Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Office fédéral de l'énergie OFEN
Ufficio federale dell'energia UFE
Uffizi federal d'energia UFE

ENERGY PERSPECTIVES 2050+
FOCUS ON THE TRANSPORT SECTOR

SFOE ENERGY PERSPECTIVES
IT ALL BEGAN BACK IN THE 1970S

1970s	Gesamtenergiekonzeption (Overall Energy Conception)
1990s	first quantitative simulation models
2007	Energy perspectives 2035
2012	Energy perspectives 2050 → basis for Energy Strategy 2050
2020	Energy perspectives 2050+ → Framework conditions have changed since 2012: - new bases such as population and GDP scenarios - new Energy Act has been in effect since 1 January 2018 - tightened climate target: net zero emissions by 2050 → basis for long-term Climate Strategy 2050

ENERGY PERSPECTIVES 2050+
ISSUES

Climate neutral Switzerland by 2050

- Net zero emissions by 2050:

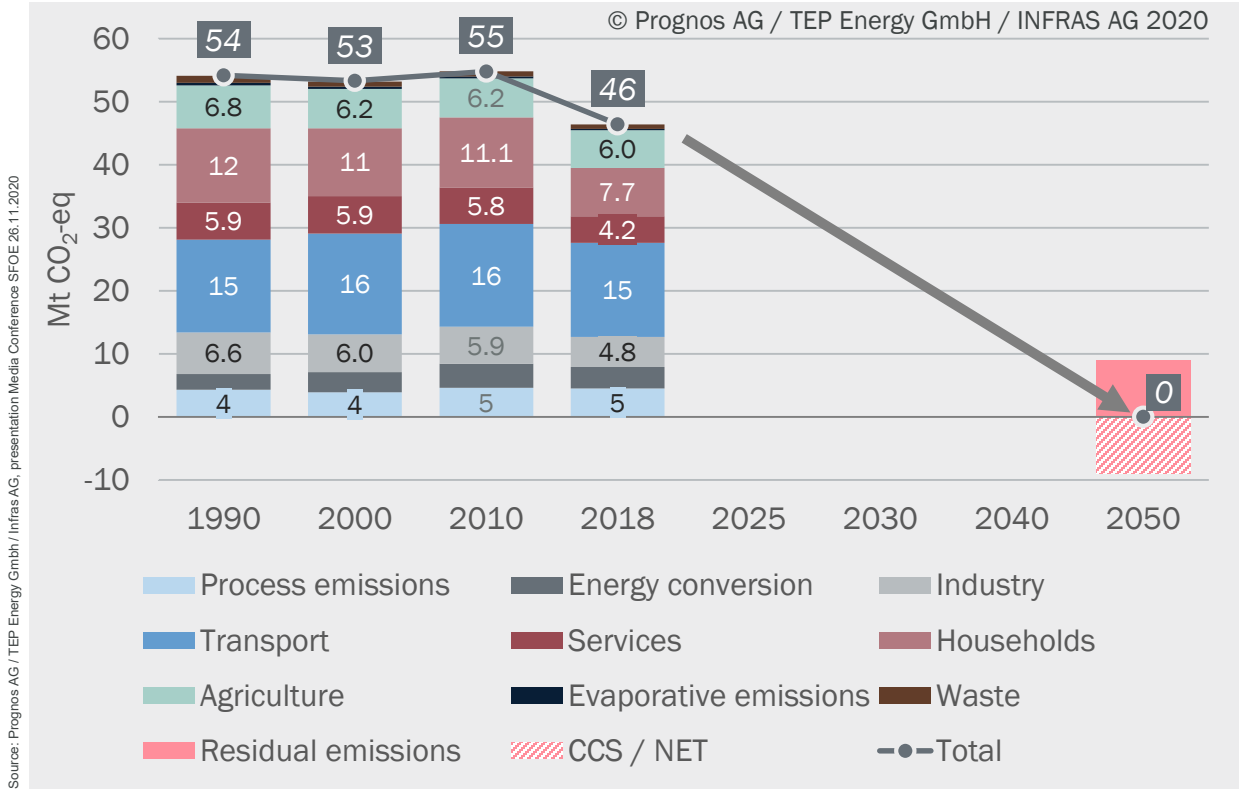
  Unavoidable residual emissions to be offset by natural or technical sinks
- Which paths enable achievement of target?

  → Working with scenarios

Delimitation

- CO_2, CH_4, N_2O, fluorinated gases
- Alongside the energy system, process emissions plus non-energy-related emissions form agriculture and waste treatment to be taken into account

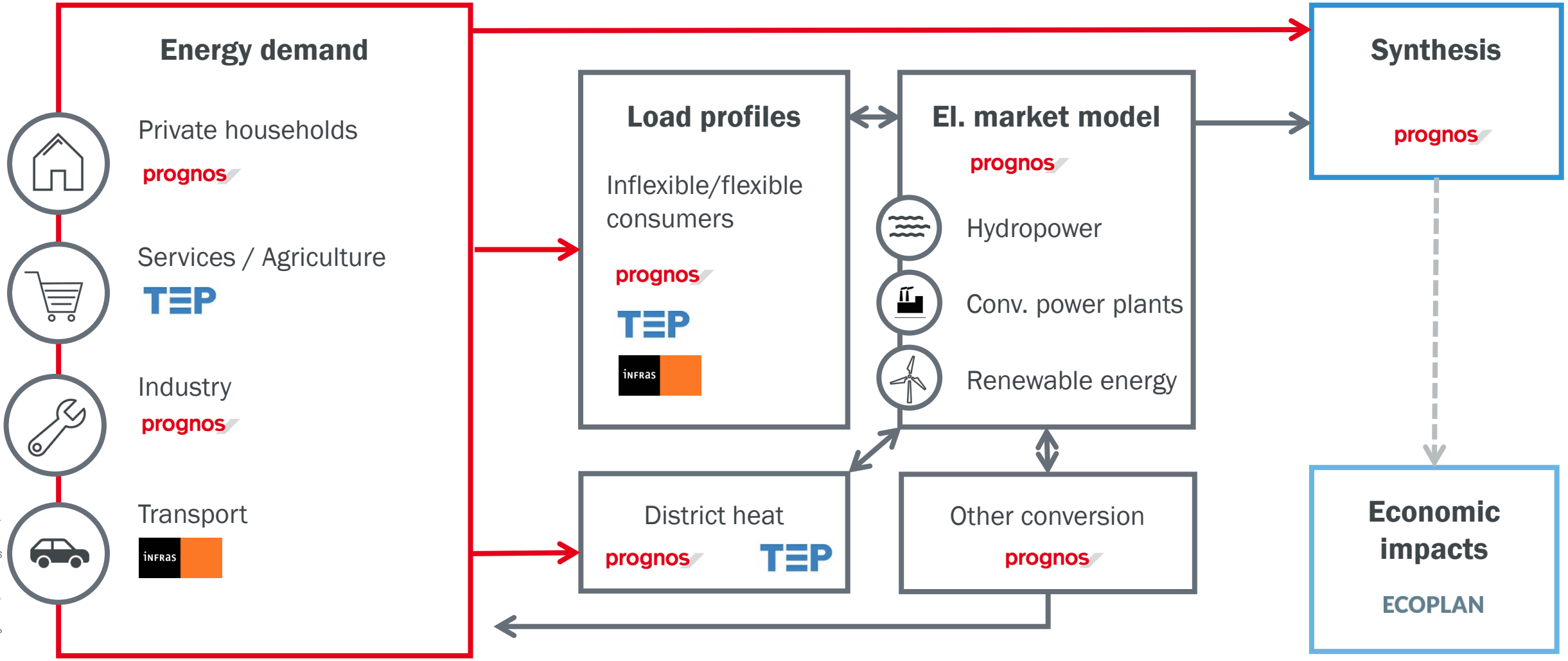
Greenhouse gas emissions & CCS/NET



SCENARIOS AND VARIANTS
VARIOUS PATHS LEADING TO THE TARGET

Scenario	Variant	Strategic electricity production variants
Net zero scenario (ZERO)	**Basis variant (ZERO Basis)**	Even annual import-export balance 2050
		Guidelines / expansion targets
		Current framework conditions
	Variant A (ZERO A) *extensive electrification*	Even annual import-export balance 2050
		Guidelines / expansion targets
		Current framework conditions
	Variant B (ZERO B) *stronger focus on gas*	Even annual import-export balance 2050
		Guidelines / expansion targets
		Current framework conditions
	Variant C (ZERO C) *stronger focus on heat networks and liquid fuels*	Even annual import-export balance 2050
		Guidelines / expansion targets
		Current framework conditions
Business as Usual scenario (BAU)	*Current energy and climate policy measures*	Existing legal and framework conditions

