Copenhagen Economics

INTERSECT

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INTERSECT is a Computable General Equilibrium Model – built for decarbonisation analysis across:

Countries

Emissions scenarios

Sectors

Technologies

INTERSECT

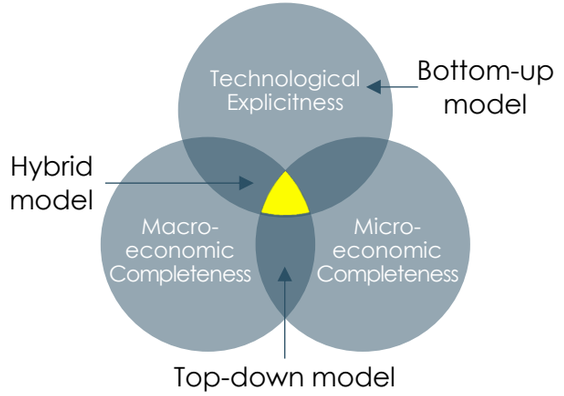
Executive summary:

- INTERSECT one-pager
- The power of scenario analysis
- What INTERSECT does do and does not do

INTERSECT is a global, multi-sector CGE model - built for decarbonisation analysis

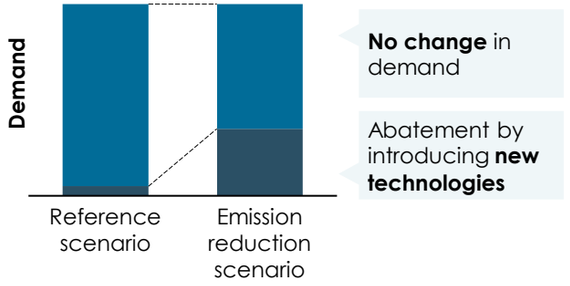
INTERSECT is a dynamic Computable General Equilibrium (CGE) model which we at Copenhagen Economics have co-developed with Bain & co.
The model features **global coverage** spanning 44 countries that make up 90% of global GDP, allowing for simulations **up to 2050**. The model integrates carbon emissions centrally, offering insights into detailed decarbonization paths and their impacts.
A range of different **technology levers** are available for sectoral decarbonization. The costs of competing technologies are determined within the model as prices of for example electricity and fossil fuels are derived from supply and demand. In addition, some technologies in the model see costs move down learning curves, depending on past deployment.
Employing an **integrated hybrid approach**, INTERSECT combines the classical welfare-maximizing macroeconomic top-down method with a bottom-up, cost-minimizing treatment of technology. This allows for explicit technology choices alongside more traditional macroeconomic shifts of demand for final and intermediate goods, as well as raw material.
As a multi-regional model, INTERSECT captures **trade flows** between economies, representing trade as bilateral flows of heterogeneous goods. The model explicitly links trade with transportation considered via land, air, or water.
The dynamics of the model are based on **economic theory**, where agents optimize utility, and firms optimize profits annually based on real-world input-output data.
INTERSECT captures the **full value chain** as it models production, consumption, employment, investment, taxes, trade, and their interconnections. Supply and demand are balanced, providing robust results for both prices and quantities in equilibrium, and across scenarios.
Each production sector is represented by a specific production function with a nesting structure of inputs. Production dynamics depend on the **vintage of capital** employed.

The hybrid model approach



Bottom-up model

- Ignores substitution possibilities across consumption goods
- Underestimates loss of welfare

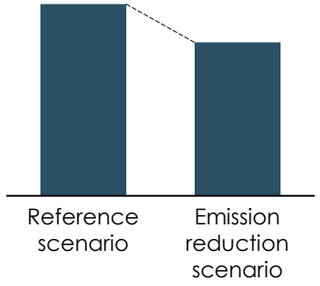


No change in demand

Abatement by introducing **new technologies**

Top-down model

- Ignores technological switch within demand of sector
- Overestimates loss of welfare

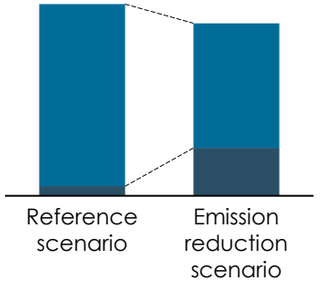


Abatement by **lowering demand**

No shift in technologies

Hybrid model

Allows for **technological switch** within sector and **substitution** across consumption goods



Partly **lower demand**

Partly shift in technologies

The power of scenario analysis

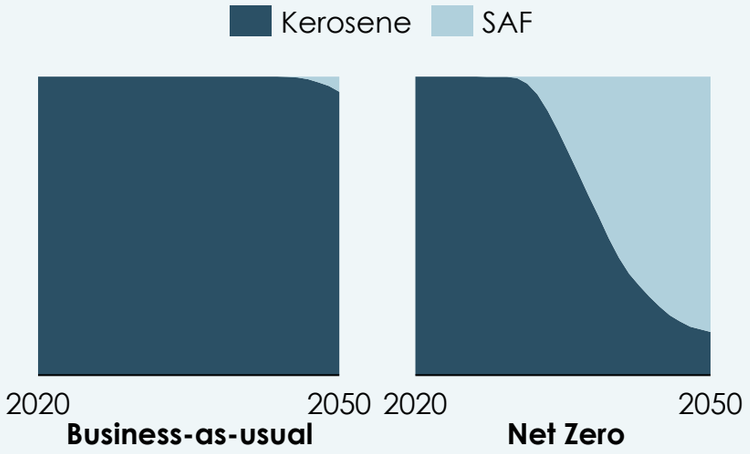
What is a scenario?
A scenario is a structured view of a possible future. Each scenario is a different outcome that may or may not materialise but helps you prepare for how your future could look.

