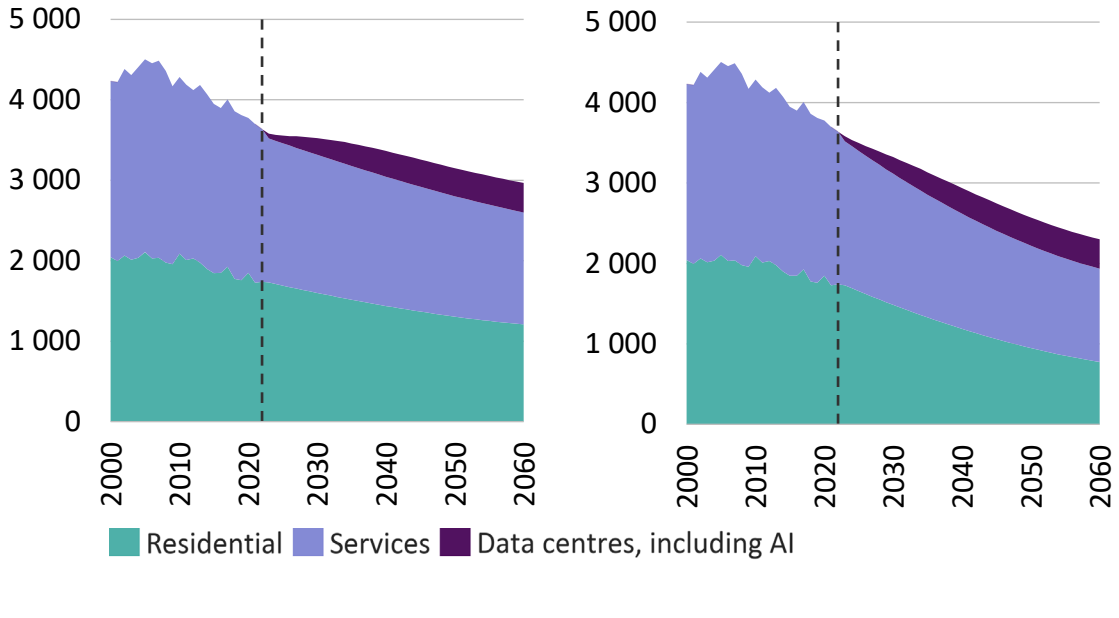
- Final energy demand declines across buildings, industry and **most strongly in transport**.
- This is driven primarily by a sharp **reduction in transport oil use**, while **oil demand for non-energy applications remain resilient** due to petrochemical feedstocks.
- **Electricity and hydrogen-based fuels expand**, with electricity becoming the largest final energy source in TGT by 2060, exceeding half of total demand.

Buildings demand declines, even while data centres demand surges

Buildings energy demand by fuel in REF & TGT (PJ)



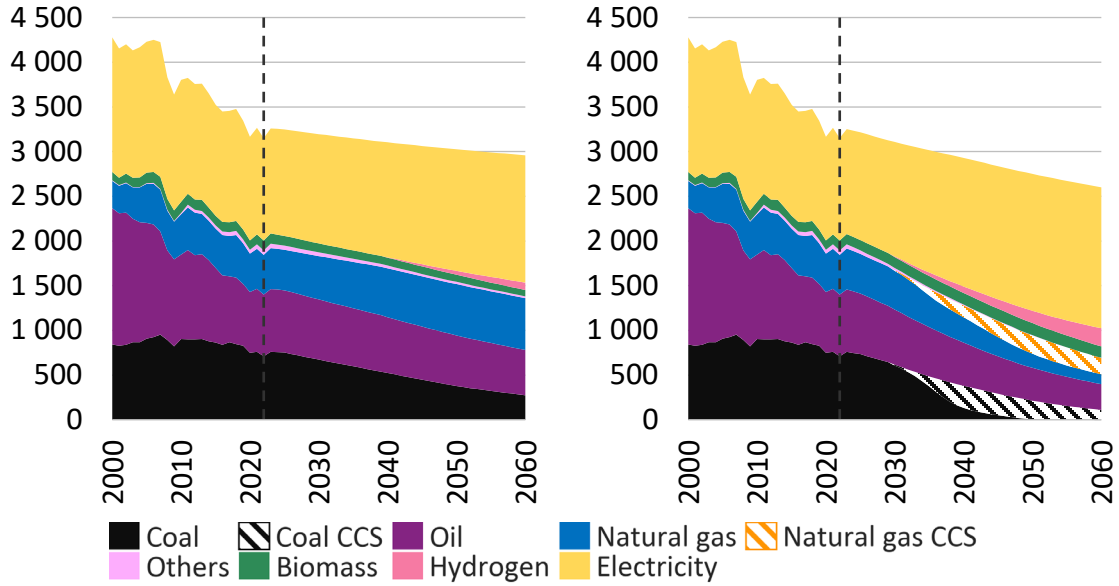
Buildings energy demand by sector in REF & TGT (PJ)