MODELLING OVERVIEW
CONSORTIUM OF 4 PROJECT PARTNERS



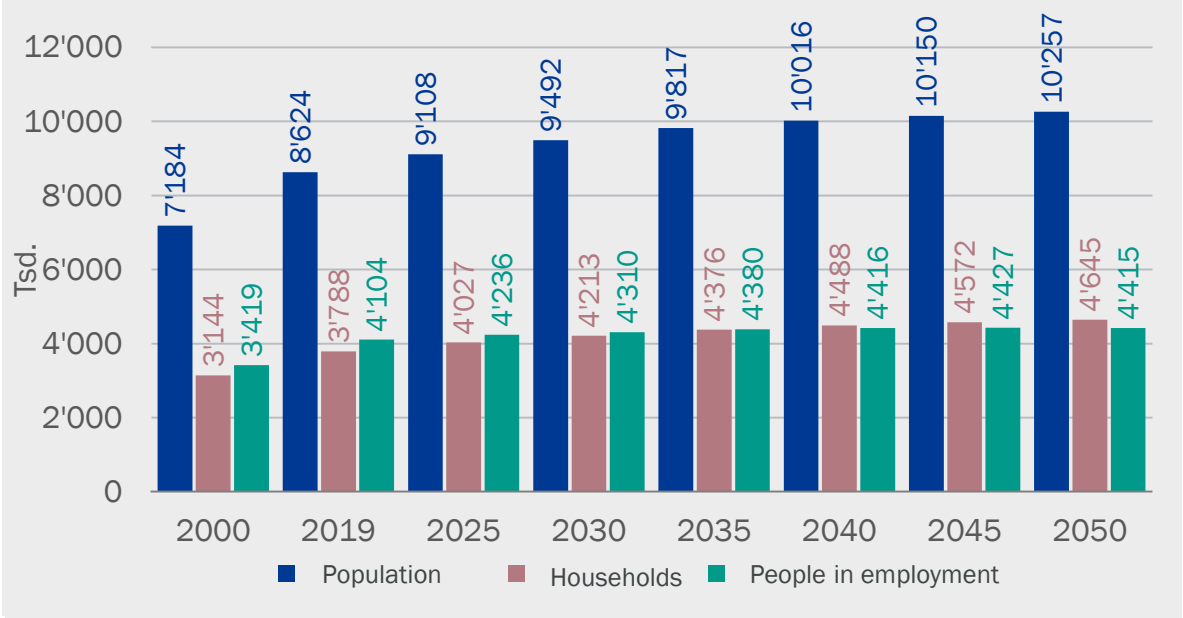
ENERGY PERSPECTIVES 2050+
FRAMEWORK DATA

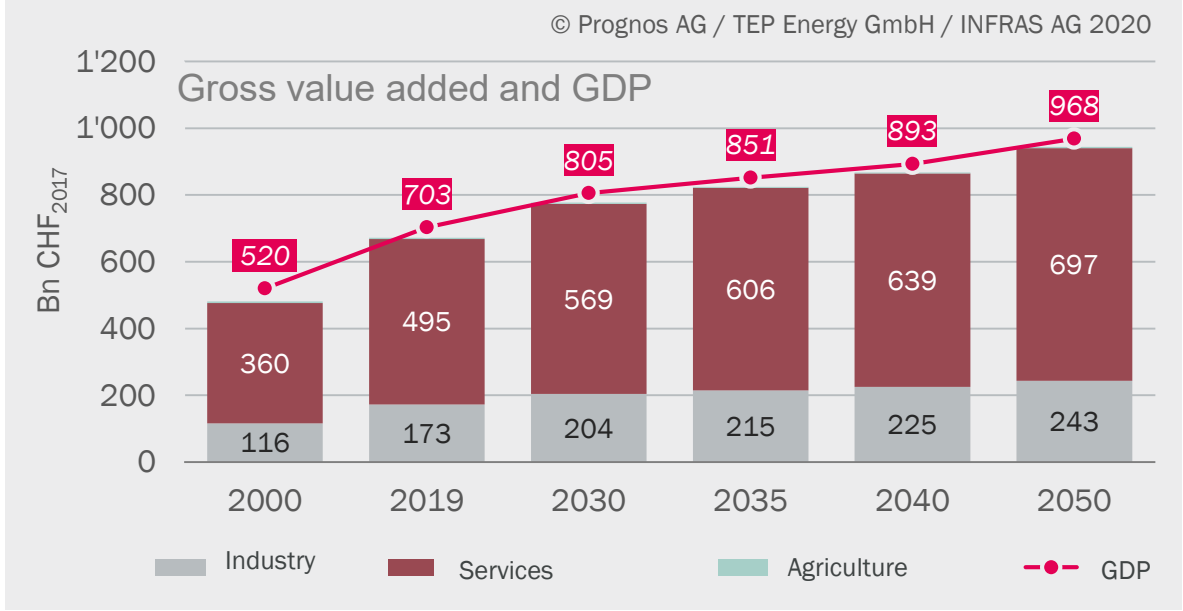
Continuous growth

- Population grows to over 10 million
- Heated area increases by 17%
- Number of people in employment increases by 8%.
- GDP rises by 8%

Development of the framework data is based on other federal perspective studies

→ these are not part of EP2050+
(population / households: FSO 2015 / 2017, GDP: SECO 2018)

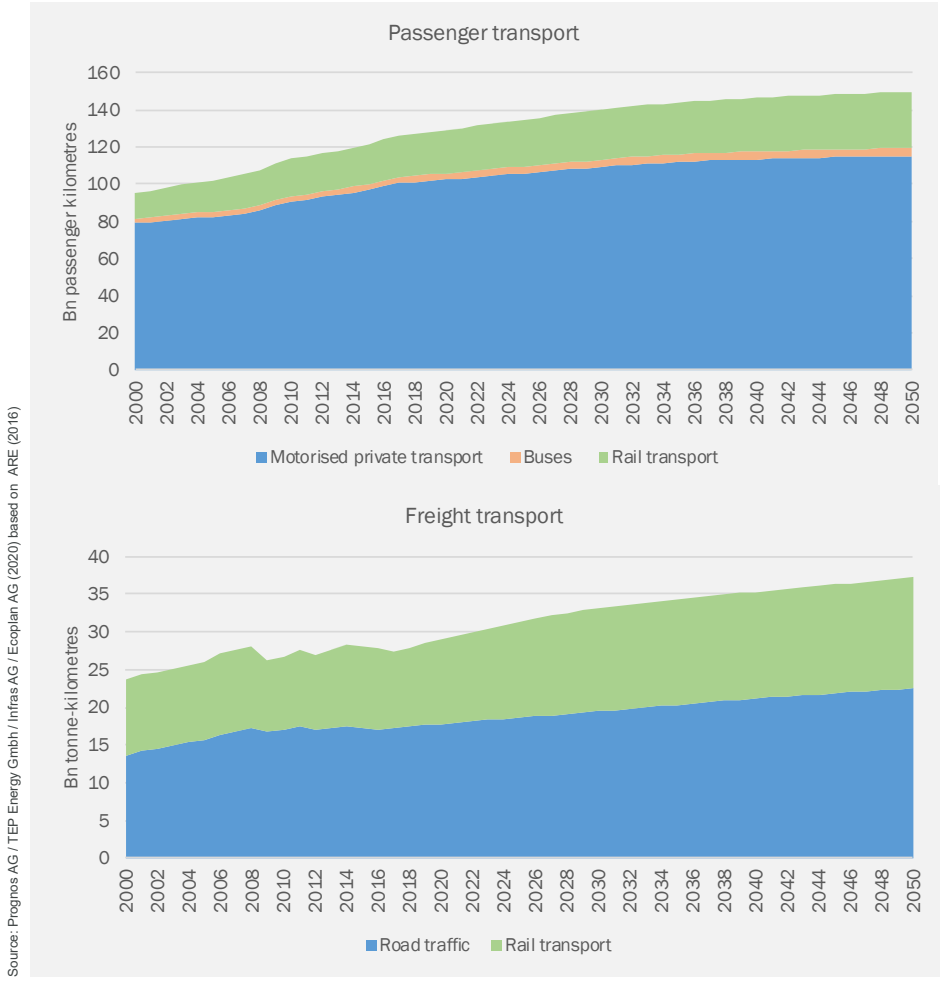




Source: Prognos AG / TEP Energy Gmbh / Infras AG / Ecoplan AG (2020)

ENERGY PERSPECTIVES 2050+
FRAMEWORK DATA TRANSPORT SECTOR

- All scenarios are based on traffic performance from the Reference scenario of the Transport Outlook 2040 (ARE 2016).
- Significant increase in passenger and freight transport performance on road and rail between 2017 and 2050
- No additional modal split change in scenario ZERO in favour of rail transport
- No sufficiency considerations in scenario ZERO (such as shorter/less journeys, abandonment of journeys, smaller vehicles,…).



