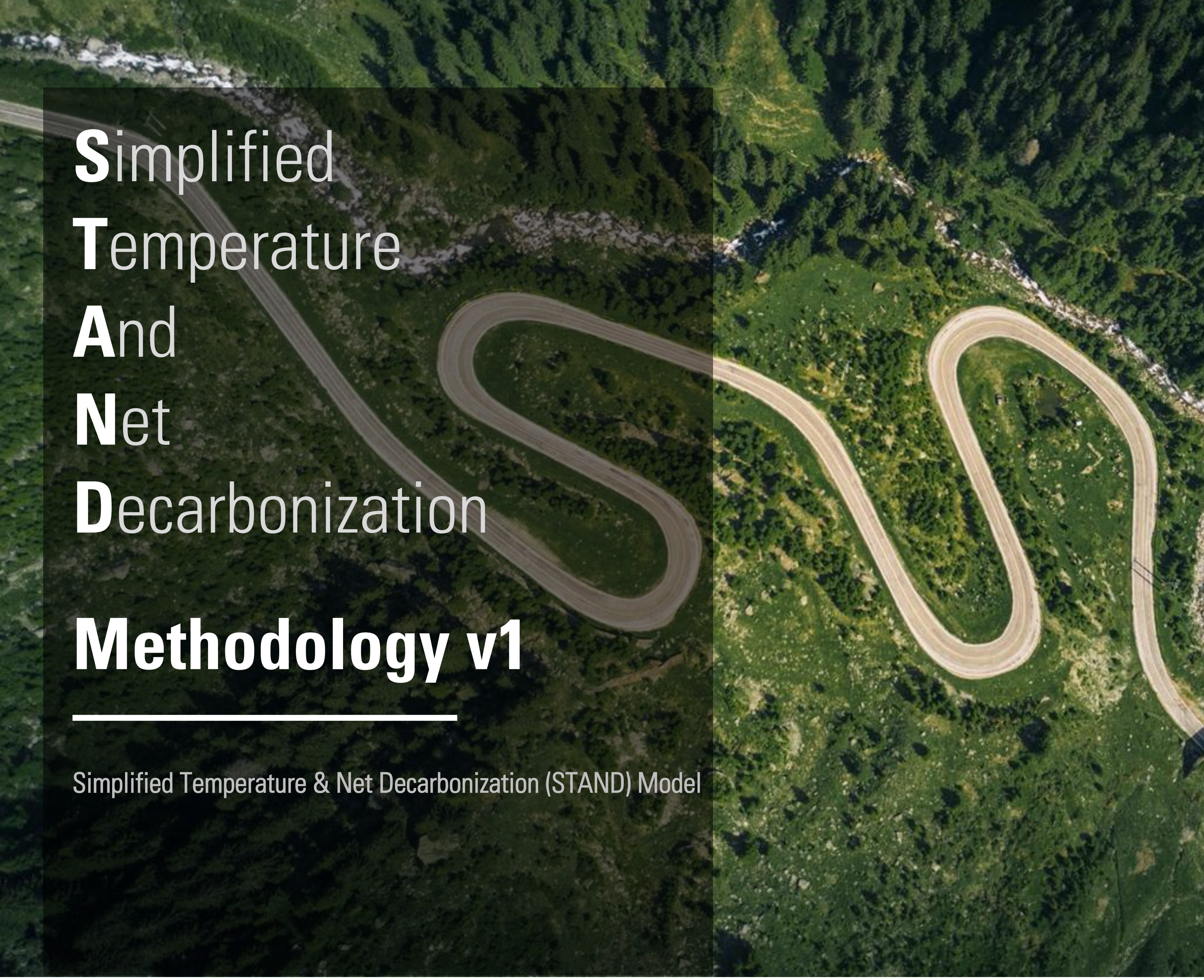

Simplified **T**emperature **A**nd **N**et **D**ecarbonization

Methodology v1

Simplified Temperature & Net Decarbonization (STAND) Model

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Inevitable Policy Response

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Disclaimer

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1. STAND Model General Principles

The Simplified Temperature & Net Decarbonization (STAND) Model utilizes technological learning curves identified in full Integrated Assessment Models (IAMs) alongside user-based assumptions on region policy timings, to forecast energy-system pathways better mapped to the user's convictions.

Crucially, the STAND model is not itself an IAM or energy-technology model. It applies a machine-learning approach to process a large universe of IAM model outputs in order to identify the likely relationship between user assumptions around transition dynamics and the 'best fit' identified in the scenario literature in terms of technology learning curves, price, and deployment dynamics.

The STAND model is a model commissioned by the Inevitable Policy Response (IPR) and can be used in conjunction with a tool to develop bespoke forecast and transition scenario pathways that directly align with user beliefs and use cases at significantly lower costs than full IAM model runs. Powered by a universe of +50 leading climate transition scenarios, users are able to integrate the collective knowledge of +10 years of transition modelling while still generating the exact outputs they need for their use cases.

This document outlines the methodology of the STAND model as it is applied by IPR . Given the specific use case of IPR and the desire for consistency with the previous Forecast Policy Scenarios (FPS) released by IPR, the model here is only trained on the 2023 Forecast Policy Scenario (FPS 2023).

If you are interested in understanding broader applications outside of the IPR scope, please reach out to the authors.

2. Application in the context of the Inevitable Policy Response Forecast Policy Scenario

For the Forecast Policy Scenario in 2025, uses STAND based on FPS 2023 and over 250 regional and topical experts' opinion on 12 key policy areas across 21 countries (G20 countries + Vietnam). It is an expert-calibrated, IAM-informed methodology to forecast energy-system pathways, rather than running a full end-to-end IAM for each value driver. Each value driver is bound by:

i. **Starting points**: historical starting values derived from our country-level research (aggregated to regions)
ii. **Curves**: 'Learning' S-curves derived from the FPS 2023 full IAM using the STAND machine-learning approach.
iii. **End points**: defined policy and adoption targets from >250 regional and topical experts surveyed in late 2024 and summarized in the table below. This survey is conducted annually, generating 7,000+ data points on critical policy developments.

Insufficient responses were received to deem results robust, hence actual policy targets were applied instead (N/A if no policy target is available)

			Economy wide		Power		Buildings	Transport		Industry	Agri	Land use	Nature	
		% of world CO_2 emissions	Net Zero CO_2 emissions	Carbon price*	All coal phase-out	Clean power	Zero-carbon heating	Light duty vehicles	Heavy duty vehicles	Industry decarb.	Low-carbon agriculture	Net deforestation	Protection**	Nature incentives
Asia Pacific excl. China	Australia	1.0%	2050-2054	$70-$82	2035-2039	2040-2044	2035-2039	2040-2044	2045-2049	2045-2049	by 2040	by 2040	2035-2039	2030-2034
	Indonesia	1.8%	2065-2069	$37-$50	2045-2049	2055-2059	N/A	2050-2054	2050-2054	2050-2054	> 2040	>2040	2040-2044	2040-2044
	India	7.0%	2070-2074	$50-$74	2045-2049	2055-2059	N/A	2050-2054	2055-2059	2055-2059	> 2040	Achieved	2050-2054	2050-2054
	Japan	3%	2050-2054	$35-$70	2040-2044	2045-2049	2045-2049	2040-2044	2045-2049	2045-2049	by 2040	by 2030	Achieved	2035-2039
	South Korea	1.6%	2055-2059	$43-$70	2045-2049	2050-2054	2050-2054	2050-2054	2045-2049	2055-2059	> 2040	>2040	2040-2044	2040-2044
	Vietnam	0.8%	2060-2064	N/A	2050	2045-2049	N/A	2040-2044	2050	>2050	> 2040	by 2030	2030	N/A
China	China	33.9%	2060-2064	$50-$62	2035-2039	2045-2049	2045-2049	2035-2039	2045-2049	2045-2049	by 2040	Achieved	2030-2034	2040-2044
Europe	France	0.8%	2050-2054	$95-$120	Achieved	Achieved	2035-2039	2035-2039	2045-2049	2045-2049	by 2035	Achieved	2030-2034	2035-2039
	Germany	1.7%	2050-2054	$85-$120	2035-2039	2035-2039	2035-2039	2040-2044	2040-2044	2040-2044	by 2040	Achieved	Achieved	2035-2039
	Italy	0.8%	2055-2059	$71-$120	2030-2034	2040-2044	2040-2044	2040-2044	2045-2049	2045-2049	by 2040	Achieved	2030-2034	2040-2044
	UK	0.9%	2050-2054	$95-$120	Achieved	2035-2039	2040-2044	2040-2044	2045-2049	2040-2044	> 2040	Achieved	2035-2039	2040-2044
Eurasia	Russia	5%	2065-2069	N/A	2050-2054	2060-2064	2050-2054	2055-2059	2060-2064	2055-2059	> 2040	Achieved	2035-2039	2040-2044
Middle East and Africa	Nigeria	0.3%	2065-2069	N/A	Achieved	2050-2054	N/A	2055-2059	2060-2064	2060-2064	> 2040	>2040	2050-2054	2045-2049
	Saudi Arabia	1.6%	2060-2064	$20-$43	N/A	2050-2054	N/A	2055-2059	2050-2054	2050-2054	N/A	Achieved	2035-2039	2045-2049
	South Africa	1.0%	2060-2064	$30-$60	2045-2049	2045-2049	2045-2049	2050-2054	2045-2049	2045-2049	> 2040	>2040	2035-2039	2040-2044
	Türkiye	1.2%	2060-2064	$30-$40	2040-2044	2045-2049	2050-2054	N/A	2050-2054	2045-2049	N/A	Achieved	2030	N/A
North America	Canada	1.5%	2050-2054	$100-$146	2030-2034	2040-2044	2040-2044	2040-2044	2045-2049	2050-2054	> 2040	>2040	2040-2044	2035-2039
	Mexico	1.3%	2065-2069	$30-$42	2045-2049	2055-2059	N/A	2055-2059	2055-2059	2050-2054	> 2040	>2040	2045-2049	2045-2049
	US	12.6%	2060-2064	N/A***	2040-2044	2045-2049	2045-2049	2045-2049	2050-2054	2050-2054	> 2040	>2040	2045-2049	2045-2049
South America	Argentina	0.5%	2055-2059	$30-$43	Achieved	2045-2049	2045-2049	2050-2054	2045-2049	2050-2054	> 2040	>2040	2045-2049	2050-2054
	Brazil	1.2%	2060-2064	$48-$50	Achieved	Achieved	N/A	2050-2054	2055-2059	2050-2054	> 2040	>2040	Achieved	2035-2039