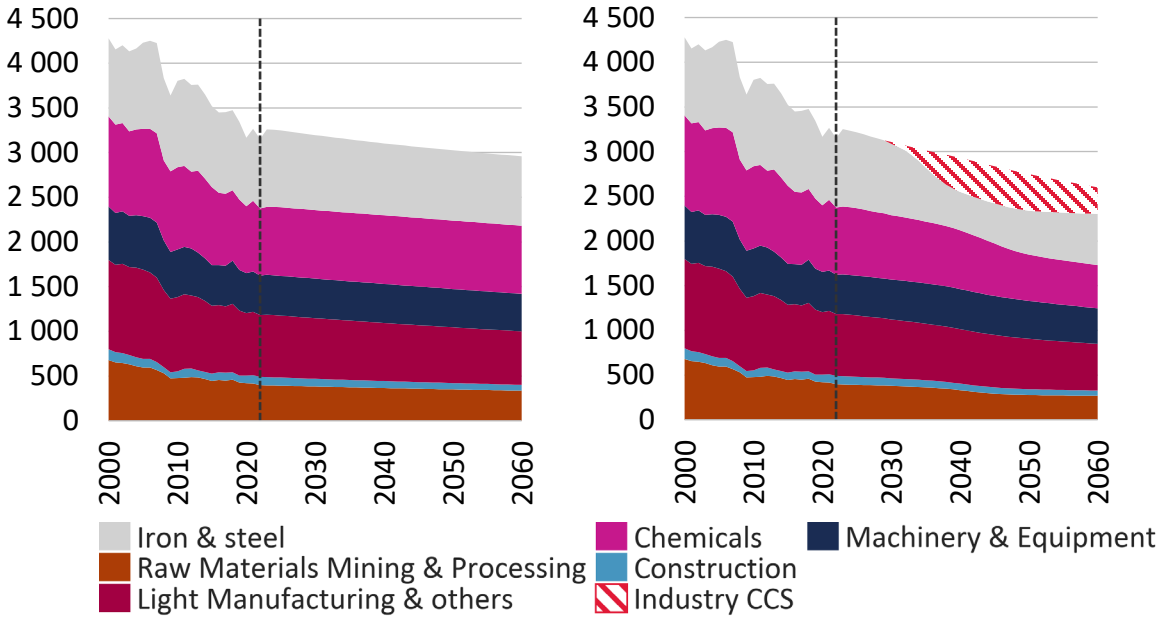
- Buildings energy demand declines in both REF and TGT as **residential and services demand falls** with efficiency gains and population ageing.
- **Data centres and AI are the key exception**, driving around **40%** of economy-wide electricity demand growth and reaching about **10%** of economy-wide electricity demand by 2040 in TGT.
- Furthermore, **electricity's share continues to rise** in the buildings sector, reflecting both the growth of data centres and continued electrification in residential and services, even as **fossil fuel use persists** due to slow building turnover.

CCS enables deep emissions cuts in steel, cement, and petrochemicals

Industry energy demand by fuel in REF & TGT (PJ)



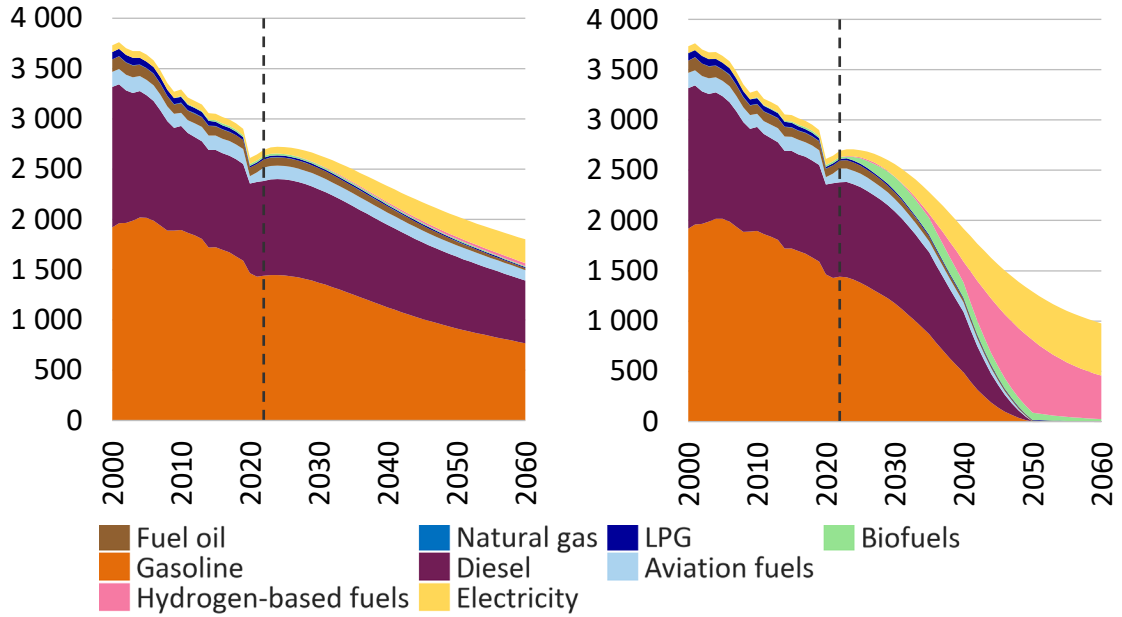
Industry energy demand by sector in REF & TGT (PJ)



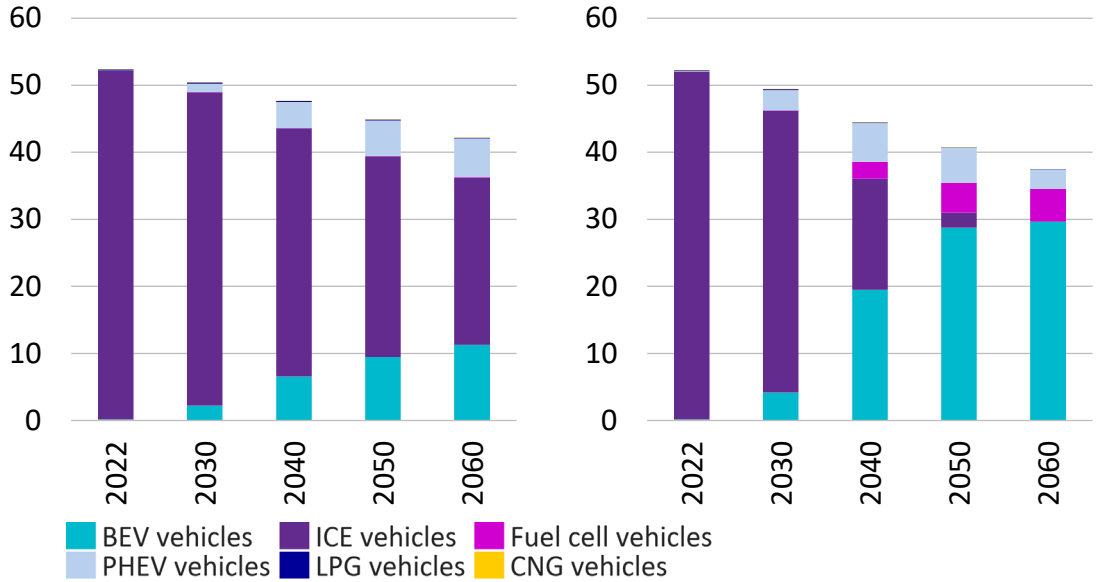
- **Industrial energy demand declines** in both REF and TGT, with a larger reduction in TGT driven by efficiency improvements and structural change in industrial activity.
- **CCS is deployed in the most carbon-intensive subsectors**, particularly steel, cement, and petrochemicals, enabling continued use of fossil fuels while cutting process and combustion emissions.
- **Hydrogen and electricity expand across industry**, with hydrogen used in hard-to-abate processes and electricity largely replacing fossil fuels in lower-temperature, machinery, and electric-arc furnace steelmaking uses.