Increase 2017-2050

+36.4%

+32.5%

+14.3%

+45.7%

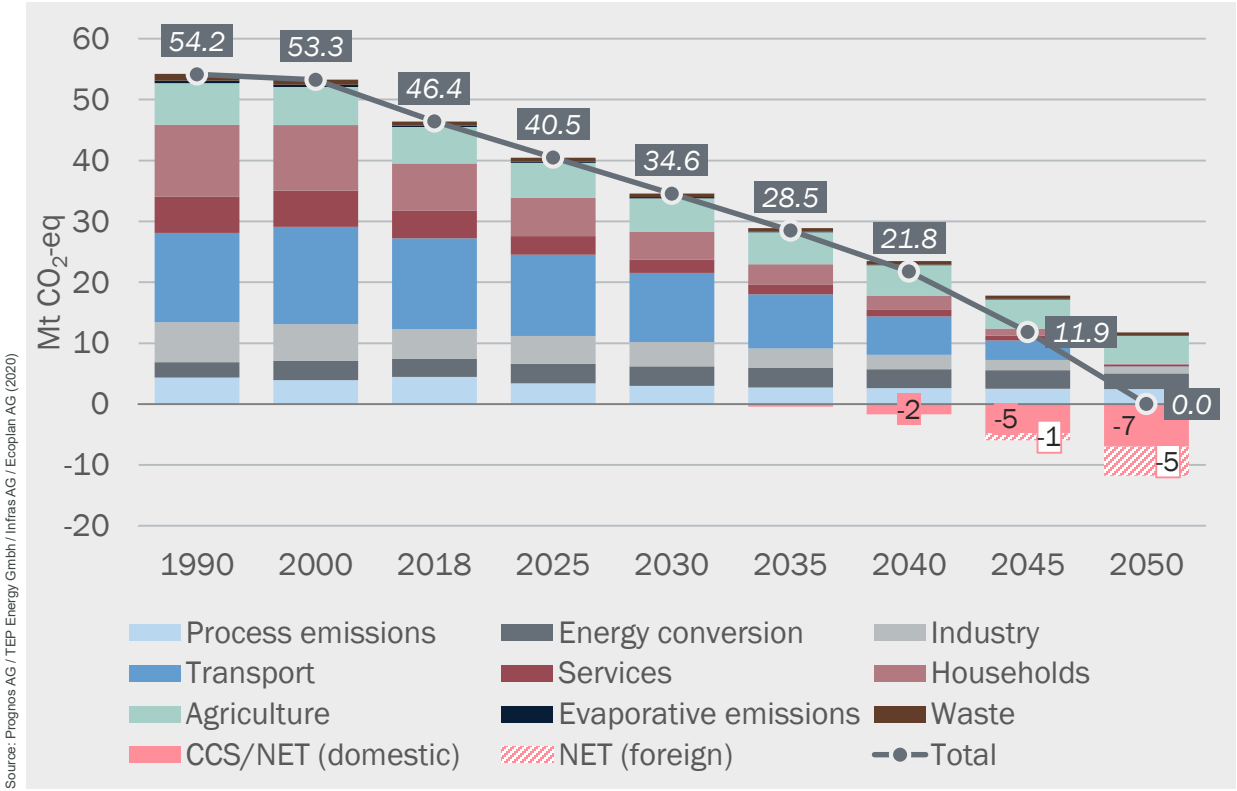
+30.6%

ENERGY PERSPECTIVES 2050+
GREENHOUSE GAS EMISSIONS

Net zero greenhouse gas emissions 2050:

- Net zero target is achievable
- In 2050, around 12 million tonnes of unavoidable residual CO_2-equivalent emissions
- Mainly in the following areas:
  - Agriculture
  - Industrial Processes (including cement)
  - Waste treatment (incineration plants)
- Application of CCS/NET necessary so that balanced zero can be achieved

Greenhouse gas emissions & CCS/NET



Source: Prognos AG / TEP Energy Gmbh / Infras AG / Ecoplan AG (2020)

Scenario ZERO Basis

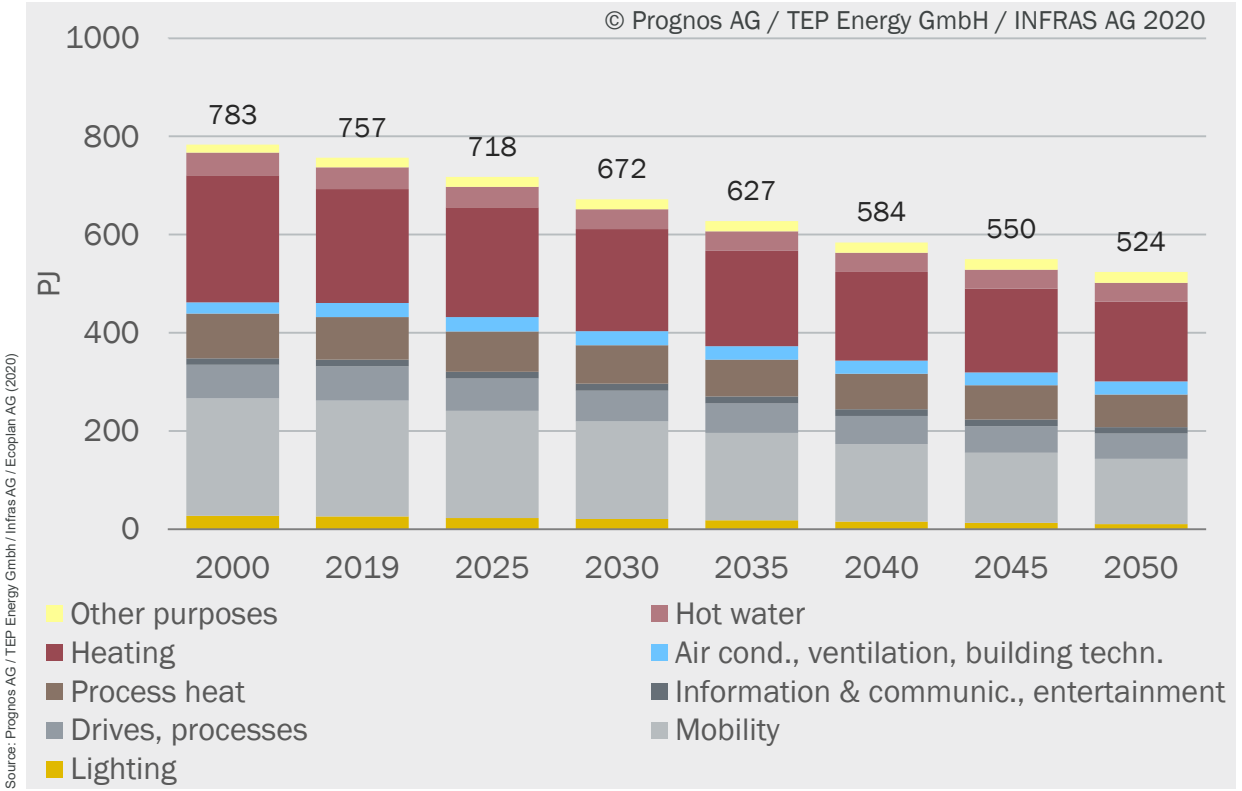
Strategic variant «even annual import-export balance 2050», lifetime NPP 50 years