Why should I use scenario analysis?
Evaluate a changing business landscape: potential investments, market size, prices. Understand how policy changes affect your business. Test your current beliefs about the future.

How do I define a scenario?
Set an emissions baseline you believe in: IEA or customised. Define key parameters that stay fixed or vary between scenarios (e.g. policies, technology costs or demand). Use the insights to shape forward-looking decisions

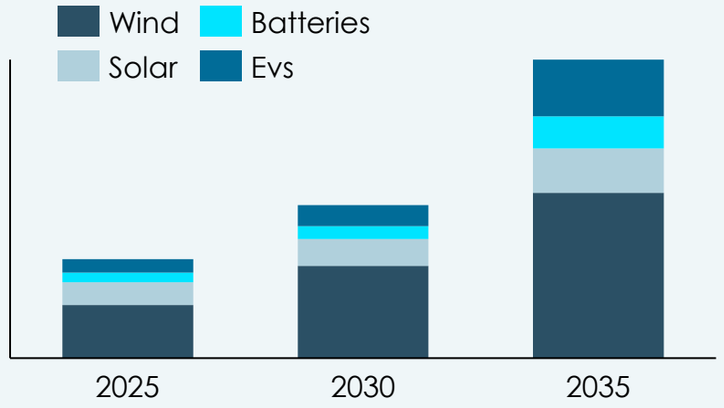
Example 1 - How sensitive uptake of new fuel types is to climate policies

Sustainable aviation fuel (SAF) can play a key role in decarbonising air transport
% technology share of total market



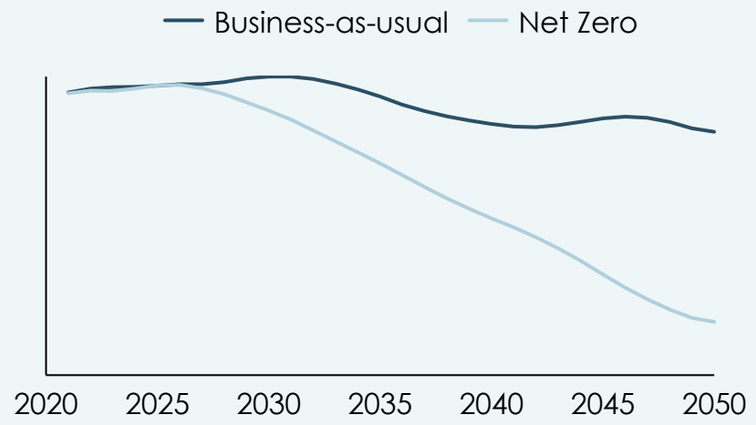
Example 2 - The role of climate ambitions in industrial policy

Green Industrial policy can revitalise European manufacturing
Millions of additional jobs supported



Example 3 - How climate policies affect the price of commodities

A Net Zero pathway could be a tipping point for oil prices
USD/Barrel of oil



What INTERSECT does and does not do

Insights offered by INTERSECT

- An understanding of what is needed for an economy to reach a certain **decarbonisation target**
- The **investments** generated across different industries to reach targets
- How the **sector composition** changes when the economy decarbonises
- What types of **jobs** are generated in the future – and which are not
- The **risks and opportunities** of the green transition from a socio-economic point of view
- The economic impacts of the green transition

What INTERSECT does

- Considers **a holistic, systemic view** of the economy, rather than sector and technology siloes
- Manages the combination of decarbonisation initiatives, politically set decarbonisation targets, and general macroeconomic development
- Based on **transparent assumptions** and robust implementation

What INTERSECT does not do

- Considers specific announced or pledged investments
- Predicts business cycle patterns

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Coverage:

- Regions & Data
- Emissions scenarios
- Sectors & Commodities
- Technology & Industry modules

The data foundation of INTERSECT enables global coverage

Data foundation of INTERSECT enables global coverage

Macro-economic data foundation	For the core description of economic flows, we rely on the GTAP11 Database. The inter-regionally consistent input-output tables and social accounting matrices completely describe economic flows between sectors and trade between regions.
Supplementary data on emissions	We supplement GTAP11 with emission data from additional sources including BP and the IEA, as well as insights from comprehensive research on new and emerging technologies.
Additional data as needed	The full list of data sources for the model include GTAP, IEA, BP, EIA, ENTSO-E, Rystad, the World Bank, OECD, Bain & Co industry experts, and more. Further, the model can be updated for specific projects with the inclusion of proprietary data.
Policies and regulation	We introduce policies and regulation into the model, with the core scenarios being the IEA STEPS, APS and NZE scenarios. Other policies include the Inflation Reduction Act and the EU Green Deal, and a range of national enacted policies.

+90% **of global GDP is covered by INTERSECT**

Complete global coverage

Our data foundation covers 44 countries (28 EU members and 16 major economies), as well as more than 150 countries combined in five rest of the world regions.