BEV efficiency drives major demand drop; e-fuels decarbonise remaining combustion

Domestic transport energy demand in REF & TGT (PJ)



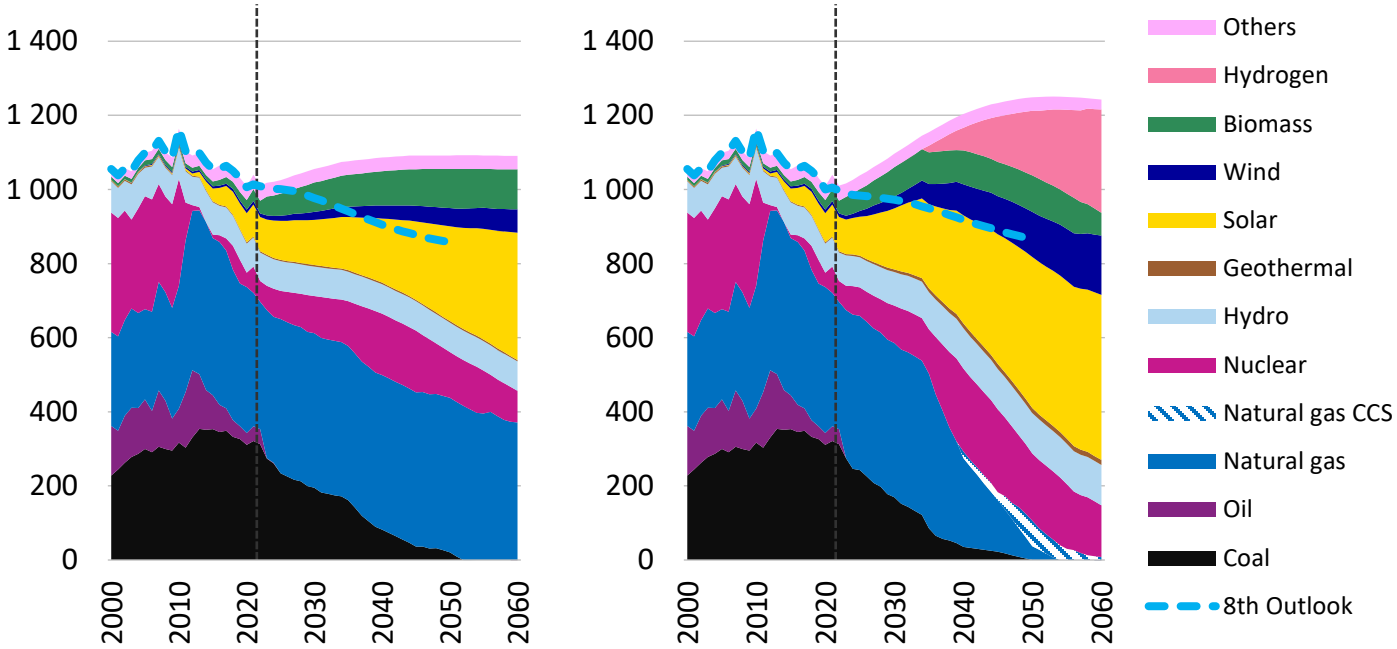
Transport vehicle stocks in REF & TGT (millions)



- **BEVs drive the largest reduction** in transport energy demand, as they are around three times more efficient than internal combustion vehicles.
- **E-fuels are used to decarbonise remaining combustion**, particularly in PHEVs and heavy vehicles, reflecting Japan's technology-neutral transition pathway.
- This approach prioritises flexibility over a purely BEV-centred transition, leaving a **larger role for e-fuels** to address residual fossil fuel use.

Electrification raises power demand in TGT, but the power mix becomes much cleaner

Electricity generation by fuel in REF & TGT (TWh)