* A different methodology was applied to define the carbon price ranges (span between the FPS 2023 and the average survey result). **. This projection aligns with GBF's Target 3, which seeks to protect 30% of the planet's land and oceans by establishing protected areas and implementing effective area-based conservation measures.*** The survey responses for the U.S. were defective, hence the forecast was descoped. 9

In parallel, we survey market participants (asset owners, managers, and investment advisers) to fine-tune technology and policy assumptions across the annual cycle, and we track policy movements quarterly by country and sector. Where needed, we add explicit assumptions and constraints. Policy-achievement outcomes are determined exclusively by external expert opinion and are not adjusted by an IPR panel.

2.1. Cross-sector dynamics

As each sector's policy outcome is driven by our expert views, and not a model with feedback assumptions, pathway dependency across sectors is not explicitly hard-wired. It is assumed that individual experts, and their aggregate views, do include cross sector dynamics. We take these policy outcomes 'as is' which also bakes-in expert's implied cross sector dependencies. The one exception for this is the aggregated fields such as primary energy demand, which are the sum of the demands from the individual sectors.

2.2. Other supplementary data sources

In addition to the FPS 2023 and the survey data, the following datasets are used for baselining historical starting points:

Sector	Source
Cement	Country specific statistics, from various sources
Livestock - Crops	Food and Agriculture Organization of the United Nations - FAOSTAT
Oil	United Nations Statistics Division - UN data Energy Statistics Database (Energy Balance)
Oil - Agriculture	World Bank Group - World Development Indicators
Oil - Asphalts	Thunder Said Energy
Oil - Aviation	International Air Transport Association
Oil - Cost curve	McKinsey Global Energy Perspective 2023: Oil outlook
Oil - Lubricants	Thunder Said Energy
Oil - Plastics	Organization for Economic Co-operation and Development - Global Plastics Outlook
Power	U.S. Energy Information Administration
Road transport (LDV and HDV)	Country specific sales and fleet volumes from various sources
Shipping	United Nations Statistics Division; International Maritime Organization
Steel	Country specific statistics, from various sources
GDP	World Bank Group (historical); Organization for Economic Co-operation and Development (forecast)
Population	International Institute for Applied Systems Analysis — Shared Socioeconomic Pathways (SSP2)

2.3. Forecast Granularity

The forecast follows the from IPR 2023 regional definitions, with the modification that Eastern and Western Europe regions now being combined into the one region, European Economic Area (EEA). In addition, global aggregation is also included. The regions include both country and regional level designations and are outlined below. The country list for each composite region is included in the Annex.

Countries:	Australia (AUS), Brazil (BRA), Canada (CAN), China (CHN), India (IND), Indonesia (IDN), Japan (JPN), Russia (RUS), South Africa (ZAF), South Korea (KOR), United Kingdom (GBR), United States (USA)
Composite regions:	Central and South America (CSA), Eurasia (EURA), European Economic Area (EEA), Gulf Cooperation Council (GCC), Middle East and North Africa (MENA), South Asia (SA), South East Asia and Oceania (SEAO), Sub-Saharan Africa (SSA

As the expert questionnaire covers the G20 countries and Vietnam, average vales and proxy need be used for specific regions: They are as follows:

Native Policy Response Regions		Aggregated and Proxy Policy Response Regions	
Region	**Policy Response Country**	**Region**	**Policy Response Proxy**
Australia (AUS)	Australia	Central and South America (CSA)	Argentina, Brazil, Mexico*
Brazil (BRA)	Brazil	European Economic Area (EEA)	France, Germany, Italy
Canada (CAN)	Canada	Gulf Cooperation Council (GCC)	Saudi Arabia
China (CHN)	China	Middle East and North Africa (MENA)	Türkiye
India (IND)	India	South Asia (SA)	India
Japan (JPN)	Japan	Southeast Asia and Oceania (SEAO)	Indonesia, Vietnam
Russia (RUS)	Russia	Sub-Saharan Africa (SSA)	South Africa
South Africa (ZAF)	South Africa		
United Kingdom (GBR)	United Kingdom		
United States (USA)	United States		

3. Power

3.1. Executive summary

Total demand: Based on investors surveys conducted between Q3 2024 and Q1 2025 on the expected impact of AI, annual global energy demand forecast from the FPS 2023 has been increased by an order of 3.5-4% by 2050 (or from 77% to 83% increase from current annual demand).

Regional demand: Region and technology-level power generation and capacity pathways for 2023-2100, consistent with the Expert 2024 Survey for clean power policy targets across all G20 countries + Vietnam are constructed and anchored to 2023 historical data. These country-level policies timings are used to proxy all IPR region pathways.

Generation demand shares by technology: Shares between clean and fossil generation are reallocated to meet the new clean-power trajectory, based on technology specific learning curves.

Capacity: Capacity is derived from generation using transparent capacity factor rules with explicit floors/ceilings and simple improvement schedules for wind/solar by economic grouping (OECD vs non-OECD).

Capex: Capacity pathways are converted into new deployments and capex via lifetime-based stock flow accounting and cost trajectories.

3.2. Scope & coverage

Geography: Standard IPR regions
Horizon: 2025–2050
Technologies: Biomass, Biomass CCS, Coal, Coal CCS, Hydro, Hydrogen, Natural gas, Natural gas CCS, Nuclear, Offshore wind, Oil, Onshore wind, Solar.
Policy lever: Clean policy target: ≥90% clean share (generation) by region-specific target year from the Expert 2024 Survey for clean power policy targets across all G20 countries + Vietnam. Once the policy target is met the pathway continues based on a 5 year rolling average growth rate.