The 44 countries covers over 90% of global GDP, ensuring detailed data coverage of production and trade. The regional coverage can be changed to meet bespoke requirements. In the baseline version of INTERSECT the economies are pooled into the following 18 regions:

Americas

- Canada
- USA
- Mexico
- Brazil
- Central America
- South America

EMEA

- European Union (EU-27)
- United Kingdom
- Eastern Europe
- Russia
- Middle East
- South Africa
- Africa
- Central Asia

Asia Pacific

- China
- India
- Japan
- Australia & New Zealand
- Asia Pacific

We cover three core IEA scenarios as our baseline with the possibility to add custom scenarios

INTERSECT is calibrated to yield results consistent with the three main scenarios outlined in the IEA World Energy Outlook. These three scenarios serve as the core benchmarks for our projections (STEPS, APS, NZE).

Custom scenarios possible

IEA STEPS	IEA APS	IEA NZE
Stated Policies Scenario	**Announced Pledges Scenario**	**Net Zero Emissions by 2050 Scenario**
Reflects the current energy-related policies in place or under development. It shows the trajectory of emissions under today's policy settings and takes into account planned clean energy capacities.	Assumes that all climate pledges and commitments made by governments and industries, including Nationally Determined Contributions (NDCs) and net-zero targets, are met in full and on time.	A pathway to achieve global net zero CO2 emissions by 2050.

Examples of Insights

Current Policy Impact	INTERSECT can simulate the trajectory of emissions based on existing policies.	**Evaluation of Current Commitments**	INTERSECT can assess how close the world gets to climate goals under current pledges, estimating the resulting emissions and energy mix across regions.	**Detailed Decarbonization Pathways**	INTERSECT can simulate sector-by-sector decarbonization strategies required to reach net zero by 2050, showing the required technological transitions and costs involved.
Comparison of Technology Costs	INTERSECT can compare technology costs under existing policy settings, showing where clean technologies might remain uncompetitive without further policy intervention.	**Ambition Gap**	The model can identify gaps between current pledges and what's necessary to meet emissions target, providing a clear picture of what additional actions are needed.	**Technology Choices**	INTERSECT can forecast how key technologies, such as renewables, electric vehicles, and carbon capture, evolve under the net-zero scenario, including the role of learning curves and cost reductions.

The sectors and commodities included cover the key elements for the green transition – with the possibility to continuously add more

Sectors

INTERSECT strategically emphasizes the sectors most relevant to the green transition. Consequently, the level of granularity is higher within the energy and energy-intensive sectors and the transportation. We add a hydrogen sector, as opposed to most similar models. *The sectoral coverage can be changed to meet the requirements of your problem. The baseline version of INTERSECT contains the following sectors:*

List of sectors

Energy sectors

- Electricity generation
- Coal extraction
- Natural gas extraction
- Gas distribution
- Crude oil extraction
- Refined oil products and chemicals
- Hydrogen production

Other energy-intensive sectors

Manufacture of
- Non-metalling mineral products
- Non-ferrous metals
- Fabricated metal products
- Iron and steel
- Machinery and equipment
- Construction
- Mining

Transportation

- Light duty vehicles
- Heavy-duty vehicles (passenger & freight)
- Air transport (passenger and freight)
- Rail (passenger and freight)
- Marine shipping
- Pipeline transportation of gas

Agriculture

Refined food and beverage products

Services

Other goods

Commodities

In the model, each sector generates a commodity, resulting in 32 commodities, equivalent to the 32 sectors. For instance, crude oil extraction results in crude oil, while the refined oil products and chemicals sector produces gasoline, diesel, kerosene, and fuel oil.

List of commodities

- Coal
- Crude oil
- Natural gas extraction
- Natural gas distribution
- Electricity
- Gasoline
- Diesel
- Kerosene
- Fuel oil
- Non-ferrous metals
- Hydrogen
- Steel
- Non-metalling mineral products
- Fabricated metal products
- Construction
- Cars
- Chemical and other fuels
- Agriculture
- Refined food and beverage products
- Mining
- Machinery and equipment
- Services
- Transportation (by type)
- All other goods

Flexibility of INTERSECT allows for additional sectoral or regional granularity

The baseline version of INTERSECT includes the mentioned regions, sectors, and commodities, many of which are aggregations. Disaggregation can be employed to concentrate on the relevant aspects in each specific situation.

Technology & industry modules set INTERSECT apart from standard economic models

Technology & Industry coverage

INTERSECT covers a wide range of industries and technologies, specifically calibrated to reflect carbon emissions and enable dynamic technology choices across sectors. The model includes specialised industry modules, ensuring accurate representation of hard-to-abate sectors.

Modules are a key feature of INTERSECT. They include technological detail that standard CGE models do not have. In particular, these are supply curves for key materials and detailed abatement cost modelling.

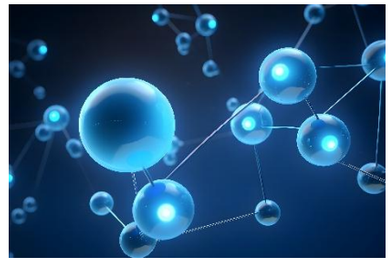
INTERSECT continuously evolves with the latest knowledge and scenarios, incorporating advanced features such as:

- Learning curves for new technologies.
- Dynamic marginal abatement cost (MAC) curves as input prices change.
- Tracking of asset lifetimes
- Explicit supply curves for oil & gas
- Short- and long-term supply curves for critical minerals
- Retrofitting of existing assets
- Stability requirements for power markets
- Carbon certificate trade mechanisms.