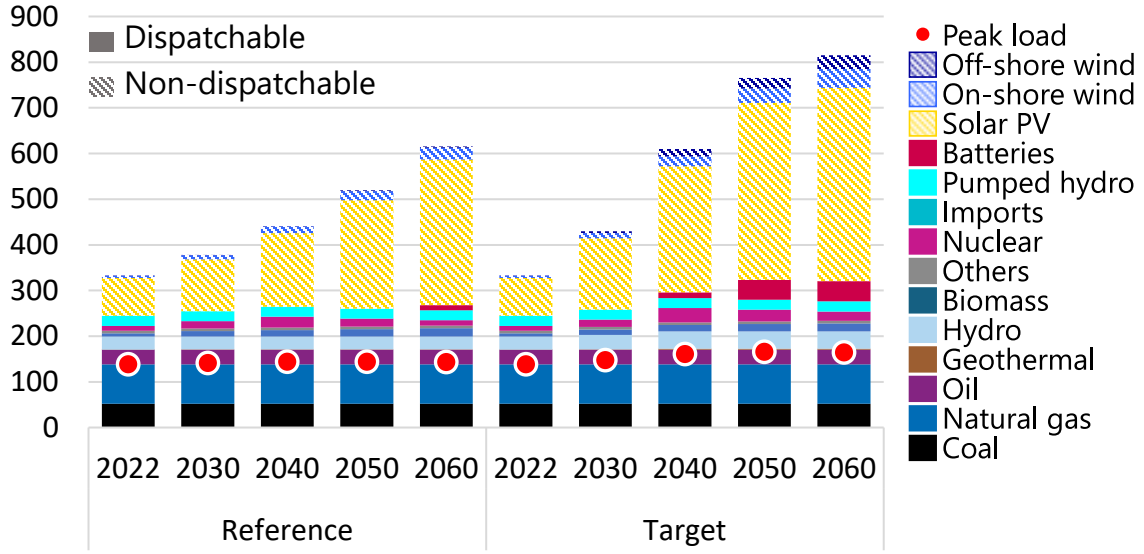


Generation mix	2022	2040 (REF)	2040 (TGT)	2060 (REF)	2060 (TGT)
Electricity generation	1010 TWh	1086 TWh	**1204 TWh**	1091 TWh	1243 TWh
Hydrogen	0%	0%	5.1%	0%	**22%**
Biomass	3.4%	8.5%	7.6%	9.9%	5.0%
Wind	0.9%	3.3%	7.0%	5.8%	**13%**
Solar	9.2%	16%	24%	32%	**36%**
Geothermal	0.3%	0.4%	1.1%	0.4%	1.1%
Hydro	7.6%	7.3%	9.0%	7.3%	8.8%
Nuclear	5.6%	15%	**19%**	7.8%	11%
Natural gas CCS	0%	0%	1.5%	0%	0.7%
Natural gas	34%	38%	20%	**34%**	**0%**
Oil	4.1%	0%	0%	0%	0%
Coal	31%	7.6%	2.9%	0%	0%

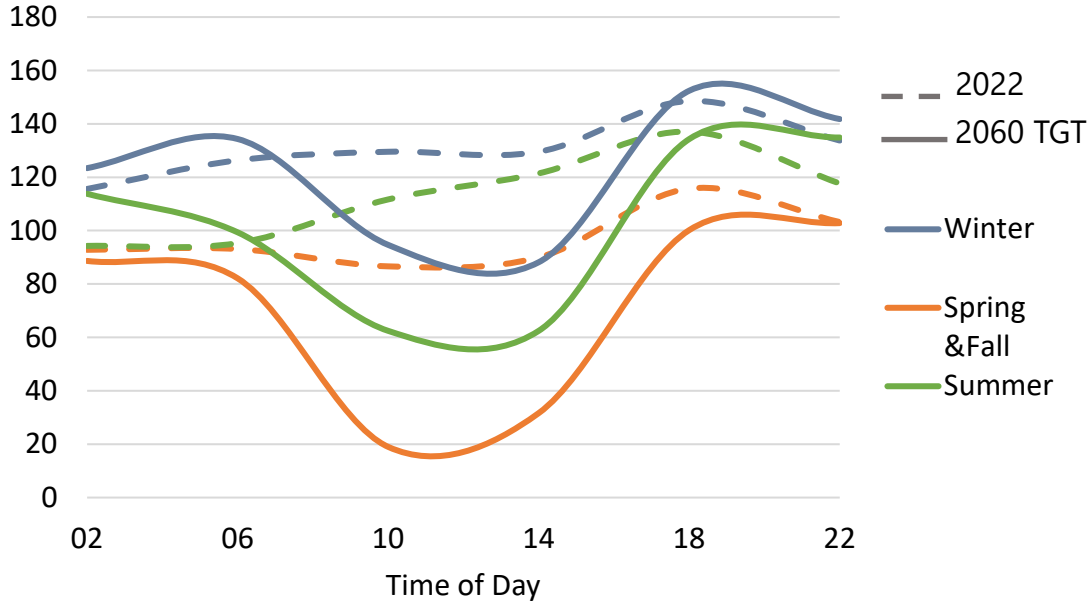
- **Electricity generation grows much faster in TGT** as electrification across transport, buildings, and industry raises demand to over 1,200 TWh by 2040, compared with around 1,090 TWh in REF.
- **In REF, it remains gas-heavy**, with natural gas still supplying around one-third of generation in 2060, whereas **in TGT, it eliminates coal, oil, and unabated gas** through a shift to **renewables, nuclear, hydrogen, and CCS**.
- **Hydrogen becomes a major low-carbon pillar of the power system in TGT**, reaching around 20% of generation by 2060, enabling deep decarbonisation while supporting grid reliability.

Surging renewable capacity leads to grid reliability challenges

Total generation capacity and peak load (GW)



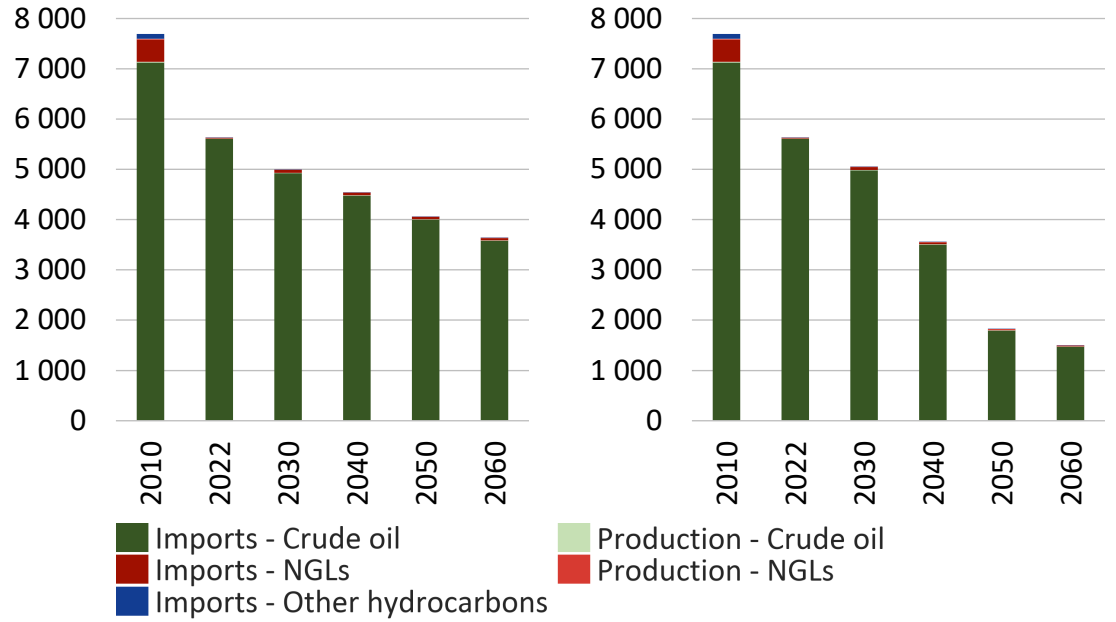
Power from dispatchable sources in TGT (GW)



