STATUS AND PERSPECTIVES OF LIQUID ENERGY SOURCES IN THE ENERGY TRANSITION

for MWV, IWO, MEW and UNITI
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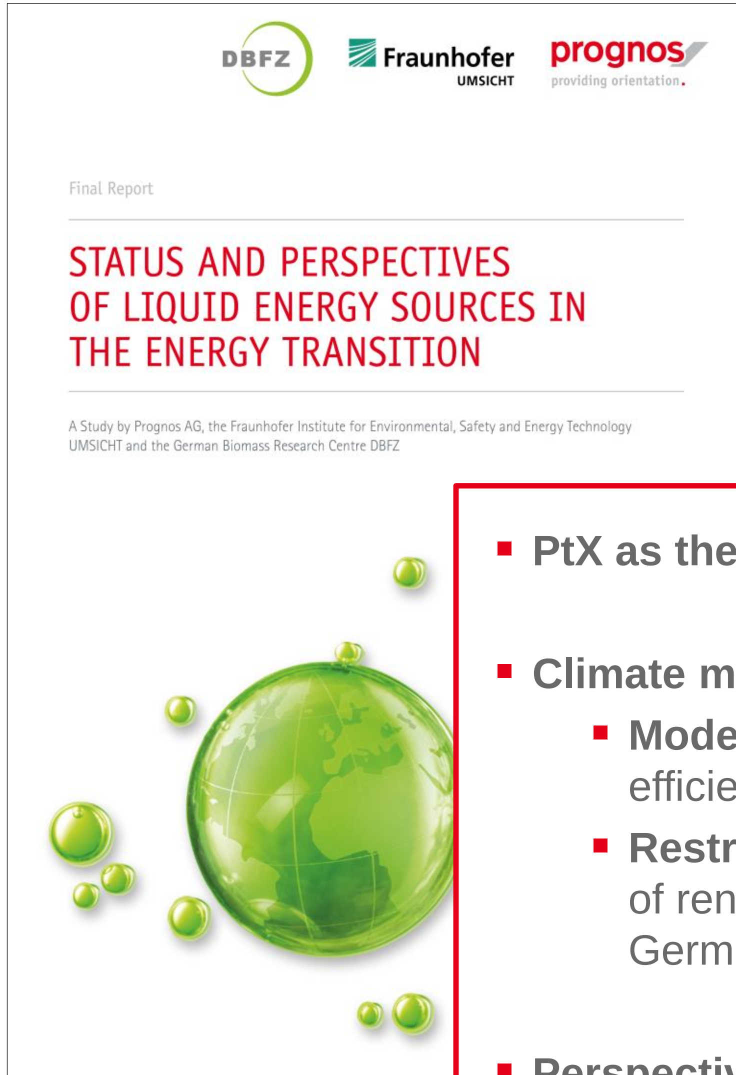
Another report on the energy transition?



- **PtX as the key solution**
- **Climate mitigation scenarios**
  - **Moderate increase** of energy efficiency
  - **Restrictions** for further expansion of renewable Energies in Germany
- **Perspective of the consumer**

Agenda

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Mineral oil is the most important primary energy source, approx. 60 % of the mineral oil is used in transport

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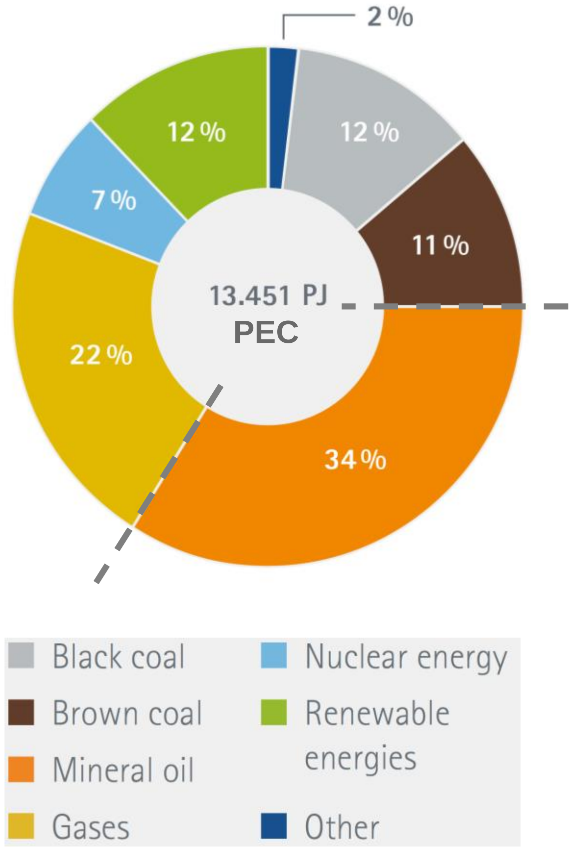
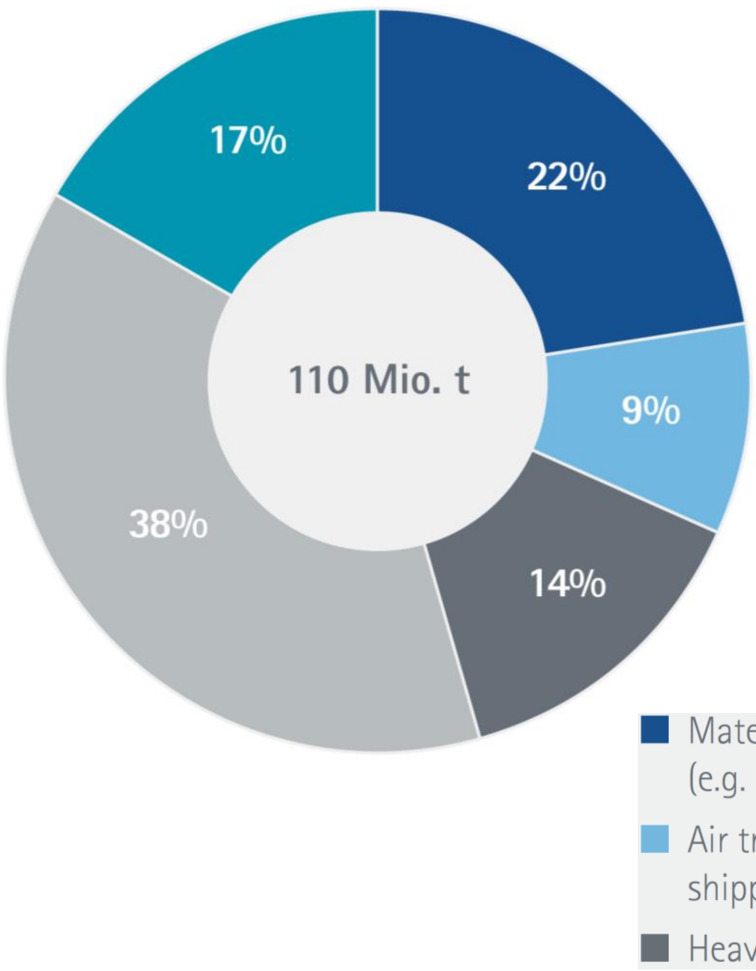
Primary Energy Consumption in Germany in 2016