Bespoke technology & Industry modules

Power Module

Transport Module



Hydrogen Module

Steel Module

Oil & Gas Module

Liquid Fuels Module

Non-Ferrous Metals Module

CCS Module

… and opportunity to develop customized modules

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Explainer – CGE models:

- Fundamental structure of a CGE model
- Demand side
- Supply side

The fundamental structure of a CGE-model

What is a CGE Model?

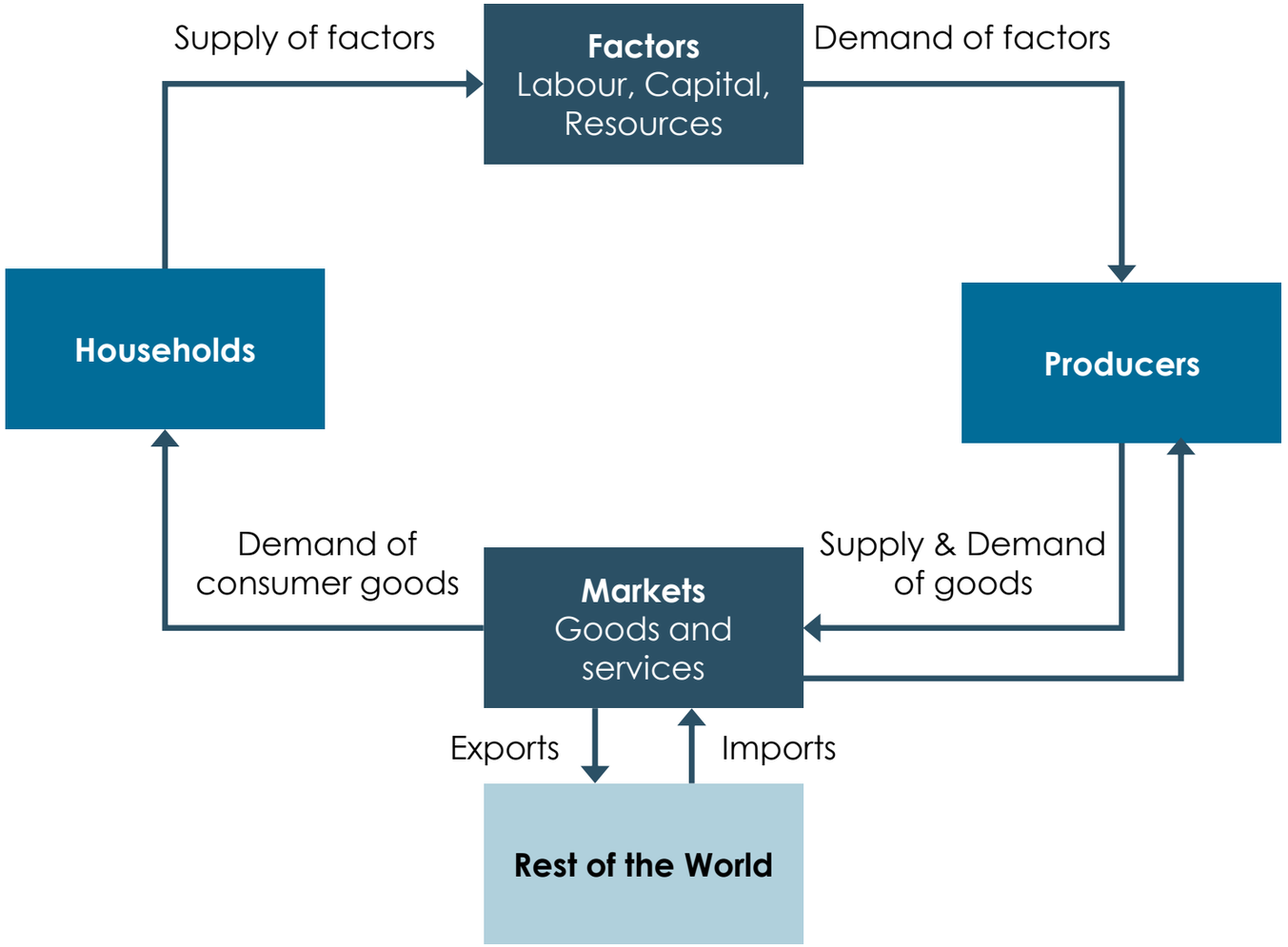
INTERSECT is a Computable General Equilibrium (CGE) model. This is an economic model used to simulate how an economy might react to changes in policy, technology and other external factors.

Key features

Holistic Economic Framework: CGE models capture the interactions between different sectors, agents (households, firms, and governments), and markets within an economy, ensuring that all economic activities and their interdependencies are considered.

Data-Driven Simulations: These models rely on real-world data, using input-output tables, national accounts, and behavioural parameters, to simulate how economies respond to shocks or policy changes.

Equilibrium Focus: CGE models are grounded in the concept of equilibrium, where supply equals demand in all markets. They solve for prices and quantities that balance all markets simultaneously, reflecting how resources are allocated efficiently under given conditions.