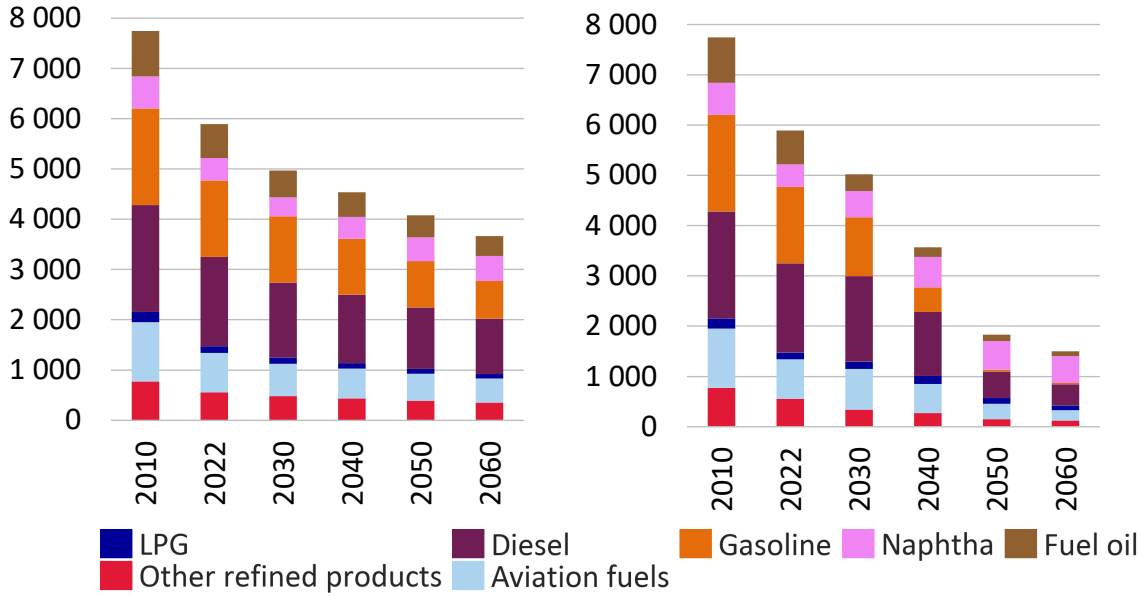
- **Installed capacity more than doubles in TGT**, rising to over **800 GW** by 2060, **even though peak load increases only modestly**, widening the gap between capacity and demand.
- **High solar penetration creates deep midday troughs and steep evening ramps**, forcing dispatchable capacity to respond rapidly across all seasons.
- **Maintaining grid reliability requires much greater flexibility**, including dispatchable power, storage, and stronger interregional transmission.

Transport fuel decline shrinks refining, but core capacity supports exports and petrochemicals

Crude oil, NGLs, and other hydrocarbon production and imports in REF & TGT (PJ)

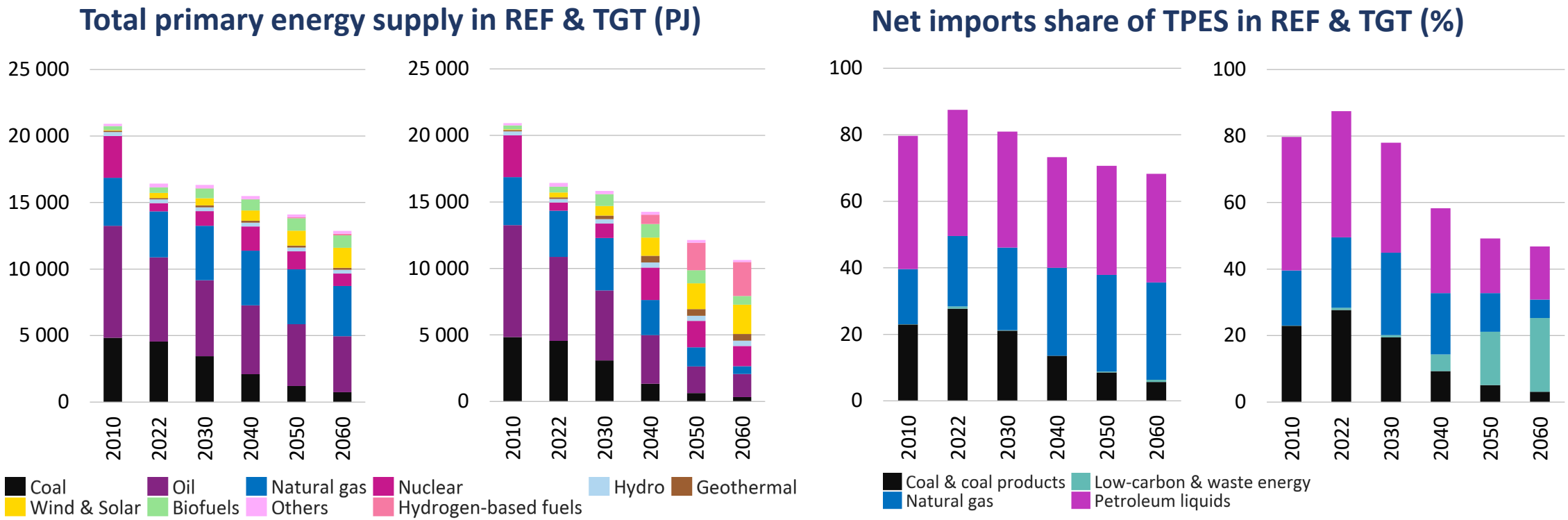


Refining outputs in REF & TGT (PJ)



- **Crude oil demand falls sharply in TGT**, driven by the phase-out of gasoline and diesel in the transport sector.
- Japan remains almost fully **import-dependent for crude oil** in both scenarios, with negligible domestic production.
- Refining capacity contracts, but Japan **retains a core refining base to supply petrochemical feedstocks and regional exports**, particularly naphtha, LPG, diesel, and jet fuel.