ENERGY PERSPECTIVES 2050+
FINAL ENERGY CONSUMPTION

Development 2019 to 2050:

- Total: -31% (BAU -19%),
  additional saving versus BAU 92 PJ
- Strong reductions in:
  - Lightning -60%, BAU -51%
  - Heating -30%, BAU -22%
  - Mobility -44%, BAU -32%
- Heating and mobility remain the segments with the highest consumption
- Consumption in all segments decreasing, except “other uses”
  (collective group with electrical applications)

Final energy consumption by purposes



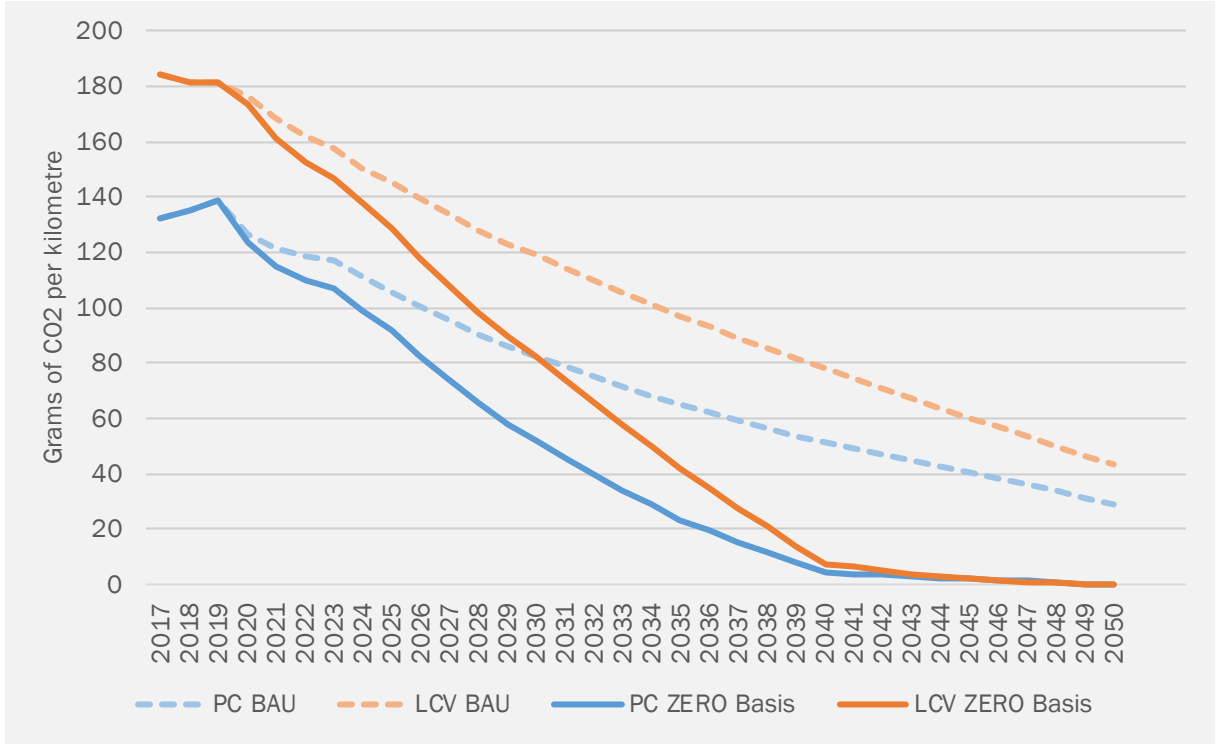
Scenario ZERO Basis

ENERGY PERSPECTIVES 2050+
CO_2 EMISSIONS OF NEW CARS

- To achieve the net-zero target, CO_2 emissions of new vehicles must already fall to practically zero in 2040 (vehicles in circulation for approx. 10 years).
- Ambitious efficiency increases are assumed for vehicles with combustion engines
- It is assumed that CO_2 emissions targets for new cars will be achieved by 2025 (95g per km for passenger cars; PC) and 2023 (147g per km for light commercial vehicles, LCV)
- After reaching these targets, CO_2 regulations for new vehicles in the EU must be significantly undercut
- For heavy commercial vehicles (HCV), ambitious efficiency increases are assumed

→ CO_2 emissions of new cars drive fleet and fuel composition

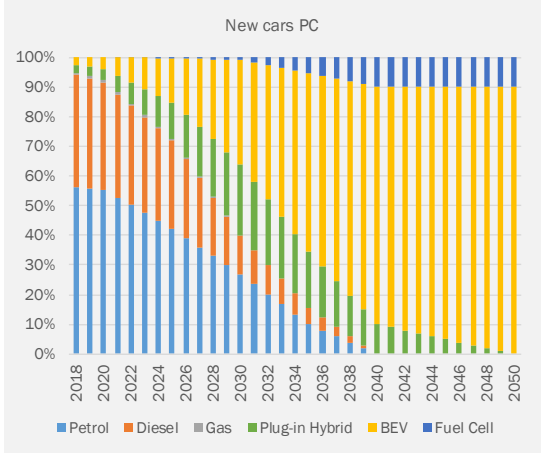
CO_2 emissions of new cars

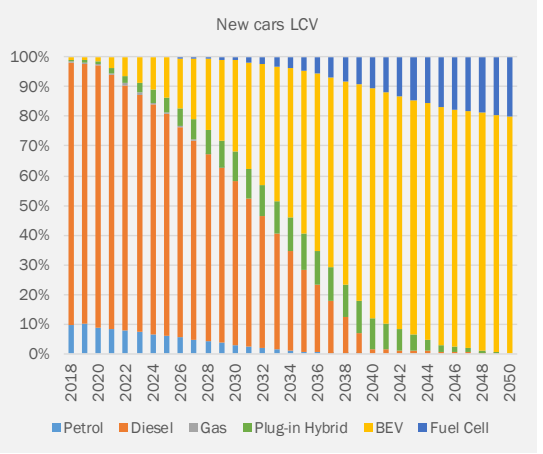


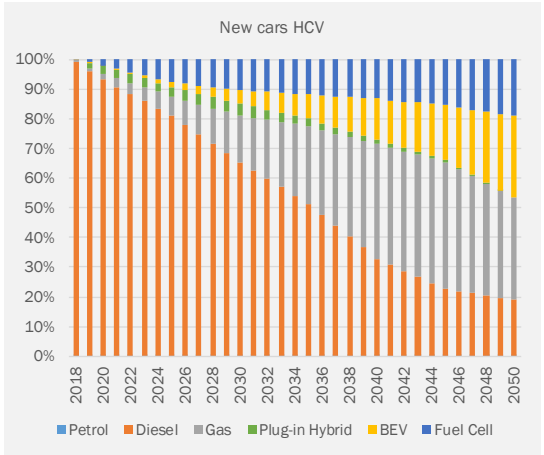
Source: Prognos AG / TEP Energy Gmbh / Infras AG / Ecoplan AG (2020)

ENERGY PERSPECTIVES 2050+
DEVELOPMENT OF NEW CAR FLEET

- In 2050, new PCs and LCVs will be 100% Battery Electric Vehicles (BEV) and Fuel Cell Electric Vehicles (FCEV) (compared to 63% for PCs and 64% for LCVs in BAU)
- Plug-in hybrid electric vehicles (PHEV), which will enter the market in the mid term, will remain in the system for a long time
- Fuel cells and Gas vehicles play an important role in the decarbonisation of heavy commercial vehicles (HCV)
- Lighter HCVs will be electrified
- The heaviest HCVs with diesel engines remain in the system for a long time