INTERSECT uses a dynamic model of consumer behaviour

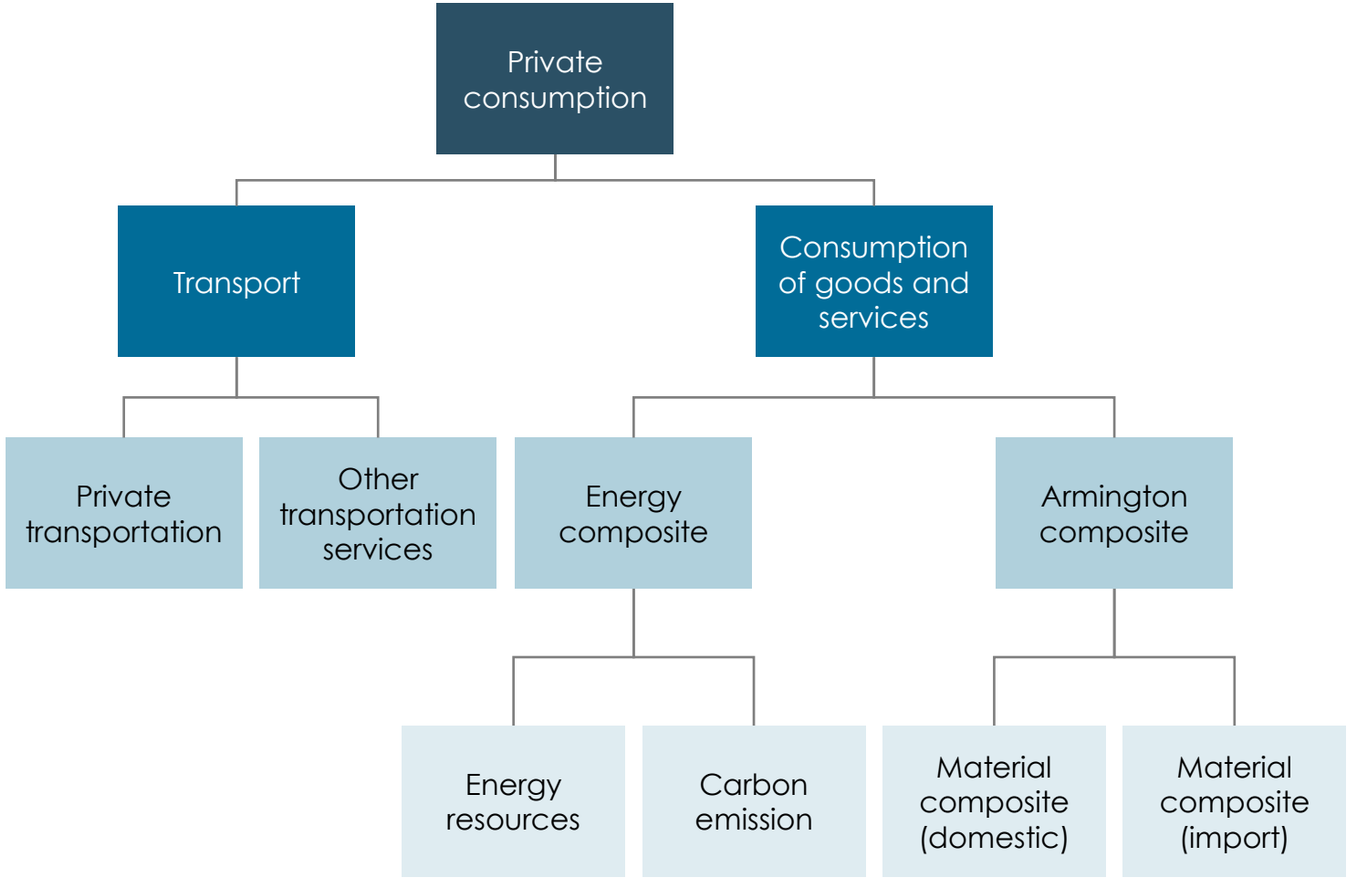
Demand side

INTERSECT uses a representative consumer to model the consumption behaviour of households. The diagram illustrates the components that make up the private consumption.

Nested structure	Represents a hierarchical framework to organise consumption into different categories. Each nest represents a level of decision-making that builds on the previous one.
Elasticities & Substitution	Elasticities between categories model how households substitute between goods in response to price changes, which are driven by policy and technology changes).
Dynamic adjustment	Households do not consume goods in fixed amounts, but dynamically adjust. For example, as countries become wealthier, their consumption patterns and industrial activities will evolve, leading to significant changes in emission profiles.
Global detail	These elasticities can differ across years and countries, allowing for a detailed understanding of consumption behaviour.

A detailed example of dynamic consumption behaviour is shown on the next slide.