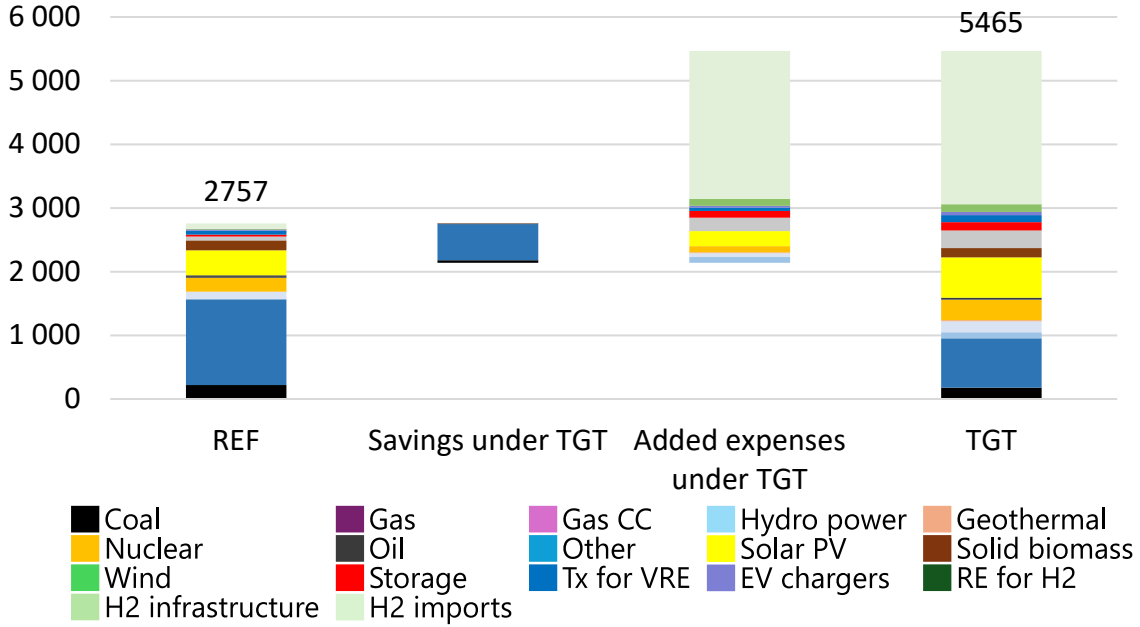
Declining fossil fuel use improves energy self-sufficiency



- **Fossil fuel imports decline**, especially coal and oil, as power generation and transport are transformed, reducing exposure to overseas supply risks.
- As a result, Japan's energy **self-sufficiency rises sharply** from around **13% in 2022** to about **32% in REF** and over **50% in TGT by 2060**.
- New import dependencies emerge for **hydrogen and e-fuels in TGT**, highlighting the importance of diversified supply chains even as overall fossil fuel import reliance declines.

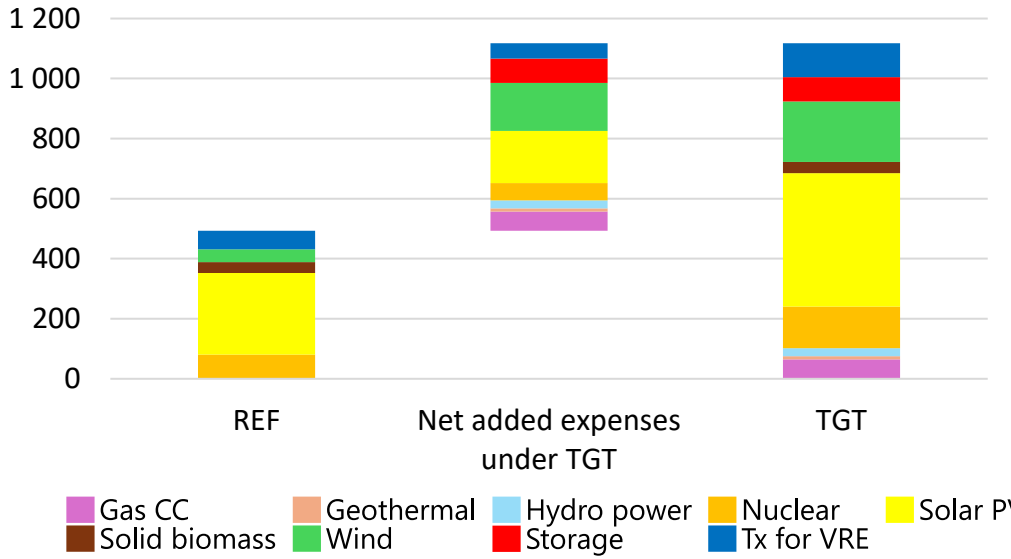
High system costs reflect Japan's technology-neutral decarbonisation pathway

Costs in the power and hydrogen sectors, 2025 to 2060 (billion USD, undiscounted)



Note: Tx for VRE is only transmission infrastructure to connect variable renewable capacity to the grid. EV chargers do not cover the cost of associated infrastructure or EV vehicles. H2 imports to meet bunkering obligations are not included in this figure.