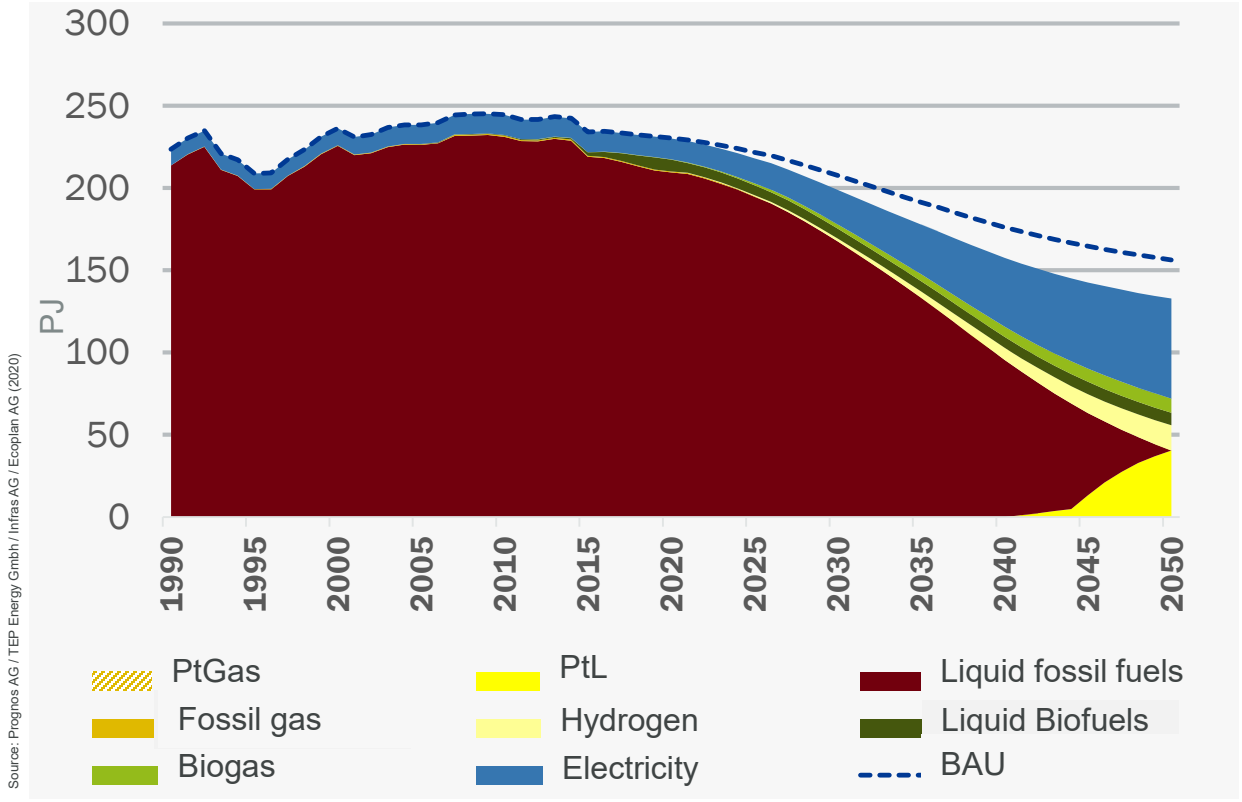
Source: Prognos AG / TEP Energy Gmbh / Infras A›leichterenG / Ecoplan AG (2020)

Scenario ZERO Basis

ENERGY PERSPECTIVES 2050+
FINAL ENERGY CONSUMPTION IN TRANSPORT

- In ZERO Basis, final energy consumption of domestic transport in 2050 is 15.2% lower compared to BAU
- Fossil fuels are completely avoided in the transport sector
- Electricity is becoming the central energy source in mobility
- Electricity-based fuels (PtL and PtH_2) are necessary to achieve the net zero target
- Limited potential of liquid and gaseous biofuels. Use only where necessary, mainly for heavy commercial vehicles

Final energy demand of domestic transport

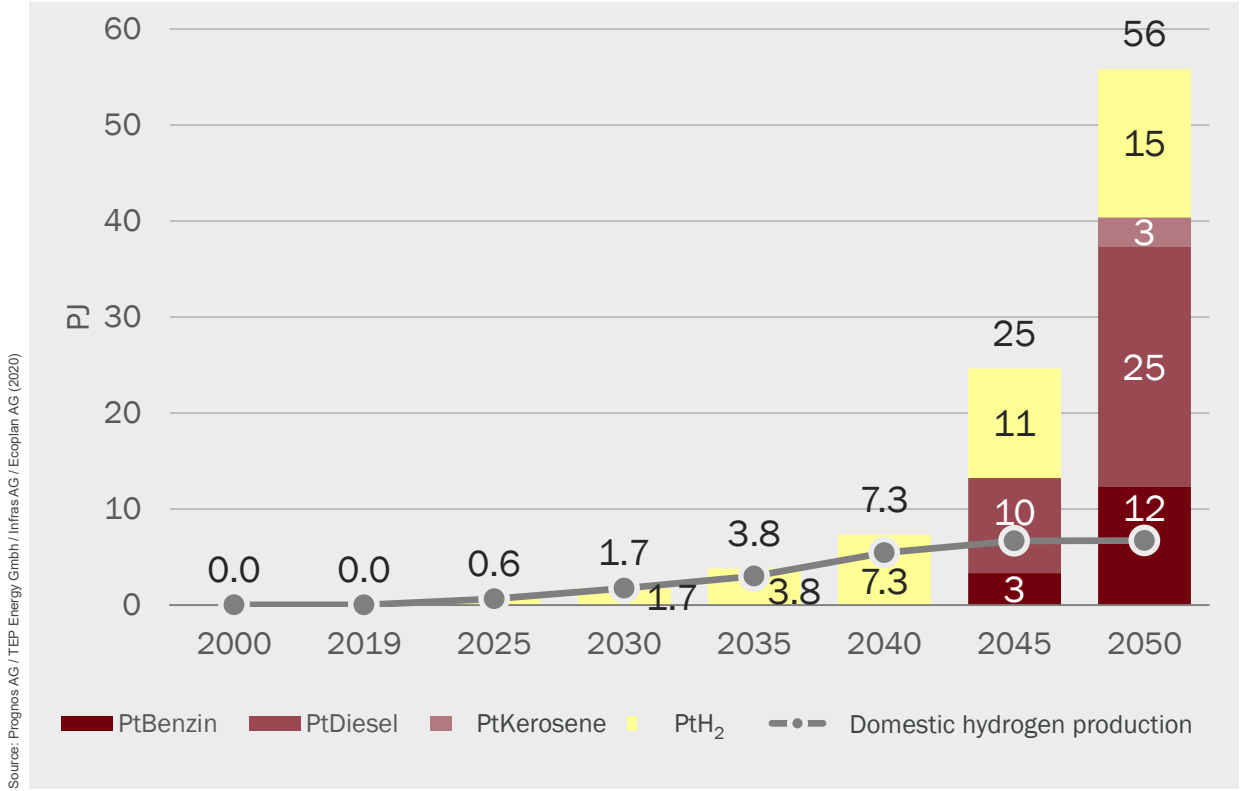


Scenario ZERO Basis
(excluding international aviation)

ENERGY PERSPECTIVES 2050+
ELECTRICITY-BASED ENERGY SOURCES (PtX)

Consumption of PtX and domestic production of H_2

- Use of PtL and hydrogen from 2040, especially in the transport sector
- PtL is completely imported due to cost advantages and higher foreign potentials
- Only hydrogen will partly be produced domestically
- International aviation would demand an additional 59 PJ of PtL