3.3. Published metrics

Generation: annual electricity produced (**TWh**)
Capacity: installed capacity (**GW**)
New Deployment: gross additions derived from stock flow. (**GW**)
Capex: New Deployment × projected unit cost (**USD$**)

3.4. High-level modelling framework

i **Historical re anchoring:** Start values are brought back into align with research historical values at the country and technology level.

ii **Baseline construction**:

- Technology level baseline generation per region is forecasts based on the existing 'S' curve parameters from the FPS 2023.
- Each generation technology is classed by their net CO2 emissions:
  - Clean: Coal CCS, Natural gas CCS, Nuclear, Hydro, Biomass, Biomass CCS, Solar, Onshore wind, Offshore wind, Hydrogen
  - Non-clean: Coal, Oil, Natural gas
- These are aggregated to obtain baseline clean shares by region-year.

iii **Policy pathway for clean share**: For each region the new clean generation percentage pathway is generated based on the Expert Survey policy times for each region (≥90% clean by year X) and the aggregated historical learning rates from the FPS 2023 IAM model.

iv **Share reallocation**: To meet the new forecast for the ratio of clean to non-clean, generation is reallocated from clean/non-clean evenly across technologies. CCS is not assumed to be economically viable until post 2035.

v **Capacity derivation**: Baseline capacity factors evolution is taken from FPS 2023. However, they are guarded with the following rules specific to each technology and region:

- Solar: linear +0.001 per year from baseline, ceiling at 0.18 (OECD) / 0.20 (Non-OECD).
- Onshore wind: +0.003 per year, ceiling 0.35.
- Offshore wind: +0.003 per year, ceiling 0.50.
- Fossil (no CCS): floors — Coal ≥0.25; Oil ≥0.05; Gas ≥0.25.
- CCS: ceilings — Coal CCS ≤0.65; Oil CCS ≤0.50; Gas CCS ≤0.60; Biomass CCS ≤0.90.
- Hydrogen: ceiling ≤0.20.
- Nuclear: ceiling ≤0.95.
- Hydro: ceiling ≤0.60.

- Biomass: ceiling ≤0.90.

vi **Deployment & capex**: Convert capacity time series to new deployments via lifetime stock flow (back cast + retirements).

- Capex values have been updated from the FPS 2023 and represent the overnight startup cost.

3.5. Assumptions & limitations

Share preserving reallocation: within each class, technologies retain baseline within class shares. This abstracts from intra class competition and system constraints.

Capacity factor rules: simple floors/ceilings and linear improvements; no endogenous system adequacy, curtailment, or weather/seasonality modelling.

Lifetimes: constant average lifetimes are used by technology; retirements proportional to stock; no age cohort distribution.

Costs: single factor default cost change; no learning curve tied to cumulative deployments; excludes O&M unless baked into cost.

4. RoadTransport (LDV & HDV Electrification)

4.1. Executive summary

Sales: Region-level Light-Duty Vehicle (LDV) and Heavy-Duty Vehicle (HDV) sales per technology are forecast based on the expected share of battery electric vehicle (BEV) sales from our 2024 climate expert survey responses. These are anchored by historical share of BEV sales in each region.

Fleet size: The total vehicle fleet per capita in each region is preserved from the FPS 2023, with historical start values are updated based on research.

Oil demand: Oil demand is computed based on the evolution of fleet efficiency and expected changes in mileage per vehicle/forced retirements to meet the experts view on vehicle sales while maintaining the forecast of total vehicles per capita.

4.2. Scope & coverage

Geographies: Standard IPR regions
Horizon: 2025–2050
Technologies: ICE, PHEV, BEV, NGV for HDVs only. (H_2 is no longer included)
Scope: Passenger vehicles and vans
Policy lever: Minimum BEV share of new LDV sales reaching ≥90% by regional market. Taken from the Expert 2024 Survey for across all G20 countries + Vietnam. Once the policy target is me the pathway continue based on a 5-year rolling average growth rate.

4.3. Published metrics

New Deployment: Vehicle sales (thousands of vehicles per annum)
Technology stock: Vehicle fleet volume (thousands of vehicles)

4.4. High level modelling framework

i Historical re anchoring. Start values are brought back into align with research historical values at the country and technology level for both sales and fleet volumes

ii Baseline construction:

- Technology level fleet and sales per region are forecasted based on the existing 'S' curve parameters from the FPS 2023.

iii Policy pathway for BEV sales share

- For each region the BEV sales pathway is generated based on the Expert Survey policy times for each region (≥90% sales by year X) and the aggregated historical learning rates from the FPS 2023 IAM model. This is done for both LDVs and HDVs.
- To redistribute non-BEV sales, the relative share of each vehicle technology is maintained from the FPS 2023.

iv Pathways for fleet volume

- BEV retirement rates simulate a natural procession to the observed retirement rates of current ICE's (around 6% of annual fleet).
- Non-BEV retirement has a baseline default of 6% of the total fleet, consistent with historical retirement rates. Retirements are brought early to balance the BEV sales share and growth of total vehicles required per capita.
- Population: We use the SSP2 population for maintain our constant vehicle per capita volumes (annualized by linear interpolation).

v Milage and oil demand assumptions

- Milage and oil demand is then calculated based on the following variables:

Variable	HDV	LDV
Fuel economy start (L/100km)	25.0 (2023)	8.3 (2023)
Fuel economy improvement	1.0%/yr	1.15%/yr
Annual mileage (start)	60,000 km/yr	12,450 km/yr
Mileage after 2030	–0.3%/yr	–0.7%/yr
BEV energy intensity	1.10 kWh/km	≈0.333 kWh/km
Primary→Useful (grid→wheel) start	0.55	0.51
Primary→Useful improvement	+0.05%/yr	+0.07%/yr

4.5. Assumptions & limitations

Policy is sales-share only: Demand for mobility is exogenous via Vehicles_per_Capita × Population; no macro feedbacks.

Retirement rules: BEV uses an exogenous schedule; ICE/PHEV fixed at 6%/yr — no age-cohort structure.

H_2 treatment: H_2 assumed negligible.

Mileage & FE: Simple trend rules; no congestion, price, or technology feedback.

BEV efficiency: Fixed 3 km/kWh equivalence for energy conversion.

PTU trajectory: Single factor increasing by 0.07%/yr; not grid-mix specific.

5. Steel Production

5.1. Executive summary

Production: Total steel demand follows the FPS 2023 baseline within a narrow demand corridor, while route shares are reallocated annually under availability, start-year, and scrap-share/recycling constraints.

Emissions: Route-level emission intensities are anchored to historical levels and evolve along parameterized logistics to meet the expert survey for policy responses in each region (80% reduction).

5.2. Scope & coverage

Geographies: Standard IPR regions.
Horizon: 2025–2050.
Technologies: Conventional coal (BF-BOF), BF-BOF with CCS, Gas DRI, Hydrogen DRI, Scrap EAF.
Policy lever: Region-specific pathway achieving ≥80% reduction in sector emissions by target year. Taken from the Expert 2024 Survey for across all G20 countries + Vietnam.

5.3. Published metrics

Production: Mt steel per year.
Emissions: Mt CO_2 per year.

5.4. High level modelling framework

i **Historical re-anchoring:** Start values align to research historical production and emissions at region and route level; aggregate intensities are computed from these anchors.

ii **Baseline construction (production):** Technology level fleet and sales per region are forecasted based on the existing 'S' curve parameters from the FPS 2023.

iii **Route-level emission-intensity progression:** Learning curves for emission intensity for each technology are estimated based on existing emission intensities across each region;
  - BF-BOF: ~3.0 → 1.4 tCO_2/t
  - BF-BOF + CCS: ~0.8 → 0.2 tCO_2/t
  - Gas DRI: ~2.0 → 1.0 tCO_2/t
  - H_2 DRI: ~0.2 → 0.2 tCO_2/t
  - Scrap EAF: ~0.01 → 0.01 tCO_2/t

iv **Baseline emissions (pre-policy):** Route-level emissions are Production × Intensity; totals are aggregated by region and year.

- v **Policy pathway & route reallocation**: Reallocate high-carbon technologies by first favoring scaping then alternative technologies.
  - Constraints (per Region, Year).
  - Capacity caps (ratchets): BF and Gas caps tighten year-to-year; CCS and H_2 floors carry forward when achieved.
  - CCS and Hydrogen are not considered viable at volume before 2028-30.
  - Scrap share ceiling: region-specific (e.g., ~0.75 OECD; ~0.50 non-OECD).

5.5. Assumptions & limitations

- No plant-level vintaging; caps/floors are aggregate and year-to-year.
- Demand corridor is exogenous (FPS 2023 forecast).
- Scrap ceilings approximate physical/market constraints only at OECD and non-OECD level not at regional/country level.

6. Cement Production

6.1. Executive summary

Production: Total cement demand follows the FPS2023 baseline within a narrow demand corridor under conservative CCS availability (≥2035) and ‘last-resort’ e-clinker (≥2028).

Emissions: Route-level emission intensities are anchored to historical levels and evolve along parameterized logistics to meet the expert survey for policy responses in each region (80% reduction).