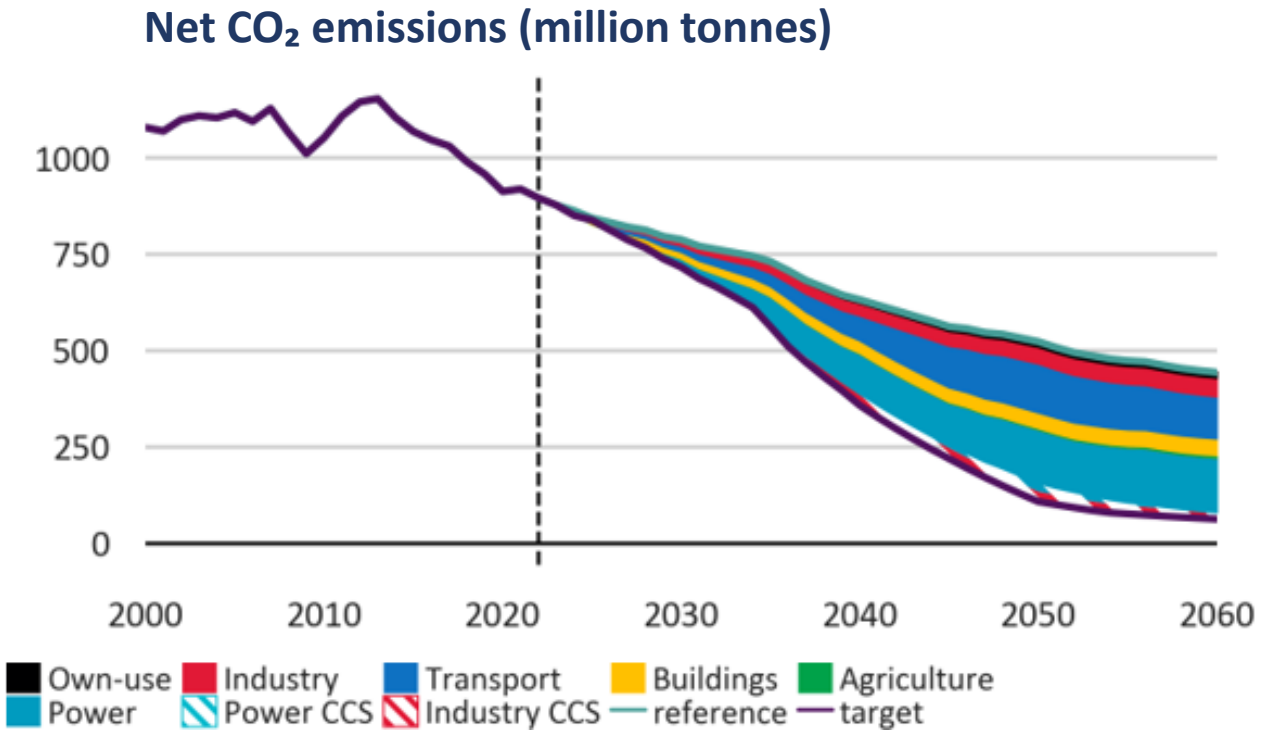
Total capital investment (CAPEX) from 2025 to 2060 in the power sector (billion USD, undiscounted)



Note: This figure only covers power and VRE transmission sector investments. Hydrogen and EV capital investments are not included.

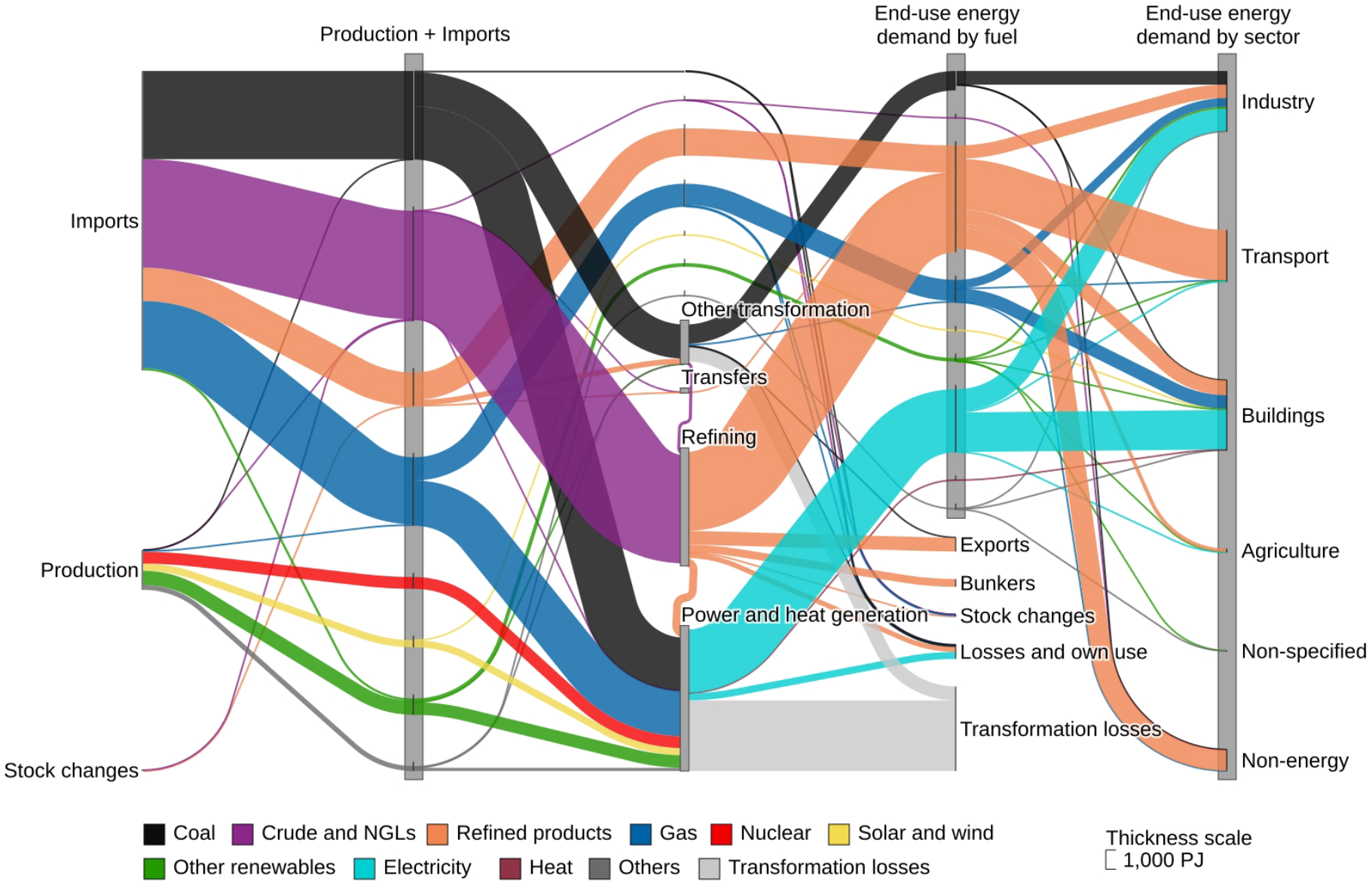
- **Total system costs nearly double in TGT**, reaching around USD 5.5 trillion compared with USD 2.8 trillion in REF.
- **Transport e-fuels and hydrogen blending in power account for most of the cost increase**, together adding over USD 2 trillion through to 2060.
- **Power-sector capital investment is much higher in TGT**, reflecting the expansion of solar, wind, storage, and transmission needed to support a high-renewables system.