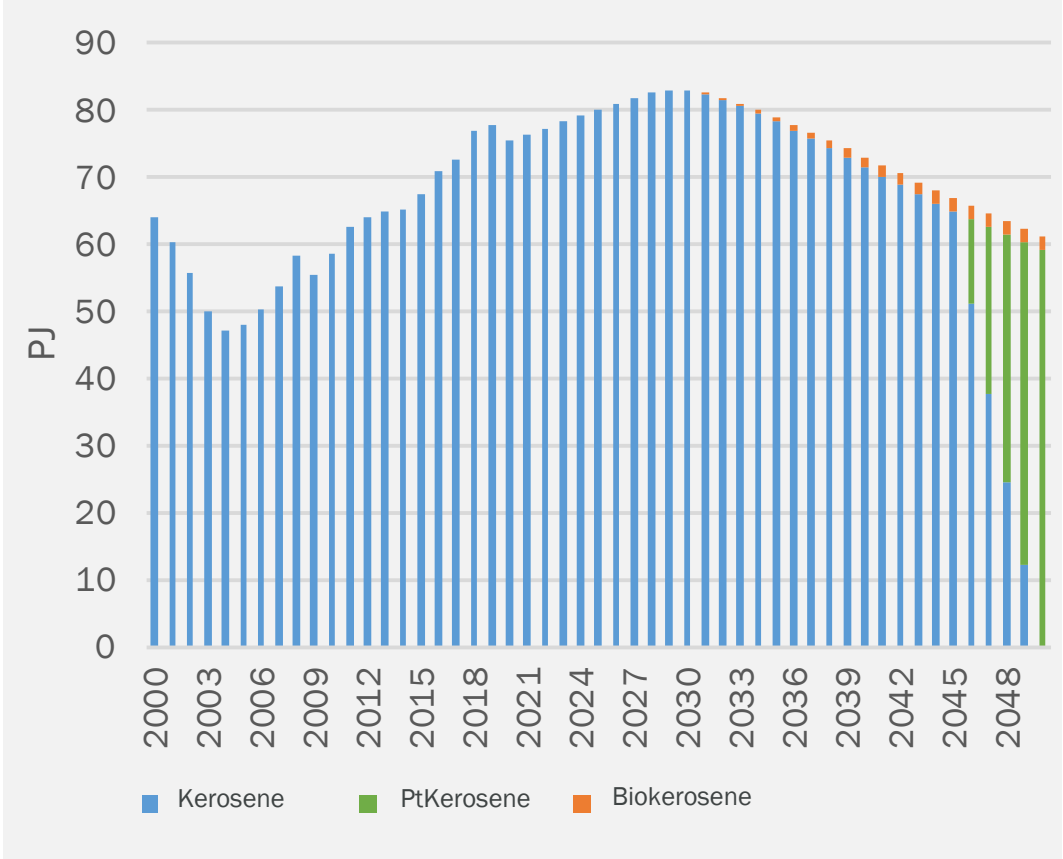
Scenario ZERO Basis

Strategic variant «even annual import-export balance 2050», lifetime NPP 50 years (excluding international aviation)

ENERGY PERSPECTIVES 2050+
INTERNATIONAL AVIATION

- International air traffic is not included in the net zero target
- However emissions from international aviation are reduced in line with the net zero target through significant efficiency improvements (2% per year) and the use of large quantities of PtL
- H_2 and/or electrification are hardly an option for international long-haul flights
- Competition with other sectors for biofuels

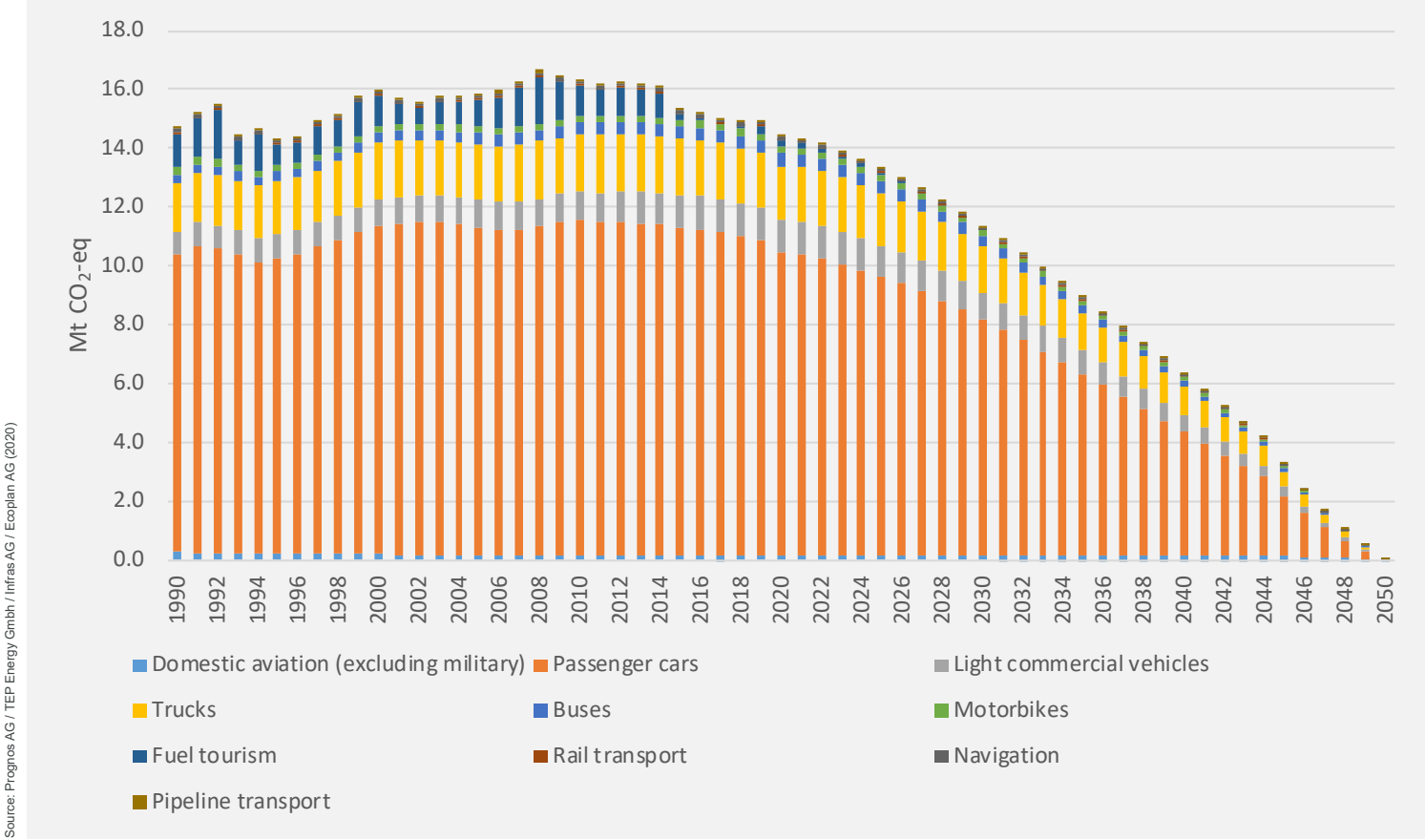
Final energy consumption of international aviation



Source: Prognos AG / TEP Energy GmbH / Infras AG / Ecoplan AG (2020)

ENERGY PERSPECTIVES 2050+
GREENHOUSE GAS EMISSIONS TRANSPORT

Greenhouse gas emissions from domestic transport



Source: Prognos AG / TEP Energy Gmbh / Infras AG / Ecoplan AG (2020)

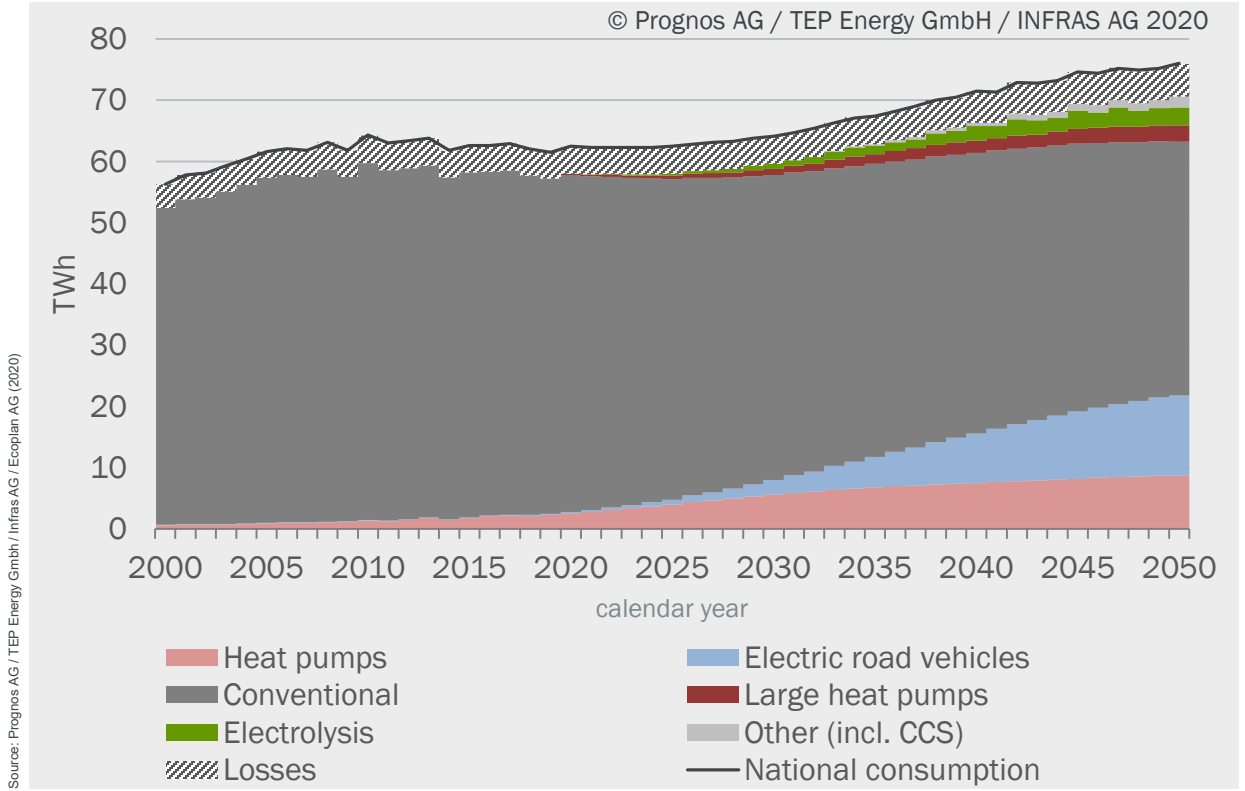
Scenario ZERO Basis (excluding international aviation)