6.2. Scope & Coverage

Geographies: Standard IPR regions.
Horizon: 2025–2050.
Technologies: Coal, Coal CCS, Oil, Natural gas, Natural gas CCS, Biomass, Biomass CCS, e-clinker.
Policy lever: 80% reduction in sector emissions. Taken from the Expert 2024 Survey for across all G20 countries + Vietnam.

6.3. Published Metrics:

Production: Mt cement per year.
Emissions: Mt CO_2 per year.

6.4. High-level modelling framework

i Historical re-anchoring: Start values align to research historical production and emissions at region and route level; aggregate intensities are computed from these anchors.

ii Baseline construction (production) : Technology level fleet and sales per region are forecasted based on the existing 'S' curve parameters from FPS 2023.

iii Process & Efficiency Levers (global baseline series)

- We construct global (Region = World) process/efficiency trajectories:
- Thermal intensity (GJ per ton of cement) – logistic decline from 3.6 (2022 baseline) toward 2.7 (asymptote).
- Clinker ratio – logistic growth/improvement.
- Carbon capture rate (share of total emissions captured) – logistic growth toward 85%.
- Electricity efficiency factor – logistic decline factor applied to electricity emissions.

iv Build a per-region net-emissions pathway that reaches —80% by each policy timeline from the expert 2024 survey, by shifting conventional production to CCS within (Coal, Gas, Biomass) pairs, no CCS before 2035, while maintaining total fuel type production capacity.

- Remaining demand from 2028+ shift residual production to e-clinker (zero-emission).
- once production moves to CCS, it cannot move back (no "un-CCS").

6.5. Emissions Accounting

For each Region × Year × Technology:

Combustion emissions

$$\text{combustion\_emissions} = \text{Production} \times \text{combustion\_intensity} \times \text{clinker\_ratio} \times \text{thermal\_intensity} \;/1000$$

where combustion_intensity (kg CO_2/GJ-equivalent, conceptually) is technology-specific:

Technology	Intensity
Coal	94.6
Coal CCS	0
Oil	73.3
Natural gas	56.1
Natural gas CCS	0
Biomass	0
Biomass CCS	−90

Electricity emissions

$$\text{electricity\_emissions} = 0.067 \times \text{Production} \times \text{electricity\_efficiency\_pct}$$

Assumption: In 2022, electricity uses account for roughly 6.7% of emissions intensity globally, scaled over time by the efficiency series.

Calcination emissions

$$\text{calcination\_emissions} = 0.37 \times \text{Production} \times \text{clinker\_reduction\_pct}$$

Assumption: In 2022, calcination contributes 37% of emissions intensity globally, then scales with clinker-ratio improvements.

Totals, carbon capture, and net

$$\text{total\_emissions} = \text{combustion} + \text{electricity} + \text{calcination}$$
$$\text{carbon\_capture} = \text{total\_emissions} \times \text{carbon\_capture\_pct}$$
$$\text{net\_emissions} = \text{total\_emissions} - \text{carbon\_capture}$$

Emissions intensity

$$\text{emissions\_intensity} = \frac{\text{net\_emissions}}{\text{Production}} \, (\text{tCO}_2/\text{t cement})$$

6.6. Assumptions & limitations

S curve logistic dynamics capture medium-/long-run growth/decline tendencies in production and process levers.

Global process shares in 2022 are approximated by constants (0.067 for electricity, 0.37 for calcination) and then scaled by process trajectories.

Combustion intensities are technology-specific constants; CCS variants are set to zero (Biomass CCS negative to reflect net removals).

Policy alignment enforces ~80% reduction by each region's Forecast_Year_2025 under irreversible CCS adoption, no CCS pre-2035, and an e-clinker backstop from 2028.

Technology granularity: Oil is not combined with CCS due to its marginal role.

Fixed intensities by technology ignore within-tech variability (e.g., kiln designs, fuel blending).

e-clinker is a stylized, zero-emission sink; it represents advanced low-carbon process (explicitly electrochemical cement clinker production using renewable power generation) routes without explicitly modeling energy system or cost constraints.

7. Oil Demand

7.1. Executive summary

Global oil demand is forecast for the 6 original sectors of the FPS 2023. It is computed at the country level across 16 underlying sectors, each have their own methodology and then aggregated. Each sector is driven either by the expert survey on the relevant sectors, or internal model, as outlined in the scope table below. Start values underpinned by the historical data from the UN Energy Statistics Division, country level stock take for Oil and Oil products.

7.2. Scope & Coverage

Units: million barrels per day (Mbpd).
Horizon: 2025–2050.
Geography: IPR regions.

Sectors:

IPR Sector	Modelled Sector	Forecast driver
Buildings	Buildings	External survey
Industry	Industry Other	Internal model
	Cement	External survey
	Iron & Steel	External survey
Non-energy use	Plastic	Internal model
	Asphalt	Internal model
	Lubricants	Internal model
Other energy	Other	Internal model
	Agriculture	Internal model
Power	Power	External survey
Transport	Light Auto	External survey
	Heavy Auto	External survey
	Aviation	Internal model
	Domestic Shipping	Internal model
	International Shipping	Internal model
	Two Wheelers	Internal model

7.3. Common drivers & data lineage

GDP & population paths

Historical country GDP (WB 2015 USD) blended with OECD nominal real 2017 USD (via FX & deflators), then extended with SSP2 annual growth rates (2024–2100). Population uses SSP2 interpolated annually to 2100. These underpin:

- Regional GDP per capita (GDP/Population) used as weights in several downscaling applications.
- GDP index used as a driver for international trade shipping ("other cargo" bucket).

7.4. Sector methodologies

7.4.1. Road Transport (Light Auto (LDV) & Heavy Auto (HDV)

See full LVD and HDV methodology

7.4.2. Two Wheelers

7.4.2.1. Scope & Coverage

Time horizon: 2025–2050

Geography: ISO3 country coverage aggregated to ~21 IPR regions, plus World, OECD, and non-OECD groupings.

7.4.2.2. High-level framework:

i Baseline: the baseline forecast for 2 wheelers is anchored by existing fleet sizes, and growth follows the LDV rates in each respective region.

ii Electrification acceleration: Two-wheeler BEV uptake rate is set as a multiple of the LDV BEV uptake. This accelerates the BEV/Non-BEV stock ratio vs. LDVs.

iii Fleet sizing: Moto fleet = LDV fleet × regional ratio (updated over time).

iv Oil demand: Non-BEV moto miles × fuel economy; converted to Mbpd using:

- Annual mileage = 6,500 km/vehicle,
- Fuel economy = 2.5 L/100 km,
- 159 L/barrel.

v Calibration & checks: Global totals are monitored for plausibility vs. source context.

Key assumptions: Simple usage and efficiency constants across regions; accelerated electrification vs. LDVs.

7.4.3. Aviation

7.4.3.1. Scope & Coverage

Time horizon: 2025–2050

Geography: ISO3 country coverage aggregated to ~21 IPR regions, plus World, OECD, and non-OECD groupings.

7.4.3.2. High-level framework

We build aviation demand bottom-up from country level and aggregate to regions, OECD/Non-OECD, and World for 2025–2050 by linking jet-fuel use to macro drivers under SSP2.

- Historical aviation activity and macro data are harmonized and modeled per country with a transparent log-ARIMA that uses GDP per capita and a post-2020 structural-break term to account for COVID 19
- Forecasts are multiplicatively calibrated to expect current demand.
- Passenger-distance is derived by combining fuel forecasts with a fleet-average efficiency path (baseline 2024 mpg derived from 2022 data, improving +0.5%/yr; yielding passenger-km and pkm per capita.
- We apply a scenario overlay that lifts OECD per-capita p.m. by +10% between 2025 and 2050 via a smooth geometric trajectory, while non-OECD remains unchanged; GCC receives temporary OECD-like uplift treatment for trajectory only.
- Regional and global totals are re-computed consistently (pkm-weighted mpg, sums for pkm and Mbpd) and validated with balancing and reasonableness checks against external benchmarks (IEA/IATA TARGETS).

7.4.3.3. Data Sources

- Historical macro & aviation activity.
- GDP per capita (PPP, constant 2021 $) and historical population: OUR WORLD IN DATA (OWID).
- Aviation passenger kilometers (pkm) by country: OUR WORLD IN DATA.
- “Airline passengers of domestically owned airlines”: TheGlobalEconomy.com — used as a cross check/activity indicator and for mpg baselining logic.