In TGT, deeper CO_2 cuts still leave a net-zero gap

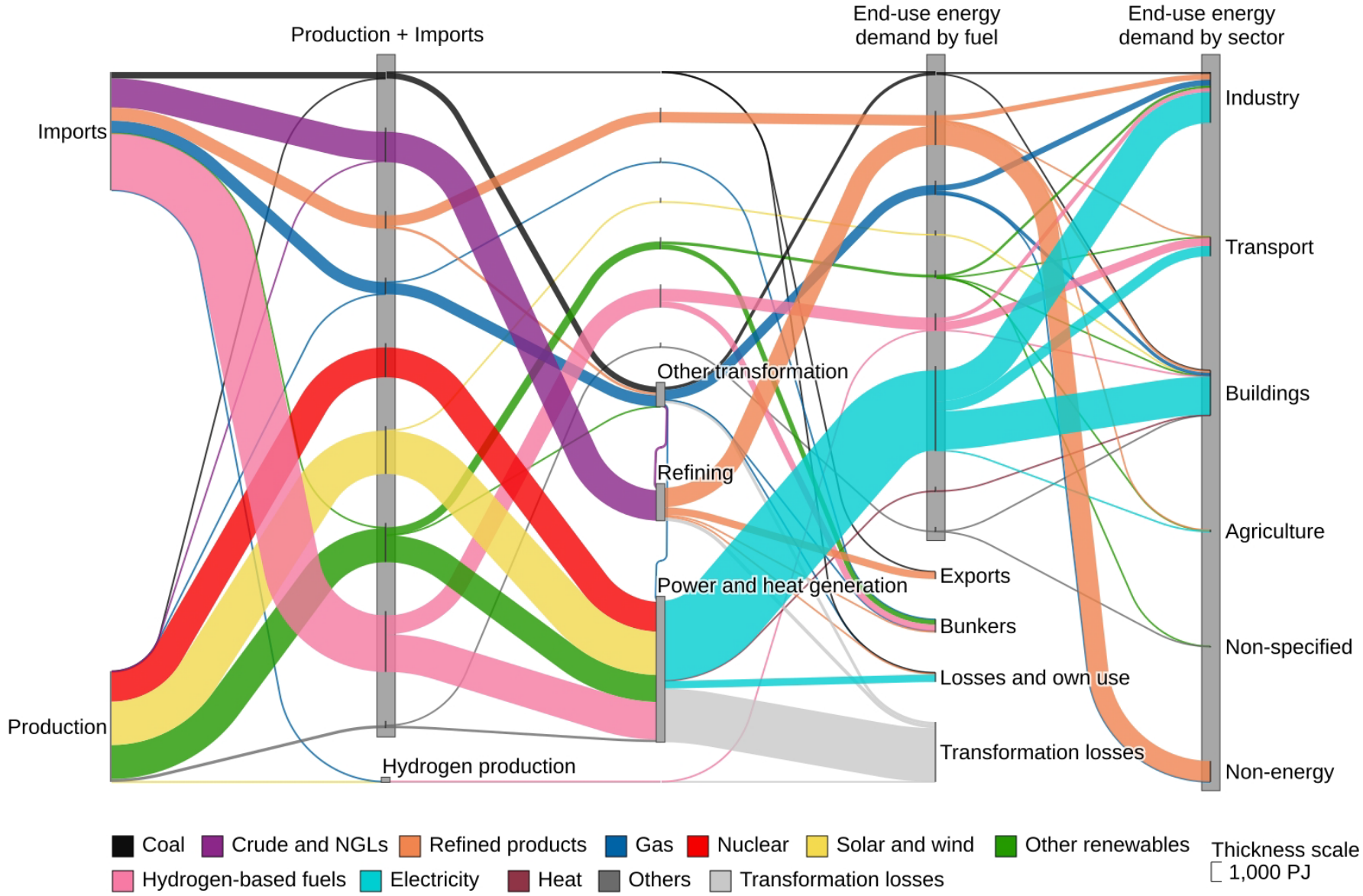


- In 2050, net CO_2 emissions fall to around **100 $MtCO_2$ in TGT**, but remain over **500 $MtCO_2$ in REF**.
- Stronger reductions in TGT are driven by widespread fuel switching, electrification, and deployment of **CCS** (**50 $MtCO_2$** captured annually by 2050 in power and industry).
- Despite this, **residual emissions persist** in TGT, highlighting the need to **enhance forest carbon sinks** and **negative emissions technologies** (e.g., DAC, BECCS) to fully close the gap.

Japan's Energy System in 2022



Japan's Energy System in 2060 (TGT)



Japan's energy future: navigating trade-offs on the path to net-zero

- Japan's transition is shaped by demographic decline and the need to **balance decarbonisation with energy security**, as fossil fuel imports fall but new **import dependencies** on hydrogen and e-fuels emerge.
- A power system dominated by renewables creates new **grid reliability challenges**, making system flexibility, including dispatchable capacity, critical to maintaining stability.
- **Deeper CO_2 emission cuts are achieved in TGT** through electrification alongside hydrogen, e-fuels, and CCS, but a **net-zero gap remains** without carbon removals.
- This pathway delivers **lower emissions** and **improved self-sufficiency**, but comes with **significantly higher system costs**, driven by fuel imports and large-scale infrastructure investment.
- Balancing **decarbonisation**, **security**, and **affordability** will require continued innovation, policy support, and regional cooperation.

Thank you.

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