Consumption function illustrated



Deep Dive: How INTERSECT forecasts global shifts of consumption patterns

Dynamic Consumption Modelling and Long-Term Projections

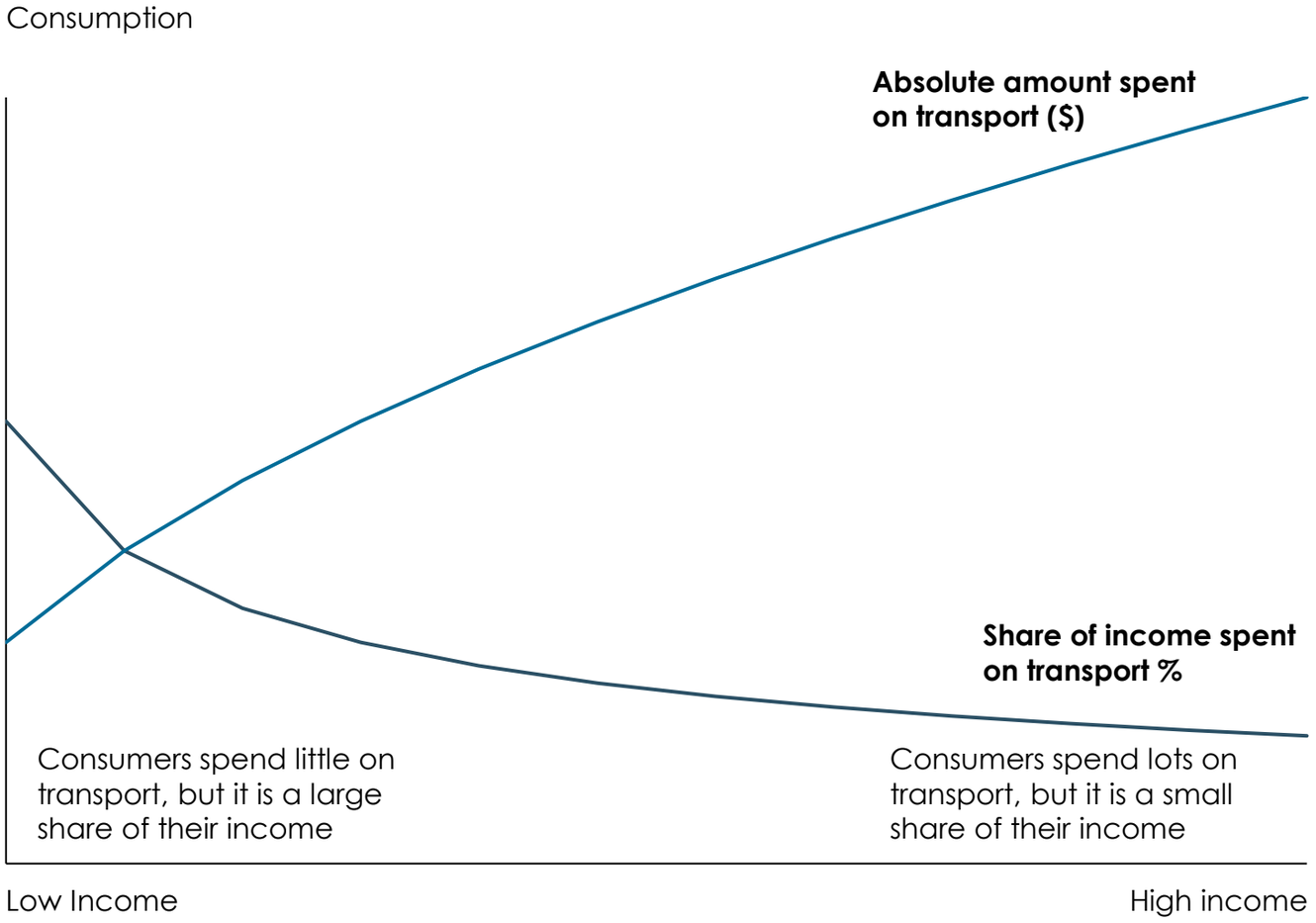
Having a detailed understanding of consumer behaviour is crucial to correctly analysing the long run nature of climate economics. For example, the diagram on the right illustrates how accounting for income elasticities is crucial to understand the effects of rising income on consumption behaviour of households in developing economies.

Therefore, to account for this, INTERSECT uses an in-depth model of consumer behaviour that can account for a range of different factors that will affect consumption behaviour of households up until 2050.

Key factors covered:

- **Economic and population growth**: The model reflects how changes in income and population influence consumption patterns across various sectors. As economies grow, particularly in developing nations, consumer spending shifts, which will affect CO_2 emissions.
- **Good-specific income elasticities**: Our model includes a diverse range of income elasticities across different sectors, both above and below 1. This ensures that it can precisely predict how demand for goods and services will change with income changes.
- **Complete global coverage up to 2050:** Understanding how the economic rise of developing nations will reshape global CO_2 emissions is crucial. INTERSECT's long-term and global perspective will enables us to accurately model how economic growth and policy shifts will drive CO_2 emissions in both developing and developed regions.