7.4.3.4. Country Level Fuel Demand Model (iso3)

Model form (log linear ARIMA with exogenous driver and a structural break dummy):

$$\log(J_t) = f_{ARIMA}(\cdot) + \beta \log(\text{GDPpc}_t) + \gamma\, \mathbb{1}(t \geq 2020) + \varepsilon_t$$

Where:

J_t= jet fuel consumption (kbd) for a country in year t.

GDPpc_t= GDP per capita (PPP, 2021$).

$\mathbb{1}(t \geq 2020)$ captures a post-2020 structural break (pandemic/structural effects).

ARIMA automatically selects differencing/order to ensure a stationary specification in the log domain.

Forecast horizon. From the last historical year to the end of available drivers (annual to 2100); later truncated to 2025–2050 for delivery.

Uncertainty bands. For each forecasted point, we compute 10th and 90th percentiles from the predictive distribution to form a wide indicative band).

Calibration to latest actuals.

- A multiplicative calibration factor (S) is applied uniformly to all forecast points to align 2025 with "latest actual" jet fuel evidence (industry data).
- Current setting: S = 1.3 (i.e., +30%).

Model inclusion rule. Countries with model failure or insufficient data are excluded Aggregations use only successful countries.

7.4.3.5. Efficiency & Passenger Distance Projection

Baseline mpg (fleet efficiency).

We take 2022 country level passenger_miles_per_gallon and treat it as 2024 baseline for each ISO3 (i.e., base year = 2024).

Annual efficiency improvement.

Constant annual improvement rate (\epsilon) applied multiplicatively to mpg from 2024 onward.

Current setting: $\boldsymbol{\epsilon = +0.5\%}$per year (i.e., mpg $_{\boldsymbol{t}}$=mpg $_{\boldsymbol{2024}}$·(1+0.005)^(t−2024)).

Passenger distance and fuel linkage.

Convert forecast fuel demand (Mbpd) to gallons per year and apply mpg to derive total passenger miles, then convert to passenger km:

Gallons/yr = Mbpd × 1e6 × 42 × 365.

Passenger miles = mpg × gallons/yr.

Passenger km = Passenger miles × 1.60934.

Per capita pkm is computed as passenger_km / Population.

7.4.3.6. Scenario Overlay — OECD Per Capita Demand Uplift (+10%)

Purpose: Implement a policy agnostic demand side uplift for OECD regions consistent with a project note: "OECD +10% rise; China and Non-OECD follow historical average"

Classification: Base OECD mapping is used with the exception of the Gulf Cooperation Council (GCC) is treated as OECD only for applying the uplift path, then reverts to non-OECD classification in labeling/aggregation (reflecting income/travel profile).

Mechanics:

- Compute each OECD region's 2025 per capita pkm baseline.

- Apply a smooth geometric growth path from 2025→2050 that totals +10% by 2050 (monotonically increasing, with gradually smaller annual increments):
  - Let $k = (1/10)^{1/24}$. Annual increment $\Delta_t = c \cdot k^t$with $c$chosen so that $\sum_{t=0}^{24} \quad \Delta_t = 0.10$.
  - The **growth multiplier** sequence is 1.0000, 1+Δ_0, 1+Δ_0+Δ_1, … up to **1.10** in 2050.
- Replace OECD per capita pkm with this path while non-OECD remains unchanged.
- Recalculate dependent variables (total pkm, mpg weighted averages, and fuel Mbpd) and regenerate World/OECD/Non-OECD aggregates to ensure consistency.

7.4.3.7. Assumptions & Limitations

Macro scenario: SSP2 GDP & population.
Calibration factor (S=1.3) to align 2025 fuel demand to latest observed data
Fleet efficiency improvement: +0.5%/yr mpg (2025 onward; base mpg = 2024 level from 2022 data).
OECD uplift: +10% per capita pkm 2025→2050 via a smooth geometric path; non-OECD unchanged; temporary GCC handling as described.
Model form: log ARIMA with log("GDPpc") and a post 2020 dummy.
Model simplicity. The log ARIMA with GDPpc and a single structural dummy abstracts from airfare, fleet mix, network effects, and policy constraints. It is designed for transparency and portability.
Calibration dependence. A single multiplier (S) is used to align to latest evidence; errors in the anchor year propagate forward.
Efficiency proxy. mpg baselining uses activity side data and a uniform annual improvement; real world improvements vary by fleet age/mix and regulation.
Regional mapping. Results inherit any classification quirks (e.g., temporary GCC treatment) and mapping choices.
Data gaps. Countries with sparse histories are excluded; regional sums therefore depend on modeled coverage.

7.4.4. Shipping

Oil demand for maritime shipping by country and by flow (international marine bunkers vs domestic navigation) is estimated using UN trade-and-transport activity and energy-balance anchors, reconciled to an external benchmark for international bunkers.

7.4.4.1. Scope & coverage

Geographies: Standard IPR regions.
Horizon: 2025–2050.
Sectors: Domestic & international.

7.4.4.2. High level modelling framework

- Pull UNCTADstat international ton-km by destination and product (2016–2023); compute OTHER = TOTAL − Σ(named products).
  - Convert ton-km → ton-nautical-miles (÷ 1.852); map HS codes to cargo buckets and apply fuel intensities (g/tnm) to get preliminary fuel tons per country‑year‑bucket.
- Gap-fill countries lacking ton-km using world bucket shares to allocate fuel, then back-solve synthetic ton-nm/ton-km across 2016–2023.
- Bring in UN Energy Balance (2022) bunkers (TJ) for international and domestic; convert to kt via 41.868 GJ/toe and $\rho = 0.953$ t/m^3 (ENERGY→MASS CHAIN TBD); replicate anchors across 2016‑2023.
- Build domestic navigation by allocating each country's domestic kt across buckets using its international fuel mix (fallback: global mix); create synthetic domestic ton-nm/ton-km.
- Scale separately for each (country, year, flow) so Σ(bucket fuel kt) = bunkers kt; target tolerance ±0.5% at country-flow level.
- Reconcile global international total to IMO 2022.
- Convert kt → Mbpd with density and m^3→bbl factors (365.25 days) and aggregate ISO3 to IRP regions.

7.4.4.3. Definitions & Conventions

Transport work (tkm): tonnes × kilometers for cargo movements in international shipping; converted to ton nautical miles (tnm) using 1 nautical mile = 1.852 km.
Fuel intensity (g/tnm): grams of fuel burned per ton nautical mile; bucket specific (see §5).
Bunkers: fuel sold to ships. Two flows: International marine bunkers and Domestic navigation.

Fuel mass (kt): thousand tonnes of fuel.

Oil demand (Mbpd): million barrels per day, derived from kt via density and volume conversion.

Unit conversions (energy↔fuel, barrels).

IEA NCV basis: 5.8 GJ per barrel (net calorific value) → used in TJ→Mbpd constant when applicable.

Draft constant: TJ_to_Mbpd = 1e3 / (5.8 × 1e6 × 365.25) → 1 TJ/year ≈ Mbpd

Mass↔volume: density ρ = 0.953 t/m³ for heavy fuel oil; 1 m³ = 1/0.1589873 barrels.

7.4.4.4. Product Coverage & Buckets

UN product codes (HS like) pulled from UNCTAD focus on tanker and major dry bulk trades, plus a residual category built from UNCTAD's TOTAL series.

Named products (examples).

- Tankers: 2709 (crude oil), 2710 (refined), 2711 (LNG/LPG), 2712–2714 (other mineral oils/bitumen).
- Coal & lignite: 2701–2708 (with metallurgical sub buckets).
- Dry bulk: 2601 (iron ore).
- Residual: OTHER = TOTAL — Σ(named products).

Bucket mapping (for intensities)

Crude oil, refined products, LNG & LPG, coal, metallurgical coal, iron ore, and other cargo.

7.4.4.5. From Activity to Preliminary Fuel (international)

Build international ton km.

- Pull transport work (tkm) by destination ISO3 and year for each product and for the TOTAL series (2016–2023). Filter out destinations coded '0000'.
- Construct OTHER = TOTAL — Σ(named) at (destinations, year).

Convert tkm → tnm.

Assign cargo buckets and intensities.