ENERGY PERSPECTIVES 2050+
ELECTRICITY CONSUMPTION

National electricity consumption:

- Increase in national consumption by around 24 % by 2050
- Main drivers:
  - Electric vehicles (road transport) (13 TWh)
  - Heat pumps (9 TWh)
  - H_2 electrolysis (3 TWh)
  - CCS / NET (2 TWh)
- The increase is damped by efficiency: decrease in conventional electricity consumption

National consumption by application



Scenario ZERO Basis

Strategic variant «even annual import-export balance 2050», lifetime NPP 50 years

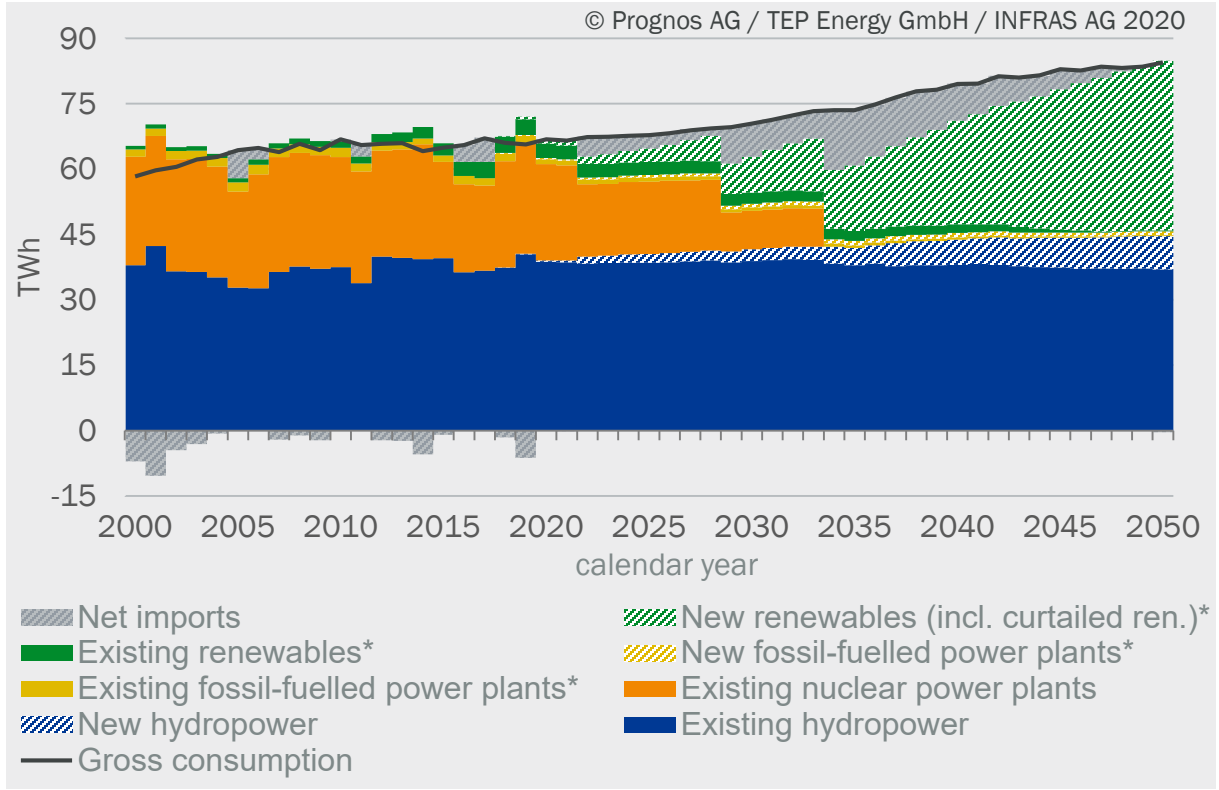
ENERGY PERSPECTIVES 2050+
ELECTRICITY SUPPLY

Electricity supply system:

Up to 2050, Swiss electricity supply sourced by hydropower and renewable energy, temporarily supplemented by electricity imports.

- Increase in total consumption (including storage pumps) to 84 TWh in 2050.
- Sharp increase in domestic electricity generation through renewable energy and hydropower.
- Net imports balanced by 2050 after withdrawal form nuclear energy.
- Flexibility plays an important role

Annual electricity generation by technology



Source: Prognos AG / TEP Energy Gmbh / Infras AG / Ecoplan AG (2020)

Scenario ZERO Basis

Strategic variant «even annual import-export balance 2050», lifetime NPP 50 years

(* coupled and uncoupled)

EP 2050+
COSTS

Accumulated figures 2020 to 2050:

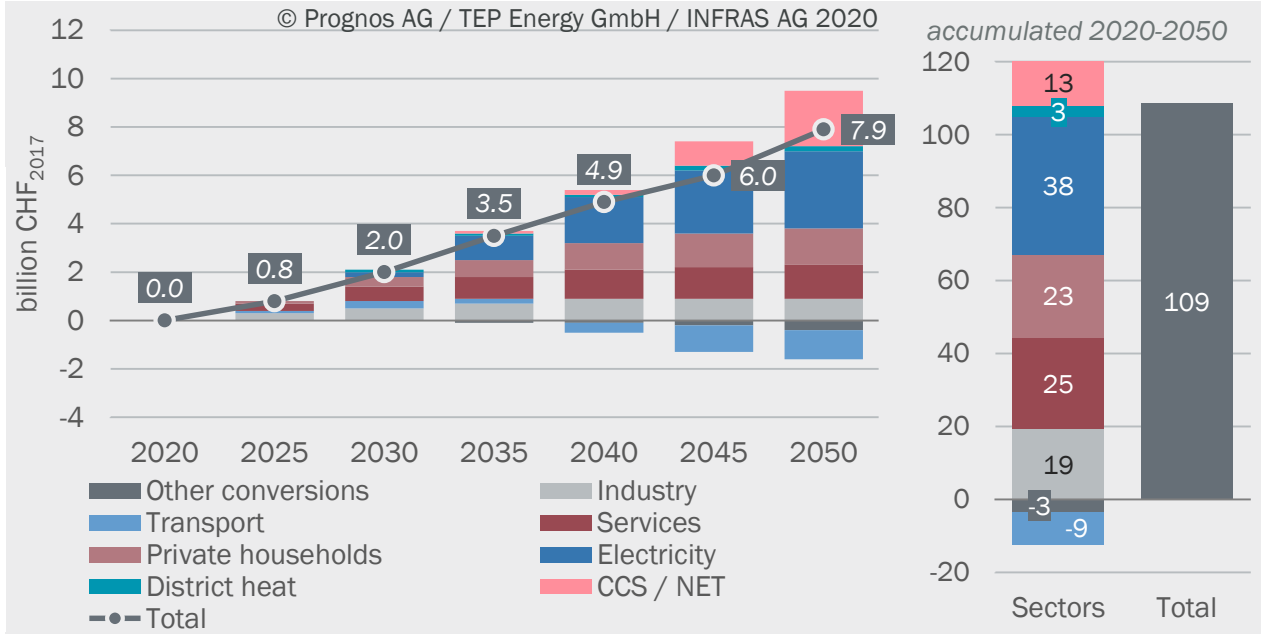
- Total additional costs of 73 billion CHF* compared to BAU, of which
  - annualised investments: 109 billion CHF
  - maintenance costs: 14 billion CHF
  - saved energy costs: -50 billion CHF
- Additional investments of 109 billion CHF means an increase of 8% compared to the existing investments in the energy system of 1’400 billion CHF
- Average annual additional costs (2020 to 2050): 2.4 billion CHF/yr