Stylised effect of rising income on absolute and relative consumption patterns



INTERSECT models the supply side in detail

Supply side

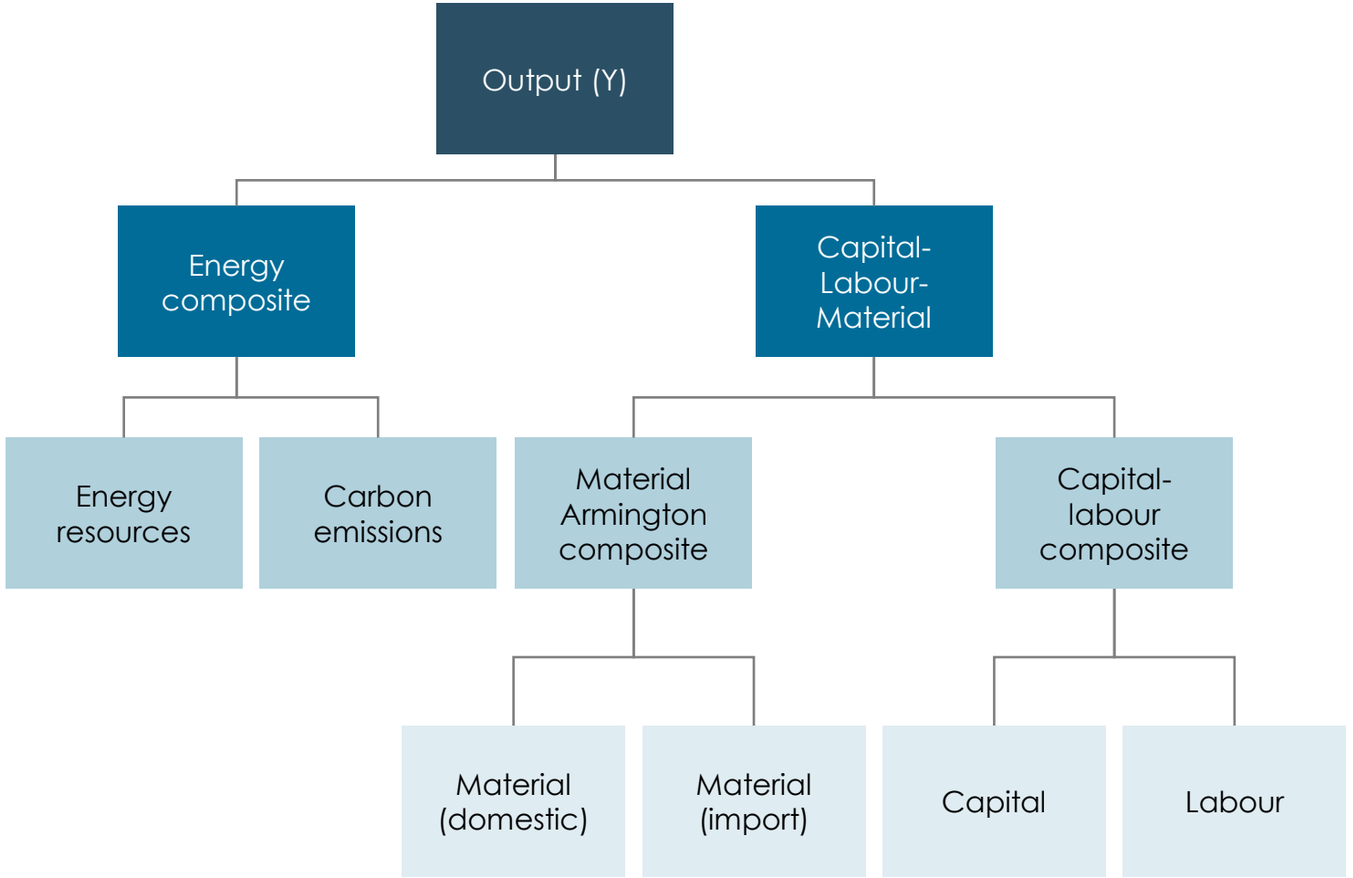
INTERSECT models the supply side of the economy though firms that act as suppliers for both final and intermediate consumption.

Firms produce output given the available technologies and their respective total cost of ownership (TCO). The diagram illustrates the components that make up production in the economy.

Nested Structure	The model organizes production inputs into a hierarchical structure. This structure allows the model to represent how firms combine resources like energy, labour, capital, and materials to final output.
Country specific technology costs	The model allows for dynamic adjustments of input usage in response to changes in prices, policies, and technological advancements. This flexibility allows it to simulate how firms might alter their production methods over time to optimize output and manage costs.

A detailed example is shown on the next slide that illustrates how production within a country changes as it industrialises.