- Map each product to a bucket. Attach fuel intensity gfuel_per_tnm (grams per ton nautical mile) from an internal intensity table based on desk research:

bucket	gfuel_per_tnm
crude_oil	2.5
refined_prod	3.6
lng_lpg	4.25
coal	3.5

bucket	gfuel_per_tnm
metallurgical_coal	3.5
iron_ore	3.5
other_cargo	6.0

7.4.4.6. Compute preliminary fuel mass (international).

- For each (destination, year, bucket): fuel_tonnes_pre = tnm × gfuel_per_tnm / 1e6.
- Coverage Gap Fill using world average gap fill for countries lacking UNCTAD ton km.

7.4.4.7. Bring in Bunkers Anchors

UN energy balance (Total energy, 2022) for two flows:

- International marine bunkers and Domestic navigation in TJ.
- Convert to fuel mass (kt) using: kt_fuel = |TJ / 41.868| × 0.953.
    - RATIONALE: 1 toe = 41.868 GJ; assume toe≈tonne oil equivalent, then adjust volume→mass by density ρ=0.953.

7.4.4.8. Split & Scale by Flow (international vs domestic)

Flow tagging: Treat all UNCTAD ton km as international; tag rows accordingly. Domestic activity is synthesized later (no UNCTAD domestic ton km series used here).

Domestic navigation synthesis: For each country with domestic_nav_kt > 0 (from UN energy balance), allocate domestic fuel across buckets using that country's international bucket fuel shares (fallback to global shares if zero/NA). Convert to synthetic domestic tnm/tkm and tag flow = 'domestic'.

Flow consistent scaling: For each (country, year, flow), scale preliminary fuel masses so that the sum over buckets equals bunkers_kt for that flow:

- scale_factor = bunkers_kt / Σ_buckets fuel_tonnes_pre.
- fuel_scaled = fuel_tonnes_pre × scale_factor.

Scaling is done separately for international and domestic flows to preserve anchors by flow.

7.4.4.9. Global reconciliation for international bunkers.

International bunkers are further reconciled to an IMO 2022 global total:

- Code uses: IMO_2022_oil_consumption_mt = 213 × 1.15 to adjust from ships ≥5,000 GT to full fleet (assuming ~85% coverage).

- The implied international total from UNDATA anchors was noted to be lower (≈173 Mt ≈ 3.6 Mbpd ≈ 9.2 EJ), requiring upward reconciliation;

7.4.4.10. Convert Fuel Mass to Oil Demand (Mbpd)

For each record (country, flow, bucket, year):

- oil_mbpd = (kt × 1e3 / ρ × BBL_PER_M3) / 1e6 / 365.25 where ρ = 0.953 t/m³ and BBL_PER_M3 = 1/0.1589873.
- Provide both fuel_kt and oil_mbpd in outputs.

NCV cross check. Where direct TJ values are used, TJ_to_Mbpd = 1e3 / (5.8 × 1e6 × 365.25) provides a secondary path.

7.4.4.11. Assumptions & Limitations

Activity scope: UNCTAD transport work represents international flows; domestic tkm are not observed here and are synthesized from energy anchors.

Intensity coefficients (g/tnm): uniform across years and countries within each bucket. Single set of g/tnm coefficients by bucket ignores speed/fleet/route heterogeneity and time variation.

IMO reconciliation factor set to 1.15 on 213 Mt to represent full fleet (≥5,000 GT coverage ~85%)

Anchor dependence: Results depend on UN energy balances and the chosen reconciliation to IMO totals; inconsistencies between sources are handled by multiplicative scaling. UN anchors (2022) and some activity years are replicated to cover 2016–2023 where gaps exist.

Product coverage: Named products are a subset; residual OTHER aggregates diverse cargo types and may mask composition changes.

Crude oil shipping: Country-level crude shipping is forced to an 80% international / 20% domestic crude flow mix (keeps total crude shipping constant while setting a fixed split).

Other cargo (not crude/refined/LNG):

- Baseline: 2022 oil use by country & flow.
- Drivers (2023→2100):
    - GDP (region-specific real GDP index), elasticity ε_GDP = 0.80;
    - Trade-intensity factor (IMF WEO April-2025: goods export/import volume vs GDP), elasticity ε_trade = 0.25; held flat after 2030.
    - Fuel-efficiency improvement: −1%/yr through 2050 (then flat).
        - Projection: Multiply baseline by driver indexes per flow (international/domestic).
        - Assumption notes: Elasticities represent long-run linkages of ton-miles to macro drivers.

Refined products / Crude oil / LNG–LPG cargo (post-2025): Scaled by the weighted average of all other sectoral oil demand (an internally consistent anchor so product shipping tracks overall liquids demand).

7.4.5. Power

Also refer to full power methodology for computation of oil-fired power demand.

Input: Regional oil-fired generation in TWh from the FPS 2023 power model (see Power section for details).
Method: Convert TWh → primary energy → barrels using:

- Thermal efficiency 35%,
- Oil heat content ~42 GJ/t,
- 7.33 bbl/ton, then /365 to Mbpd.

Key assumptions: Represents thermal oil generation only; no additional fuel-switch overlays beyond provided generation pathway.

7.4.6. Industry

Historical baseline: UNdata energy balance, 2022 (published April 2025), "Oil Products" converted from TJ→Mbpd. Country values mapped to regions.

Driven by 3 sectors:

i. Cement
ii. Iron & Steel
iii. Other industry

Cement

- Baseline (2023): Regional 2022 oil use (cement = "Non-metallic minerals") rolled forward to 2023.
- Driver: Regional cement production trajectory (see full cement methodology).
- Assumption: Constant oil-to-production intensity within each region unless implied by the production path.

Iron & Steel

- Baseline (2023): Regional 2022 oil use (iron & steel) rolled to 2023.
- Driver: Regional steel production trajectory (see full steel production methodology).
- Assumption: Same as cement regarding intensity.

Other Industry

- Baseline (2023): 2022 Manufacturing, construction & non-fuel mining minus cement minus iron & steel.

- Driver: Heavy-duty road fuel growth (HDV demand path) as a proxy for other industry oil growth. Refer to LDV and HDV methodology for further HDV model details.
- Assumption: HDV fuel trajectory is a reasonable macro-proxy for industrial oils.
- Checks: Sector sums re-aggregate to UN data baselines for 2022 at the regional level before forward projection.

7.4.7. Buildings

Historical baseline: UN data 2022 oil use for Households + Commerce/Public services (Oil Products).

Inputs: Expert Policy survey targets summarized to regional "target year" for demand reduction; proxies used where gaps exist:

- Turkey→MENA, Nigeria→Sub-Saharan Africa, Saudi Arabia→GCC, Mexico/Argentina→Central & South America, Indonesia/Vietnam→SE Asia & Oceania.
- EU answers cloned to "Eastern Europe" (+7.5 years), India to "South Asia", Russia to "Eurasia".

Method: For each (country, subsector), run a modified logistic decline starting at V_0 (2022) toward an asymptote K = 0, inflecting at midpoint $t_0 = (2022 + \text{target\_year})/2$.
The growth rate r is solved so that demand at target_year equals 66% of the 2022 level (i.e., a 34% reduction by the target year). Series summed to regions and trimmed to 2050.

Key assumptions:

- Decline shape fits policy timing.
- 66% target ratio at policy year is a modeling choice.
- Regional target years fall back to regional/global averages if missing.

7.4.8. Plastics

Historical baseline: OECD plastics consumption mapped to IPR regions.

Inputs:

- Desk research on regional production shares to split each group to regions.
- Desk research on regional recycling baselines & projections, baseline year 2020.

Method:

- **Downscaling**: Sum OECD source by group & year; split to regions using production shares.
- **Gross oil demand**: Regional plastic production × 8.03 barrels/ton / 365 → Mbpd.
- **Recycling trajectory**: Piecewise-linear in multiplier space with 2020–24 flat, 2025–2050 ramp to scenario endpoints (clamped to 0–100%):
  - OECD: 13% in 2025 → 35% in 2050
  - Non-OECD: 6.5% in 2025 → 25% in 2050
- **Net oil demand** = gross × (1 – projected recycling rate).

Key assumptions: Recycling paths are scenario inputs; oil intensity per ton constant.

7.4.9. Asphalt

Inputs: TSE "Asphalts" aggregate (OECD, Non-OECD, U.S.) and paved/sealed road surface area by region.

Method:

- U.S.: take published U.S. series.
- OECD (ex-U.S.) & non-OECD splits: Allocate aggregates to regions using index = sealed road area × GDP per capita (exponents $\alpha=\beta=1$).
- Check: Re-sum to exactly match aggregates each year.
-

Key assumptions: Road surface and income levels jointly proxy asphalt demand allocation.