* CHF in real terms at 2017 prices

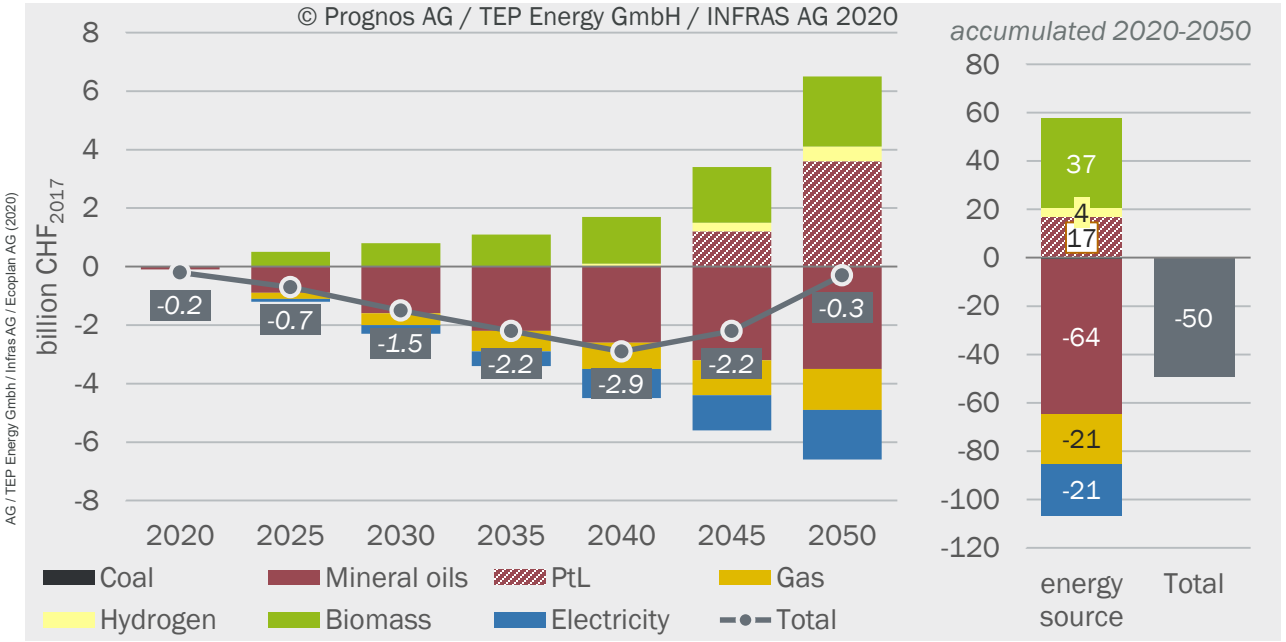
Scenario ZERO Basis

Strategic variant «even annual import-export balance 2050», lifetime NPP 50 years

annualised difference investments



saved energy costs



CONCLUSION 1/2
GREENHOUSE GAS EMISSIONS

Reducing greenhouse gas emissions to net zero by 2050 is possible with technologies known today, but the pressure to act is high.

- Energy-related greenhouse gas emissions in the household, services, industry and transport sectors can be almost completely avoided by 2050.
- Residual emissions of around 12 million tonnes remain mainly from agriculture, thermal utilisation of waste and industrial processes. These make the use of carbon capture and storage and negative emission technologies necessary both at home and abroad.
- Due to the long investment cycles in the energy system, the pressure to act is high. Measures with great depth of intervention must be implemented quickly in all sectors.

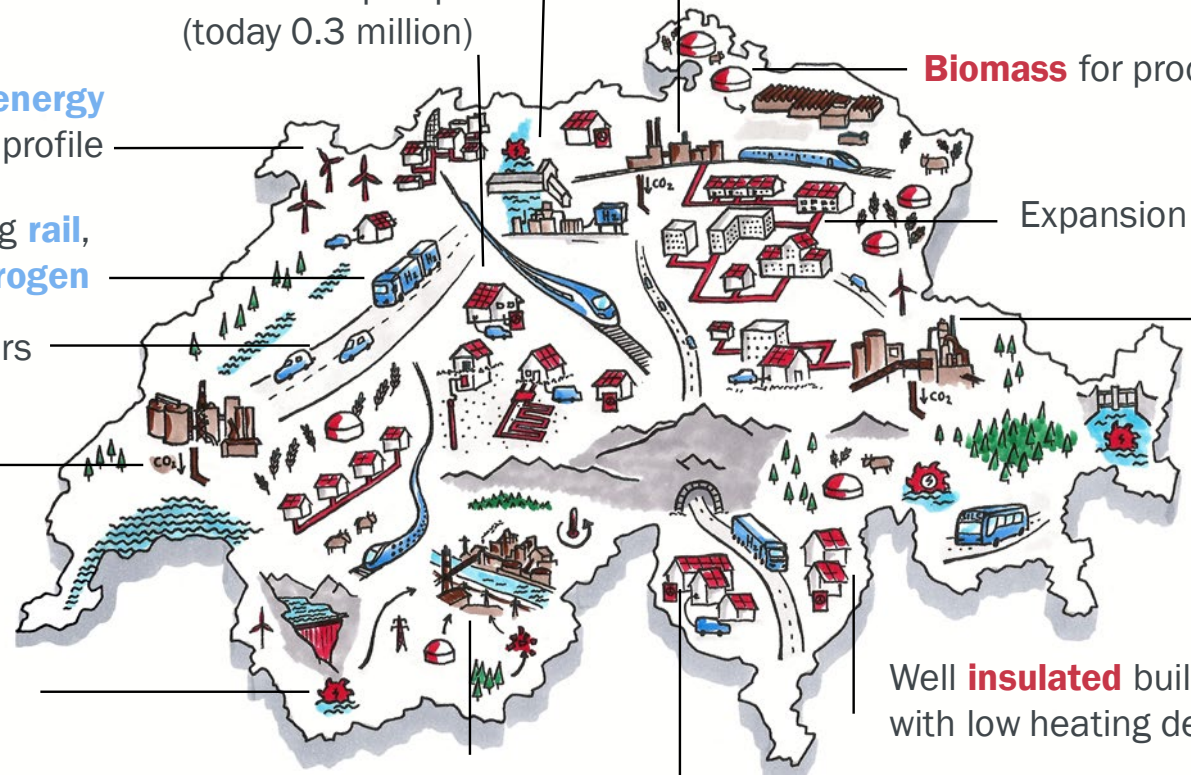
CONCLUSION 2/2
TRANSPORT SECTOR

E-Mobility and electricity-based fuels in the transport sector

The transport sector is currently the largest emitter of GHG emissions and therefore plays a central role in achieving GHG targets.

- The share of battery electric vehicles must grow rapidly in all vehicle categories. In 2050, the stock of battery electric cars will be around 3.6 million vehicles.
- In the long term, hydrogen and biofuels will play an important role in heavy goods transport alongside battery electric vehicles. Hydrogen is partly produced domestically.
- In addition, electricity-based fuels (PtL and PtH_2) are needed to reduce GHG emissions to zero. However, the consequences of this are high energy costs and lower overall energy efficiency.
- Rail transport can play an important role in reducing energy consumption, CO_2 emissions and the demand of PtX and biofuels

CLIMATE-NEUTRAL SWITZERLAND IN 2050



Hydrogen production at run-of-river sites (7 PJ)

1.5 million heat pumps (today 0.3 million)

Wind and **geothermal energy** with attractive generation profile

Heavy vehicles using **rail**, **bioenergy** and **hydrogen**

3.6 million battery-powered cars

Negative emission technologies: storage in Switzerland (3 Mt CO_2 pa)

45 TWh from hydropower (53% of production)

Waste incineration with **CCS** (3.6 Mt CO_2 pa)

Biomass for process heat

Expansion of **heat grids** in urban areas

Cement and chemical plants with **CCS** (2.9 Mt CO2 pa)

Well **insulated** buildings with low heating demands

High levels of **efficiency** in industrial processes

34 TWh from PV systems, 40% of production (today 2 TWh)

Graphics: Dina Tschumi; Prognos AG