Production function illustrated



Deep Dive: How INTERSECT forecasts global shifts of production patterns

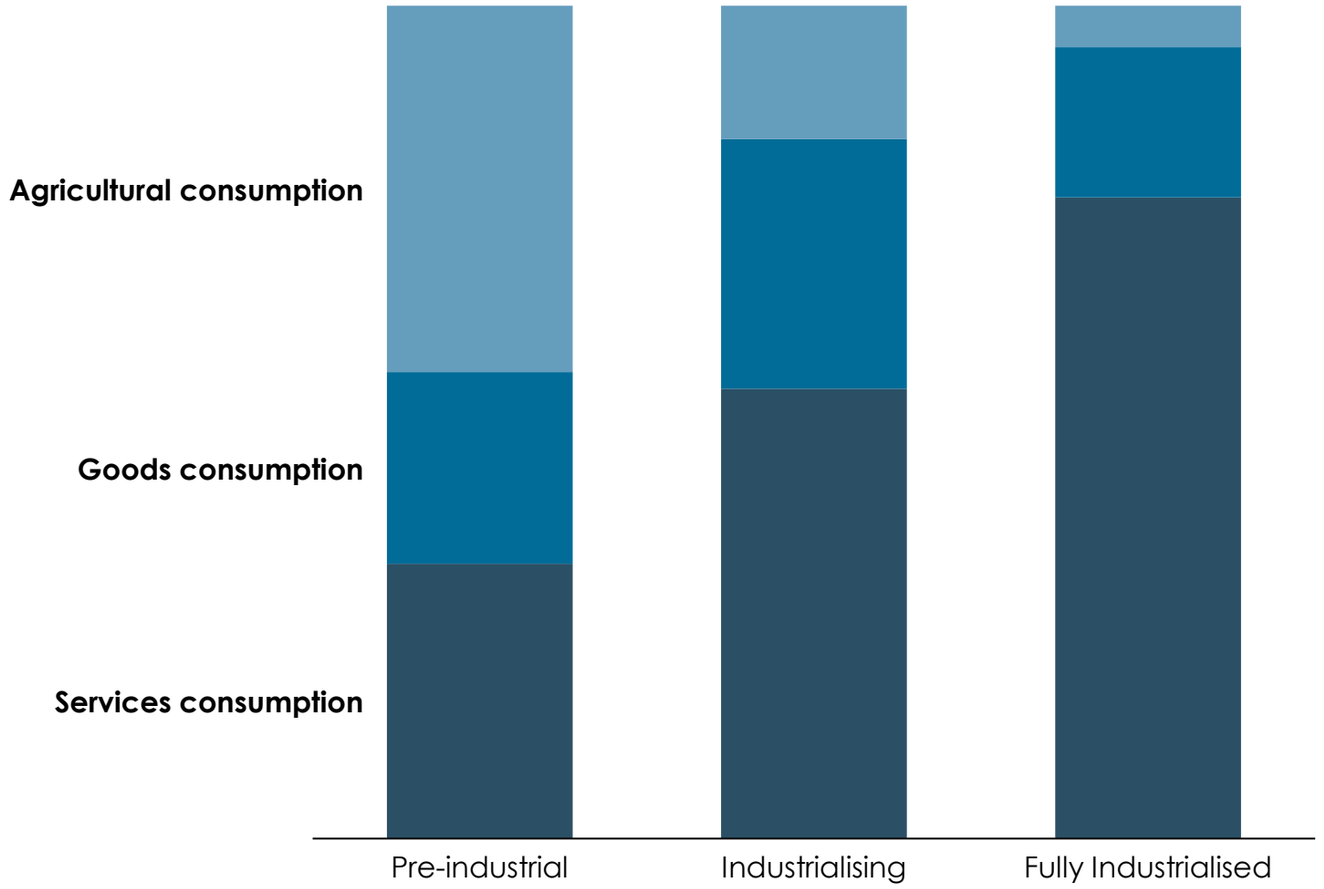
Modelling Industrialisation shifts through changes in consumer demand

In INTERSECT, we simulate how countries shift their production structures during industrialisation. We assume the transition of economies follows a universal setting from primary production (agricultural goods, mining etc.) to secondary production (manufacturing) to tertiary production (services).

This development process is driven by the final consumer demand of developing nations converging toward patterns seen in developed regions, with flexibility for manual adjustments. Final consumer demand is defined as encompassing consumption (C), investment (I), and government spending (G).

- **Convergence Path**: Regions are classified as either fully developed or on a convergence path toward a developed archetype. These archetypes are based on GTAP-defined categories.
- **Final Demand Alignment**: For regions on a convergence path, we define which developed region they are moving towards in terms of final consumer demand. The developing region is matched automatically to a target region based on country characteristics.
- **Speed of Convergence**: The pace at which regions converge is calibrated to match empirically observed income elasticities. This speed can also be adjusted based on other factors, such as GDP per capita.

Stylised consumption shares of the 3 model archetypes



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Glossary of key terms

Glossary

Input-Output	A method used in CGE models to represent the flow of goods and services between sectors within an economy. It details how the output from one sector (such as manufacturing) serves as an input for another (such as construction), allowing the model to simulate the interdependence of sectors.
Vintage of Capital	In economic modelling, the term refers to the age or generation of capital assets (like machinery, infrastructure, or technology) used by firms. Different vintages represent assets installed at different times, with older vintages often being less efficient or productive than newer ones.
Welfare/Utility	In economic models, utility represents the satisfaction or benefit individuals derive from consuming goods and services, while welfare refers to the overall economic well-being of individuals or society. In CGE models, welfare is often used as a measure of how different policies, such as carbon pricing or technology changes, affect the economic health of households or the population. These models simulate how households maximize their utility given constraints like income and prices, allowing policymakers to assess the trade-offs between economic efficiency and environmental goals.
Social Accounting Matrix (SAM)	A comprehensive data framework used in CGE models that captures the flow of all economic transactions within an economy. It extends input-output tables by including institutions such as households, governments, and foreign sectors, linking income distribution, consumption, production, and capital flows. SAMs are used to provide a detailed picture of how income is generated, distributed, and spent in an economy, making them essential for analysing the broader impacts of economic policies, including environmental and social outcomes.
Marginal Abatement Cost (MAC) Curve	A tool used to represent the cost of reducing each additional unit of emissions. It shows the range of available options for reducing emissions, ordered from the least expensive to the costliest. The curve helps policymakers understand how much emissions can be reduced at different cost levels, making it useful for comparing the cost-effectiveness of various mitigation strategies or technologies.
Substitution	In economic modeling, substitution refers to how consumers or producers switch between different goods or inputs in response to changes in relative prices. The ease of substitution can be modeled with elasticities, showing how readily agents switch from one technology or good to another based on cost, availability, and policy changes.
Learning Curves	A concept that describes how the cost of a technology decreases as its adoption and production scale increase over time. This is due to factors such as technological improvements, increased worker efficiency, and economies of scale. Learning curves are applied in modeling to forecast the future costs of technologies like renewable energy or electric vehicles as they are deployed more widely.
CGE Model	(Computable General Equilibrium Model): A type of economic model that simulates the economy's response to policy changes or external factors, balancing supply and demand across sectors.