7.4.10. Agriculture

Inputs: TSE "Agriculture" aggregate (OECD, Non-OECD, U.S.) and agricultural land area (sq-km) derived from World Bank 2021 land area × % agricultural land.

Method:

- U.S.: take published U.S. series.
- OECD (ex-U.S.) & non-OECD splits: Allocate using index = agricultural land area × GDP per capita ($\alpha=\beta=1$).
- Check: Re-sum equals the aggregates each year.

Key assumptions: Land extent & income proxy the intensity of agricultural oil use.

7.4.11. "Other Oil"

Inputs: TSE "Other" aggregate (OECD, Non-OECD, U.S.).

Method:

- U.S.: take published U.S. series.
- OECD (ex-U.S.) & non-OECD splits: Allocate using GDP per capita weights.
- Exogenous uplift: Apply a year-specific uplift schedule (2020–2035) to better align totals with target external totals.
    - Check: Allocation preserves aggregates before uplift; uplift then applies uniformly to allocated regional values.

7.4.12. Lubricants

Inputs: TSE “Lubricants” aggregate (OECD, Non-OECD, U.S.), plus regional vehicle fleet (LDV + ½ of two-wheelers as an exposure proxy).

Method:

- Split 2024:
  - Keep U.S. as published;
  - Split OECD (ex-U.S.) and non-OECD using 2024 fleet shares.
- Project 2025–2050: Scale each region’s 2024 lubricant level by the growth in total vehicle fleet.
  - For U.S., overwrite each year with the published U.S. lubricant series.
- Re-scale (calibration): Within OECD (ex-U.S.) and non-OECD, scale lines so regional sums equal the published aggregates each year.

Key assumptions: Lube demand is proportional to motor fleet; U.S. series is authoritative annually.

7.4.13. Buildings, Industry, Power, Aviation, Shipping — Interaction Notes

- No double counting: sector series are constructed separately and then summed by Year×Region.
- Shipping refined, crude, LNG/LPG cargoes after 2025 scale with total liquids demand from all sectors to maintain coherence in product-shipping activity.

7.5. Oil Price

7.5.1.1. Scope & Coverage

Units: USD per barrel (USD/bbl) for low, mid and high demand case.
Horizon: 2025–2050.
Geography: Global.

7.5.1.2. High-level framework

- Formulate high and low cases for global oil demand. Using a linear ramp of ±15%, with the mid-range being the baseline demand from the oil demand model.
- Map demand to the cost curve to obtain a 2050 marginal price for each scenario (i.e., the cost of the marginal tranche needed to meet that year's demand).
- Construct price paths by linearly transitioning from a fixed 2025 spot price to each scenario's 2050 marginal price.

7.5.1.3. Assumptions & Limitations

- Marginal tranche cost ≈ long-run price.
- Cost curve fixed in real terms (capacities/costs static).
- Demand is exogenous and treated independent of location/quality (e.g., Brent–WTI).

8. Land-Use (Livestock – Crops)

- We use the initial values from historical official country level reporting statistics from the UN Food and Agriculture Organization (FAOSTAT).
- Livestock and crops are all reported as mass in tones of wet matter – FPS 2023 is dry matter.
- For livestock, the units are in dressed carcass weight (We do not know what the FPS 2023was, but it is consistently larger, thus assumed to be live-weight).
- The FPS- 2025 unit is tones of carcass weight wet matter for livestock and tones of wet matter for crops.

9. Annex

9.1. Region Classification Table

Countries	Australia (AUS), Brazil (BRA), Canada (CAN), China (CHN), India (IND), Indonesia (IDN), Japan (JPN), Russia (RUS), South Africa (ZAF), South Korea (KOR), United Kingdom (GBR), United States (USA)
Composite regions	Central and South America (CSA), Eurasia (EURA), European Economic Area (EEA), Gulf Cooperation Council (GCC), Middle East and North Africa (MENA), South Asia (SA), South East Asia and Oceania (SEAO), Sub-Saharan Africa (SSA

9.2. Country Classification Table

Country	Region	Country	Region	Country	Region
Australia	AUS	Brazil	BRA	Canada	CAN
China (P.R. of China and Hong Kong, China)	CHN	Argentina	CSA	Plurinational State of Bolivia	CSA
Chile	CSA	Colombia	CSA	Costa Rica	CSA
Cuba	CSA	Curaçao/Netherlands Antilles	CSA	Dominican Republic	CSA
Ecuador	CSA	El Salvador	CSA	Guatemala	CSA
Haiti	CSA	Honduras	CSA	Jamaica	CSA
Mexico	CSA	Nicaragua	CSA	Panama	CSA
Paraguay	CSA	Peru	CSA	Suriname	CSA
Trinidad and Tobago	CSA	Uruguay	CSA	Bolivarian Republic of Venezuela	CSA
Other non-OECD Americas	CSA	Bulgaria	EEA	Croatia	EEA
Czech Republic	EEA	Estonia	EEA	Hungary	EEA
Latvia	EEA	Lithuania	EEA	Poland	EEA
Romania	EEA	Slovak Republic	EEA	Slovenia	EEA
Albania	EURA	Armenia	EURA	Azerbaijan	EURA
Belarus	EURA	Bosnia and Herzegovina	EURA	Georgia	EURA
Kazakhstan	EURA	Kosovo	EURA	Kyrgyzstan	EURA
Republic of Moldova	EURA	Mongolia	EURA	Montenegro	EURA
Republic of North Macedonia	EURA	Serbia	EURA	Tajikistan	EURA
Turkmenistan	EURA	Ukraine	EURA	Uzbekistan	EURA
Former Soviet Union (if no detail)	EURA	Former Yugoslavia (if no detail)	EURA	Bahrain	GCC
Kuwait	GCC	Oman	GCC	Qatar	GCC
Saudi Arabia	GCC	United Arab Emirates	GCC	India	IND
Indonesia	IDN	Japan	JPN	Algeria	MENA
Egypt	MENA	Eritrea	MENA	Islamic Republic of Iran	MENA
Iraq	MENA	Israel	MENA	Jordan	MENA

Lebanon	MENA	Libya	MENA	Morocco	MENA
Sudan	MENA	Syrian Arab Republic	MENA	Tunisia	MENA
Turkey	MENA	Yemen	MENA	Other non-OECD Asia	MENA
Russian Federation	RUS	Bangladesh	SA	Nepal	SA
Pakistan	SA	Sri Lanka	SA	South Africa	ZAF
Democratic People's Republic of Korea	SEAO	Brunei Darussalam	SEAO	Cambodia	SEAO
Lao People's Democratic Republic	SEAO	Malaysia	SEAO	Myanmar	SEAO
New Zealand	SEAO	Philippines	SEAO	Singapore	SEAO
Chinese Taipei	SEAO	Thailand	SEAO	Viet Nam	SEAO
Korea	KOR	Other Africa	SSA	Angola	SSA
Benin	SSA	Botswana	SSA	Cameroon	SSA
Republic of the Congo	SSA	Côte d'Ivoire	SSA	Democratic Republic of the Congo	SSA
Equatorial Guinea	SSA	Ethiopia	SSA	Gabon	SSA
Ghana	SSA	Kenya	SSA	Mauritius	SSA
Mozambique	SSA	Namibia	SSA	Niger	SSA
Nigeria	SSA	Senegal	SSA	South Sudan	SSA
United Republic of Tanzania	SSA	Togo	SSA	Zambia	SSA
Zimbabwe	SSA	United Kingdom	GBR	United States	USA
Austria	EEA	Belgium	EEA	Cyprus	EEA
Denmark	EEA	Finland	EEA	France	EEA
Germany	EEA	Gibraltar	EEA	Greece	EEA
Iceland	EEA	Ireland	EEA	Italy	EEA
Luxembourg	EEA	Malta	EEA	Netherlands	EEA
Norway	EEA	Portugal	EEA	Spain	EEA
Sweden	EEA	Switzerland	EEA	Greenland	EEA

9.3. Expert Survey Responses

Country	80_percent_reductions		Afforestation		BEV_2030	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina		2054	2030	2043		13
Australia		2047	2030	2030		48
Brazil		2053	2030	2037		21
Canada		2047	2025	2040		33
China		2056	2025	2038		67
European Union		2046		2034		32
France		2045				49
Germany		2045	2030	2033		43
India		2061	2030	2051		22
Indonesia		2058	2030	2043		15
Italy		2048	2025	2034		22
Japan		2047	2025	2037		17
Mexico		2058	2030	2058		10
Nigeria		2061	2035	2045		33
Russia		2059	2030	2046		6
Saudi Arabia		2056				15
South Africa		2056	2035	2046		14
South Korea		2049	2030	2048		14
Turkey		2055	2025	2033		20
United Kingdom		2046	2025	2037		46
United States		2051	2025	2044		27
Vietnam		2056	2025	2033		10

Country	Carbon_price		Clean_power_share		Clean_power_share_2030	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina	30	43	2050	2048		52
Australia	70	83	2045	2040		58
Brazil	50	48	2030	2034		91
Canada	100	146	2035	2042		86
China	50	62	2050	2045		43
European Union		86		2041		44
France	120	95	2035	2033		81
Germany	120	85	2040	2036		65
India	50	74	2060	2056		39
Indonesia	50	37	2055	2059		24
Italy	120	71	2045	2041		44
Japan	70	35	2045	2046		47
Mexico	30	42	2050	2059		31
Nigeria	20	42	2050	2050		34

Russia	0	20	2060	2063		29
Saudi Arabia	20	43	2060	2050		26
South Africa	30	60	2055	2049		27
South Korea	70	43	2045	2050		37
Turkey	30	40	2050	2048		47
United Kingdom	120	95	2035	2039		52
United States	30	99	2040	2049		49
Vietnam			2050	2046		35

Country	Coal_phaseout		Deforestation_free_supply		HDV	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina			2040	2048	2045	2049
Australia	2040	2039	2030	2033	2045	2049
Brazil			2035	2049	2050	2057
Canada	2030	2033	2035	2048	2040	2047
China	2045	2038	2035	2047	2040	2046
European Union		2037		2034		2043
France			2030	2034	2040	2046
Germany	2035	2036	2030	2036	2040	2042
India	2060	2048	2040	2056	2045	2055
Indonesia	2055	2048	2040	2048	2050	2053
Italy	2024	2031	2030	2036	2040	2049
Japan	2045	2043	2035	2035	2040	2048
Mexico	2040	2046	2040	2060	2045	2056
Nigeria			2040	2048	2050	2061
Russia	2060	2054	2040	2075	2055	2061
Saudi Arabia			2040	2050	2045	2053
South Africa	2055	2048	2040	2048	2045	2048
South Korea	2045	2048	2040	2048	2040	2047
Turkey	2045	2042	2040	2038	2045	2050
United Kingdom	2025	2032	2030	2041	2040	2045
United States	2035	2041	2035	2046	2045	2051
Vietnam	2045	2043			2045	2036

Country	Industry_cement		Industry_chemicals		Industry_steel	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina	2075	2052	2075	2053	2075	2052
Australia	2065	2046	2065	2043	2065	2045
Brazil	2070	2051	2070	2050	2070	2050
Canada	2065	2054	2065	2054	2065	2045
China	2075	2045	2075	2048	2075	2046
European Union		2044		2041		2043
France	2065	2047	2065	2043	2065	2044
Germany	2060	2044	2060	2042	2060	2044

India	2075	2054	2075	2056	2075	2055
Indonesia	2075	2054	2075	2053	2075	2055
Italy	2070	2046	2070	2043	2070	2048
Japan	2065	2048	2065	2050	2065	2050
Mexico	2075	2052	2075	2055	2075	2055
Nigeria	2075	2062	2075	2059	2075	2059
Russia	2075	2060	2075	2058	2075	2057
Saudi Arabia	2075	2052	2075	2049	2075	2050
South Africa	2075	2047	2075	2049	2075	2049
South Korea	2065	2057	2065	2055	2065	2053
Turkey	2075	2051	2075	2047	2075	2048
United Kingdom	2065	2043	2065	2042	2065	2041
United States	2065	2053	2065	2050	2065	2051
Vietnam	2075	2044	2075	2043	2075	2043

Country	LDV		agriculture_fertilizer		agriculture_livestock	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina	2040 / 2045	2051	2035	2045	2035	2050
Australia	2040 / 2045	2043	2030	2041	2030	2041
Brazil	2045 / 2050	2051	2030	2041	2030	2047
Canada	2035 / 2040	2042	2025	2042	2025	2044
China	2035 / 2040	2038	2030	2038	2030	2042
European Union		2039		2037		2041
France	2035 / 2040	2039	2025	2032	2025	2033
Germany	2035 / 2040	2042	2025	2037	2025	2042
India	2040 / 2045	2052	2035	2051	2035	2054
Indonesia	2045 / 2050	2051	2035	2047	2035	2044
Italy	2035 / 2040	2043	2025	2038	2025	2038
Japan	2040	2040	2025	2043	2025	2039
Mexico	2040 / 2045	2058	2035	2055	2035	2058
Nigeria	2045 / 2050	2058	2035	2042	2035	2045
Russia	2050 / 2055	2060	2035	2049	2035	2056
Saudi Arabia	2040 / 2045	2057				
South Africa	2040 / 2045	2051	2035	2042	2035	2043
South Korea	2035 / 2040	2051	2030	2043	2030	2045
Turkey	2040 / 2045	2062	2035	2036	2035	2045
United Kingdom	2030 / 2040	2041	2025	2039	2025	2044
United States	2040 / 2045	2048	2030	2045	2030	2046
Vietnam	2040 / 2045	2041	2030	2034	2030	2034

Country	Low_emissions_heating		Nature_incentives		Net_deforestation	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina	2045	2048	2035	2052	2030	2044
Australia	2035	2038	2025	2031	2030	2039
Brazil			2030	2033	2030	2043
Canada	2035	2043	2030	2036	2025	2043
China	2045	2046	2030	2039	2025	2039
European Union		2040		2036		2033
France	2035	2036	2025	2039		
Germany	2030	2039	2030	2035	2030	2034
India			2035	2048	2030	2054
Indonesia			2035	2042	2030	2049
Italy	2035	2041	2030	2043	2025	2034
Japan	2040	2045	2030	2036	2025	2029
Mexico			2035	2047	2030	2055
Nigeria			2040	2044	2035	2052
Russia	2050	2053	2040	2040	2030	2056
Saudi Arabia			2040	2042		
South Africa	2050	2045	2035	2044	2035	2045
South Korea	2040	2052	2030	2045	2030	2047
Turkey	2050	2052	2040	2039	2025	2034
United Kingdom	2035	2042	2025	2038	2025	2038
United States	2040	2046	2030	2044	2025	2042
Vietnam			2030	2032	2025	2030

Country	Net_zero		New_coal_phaseout		Payments_for_nature	
	IPR 2023	Survey 2025	IPR 2023	Survey 2025	IPR 2023	Survey 2025
Argentina	2060	2058			2035	2051
Australia	2050	2054	2023	2031	2025	2034
Brazil	2050	2060			2030	2040
Canada	2050	2053		2031	2030	2040
China	2060	2063	2030	2034	2030	2045
European Union		2053		2030		2040
France	2050	2051			2025	2039
Germany	2045	2051		2029	2030	2040
India	2065	2070	2030	2048	2035	2053
Indonesia	2060	2066	2025	2045	2035	2045
Italy	2050	2055		2031	2030	2040
Japan	2050	2053	2025	2038	2030	2035
Mexico	2070	2065		2048	2035	2052
Nigeria	2070	2069			2040	2048
Russia	2070	2068	2030	2048	2040	2044

Saudi Arabia	2060	2064			2040	2040
South Africa	2070	2061	2030	2042	2035	2042
South Korea	2050	2056	2025	2041	2030	2042
Turkey	2060	2062	2030	2035	2040	2040
United Kingdom	2050	2053		2030	2025	2042
United States	2050	2060		2038	2030	2049
Vietnam	2060	2060	2025	2033	2030	2033

Country	Protection_restoration	
	IPR 2023	Survey 2025
Argentina	2040	2047
Australia	2030	2036
Brazil	2030	2036
Canada	2035	2042
China	2035	2033
European Union		2035
France	2030	2032
Germany	2025	2040
India	2040	2051
Indonesia	2045	2042
Italy	2030	2034
Japan	2030	2038
Mexico	2040	2048
Nigeria	2045	2046
Russia	2045	2038
Saudi Arabia	2040	2038
South Africa	2040	2048
South Korea	2040	2040
Turkey	2045	2035
United Kingdom	2030	2038
United States	2035	2047
Vietnam		