Sales of Mineral Oil Products in 2016 in Germany

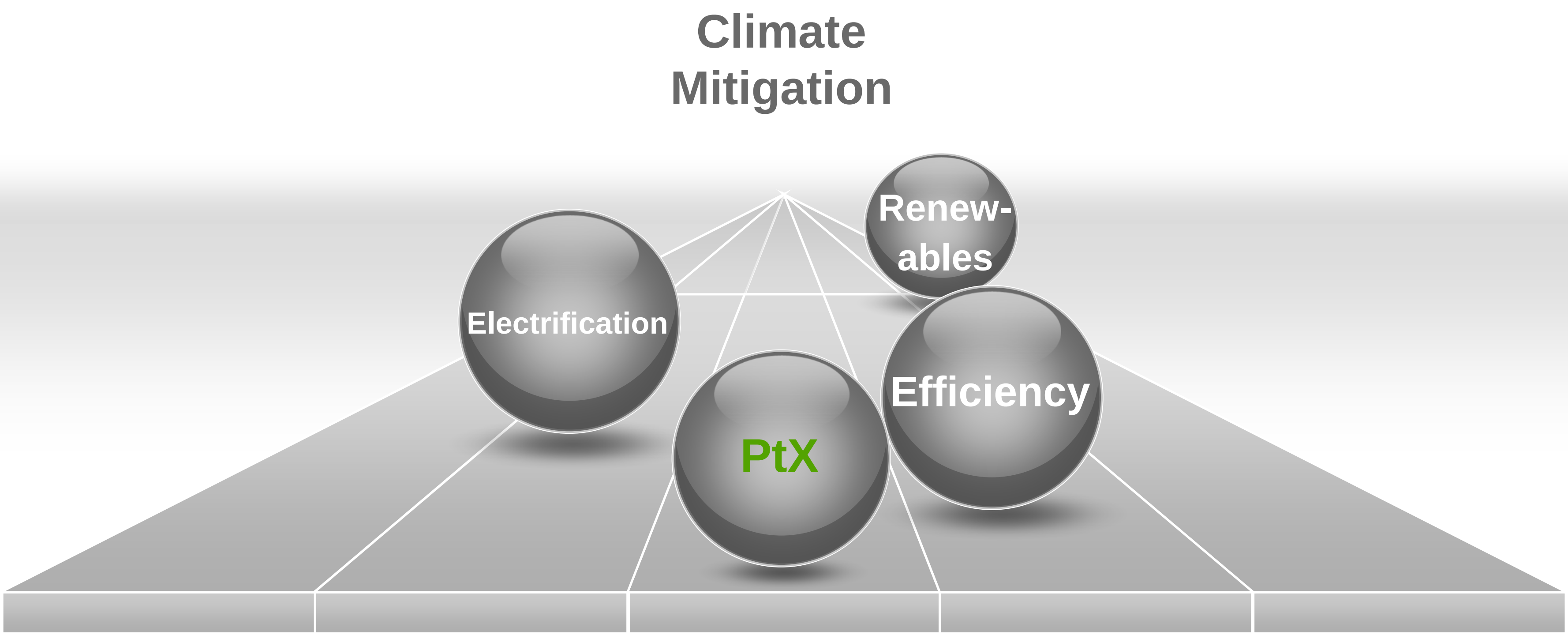


Sales of liquid Biofuels (2016 in Germany)

Agenda

01	Status of Liquid Energy Sources in the German Supply of Energy and Raw Materials
02	Prospect of Greenhouse Gas Neutral Synthetic Fuels
03	Perspective of the Consumer
04	Scenarios of the German Energy System until 2050
05	Economic Classification
06	Conclusions and Options for Action

Central thesis:
PtX completes the set of climate mitigation options



In the future GHG-neutral liquid energy sources will also be produced from renewable electricity

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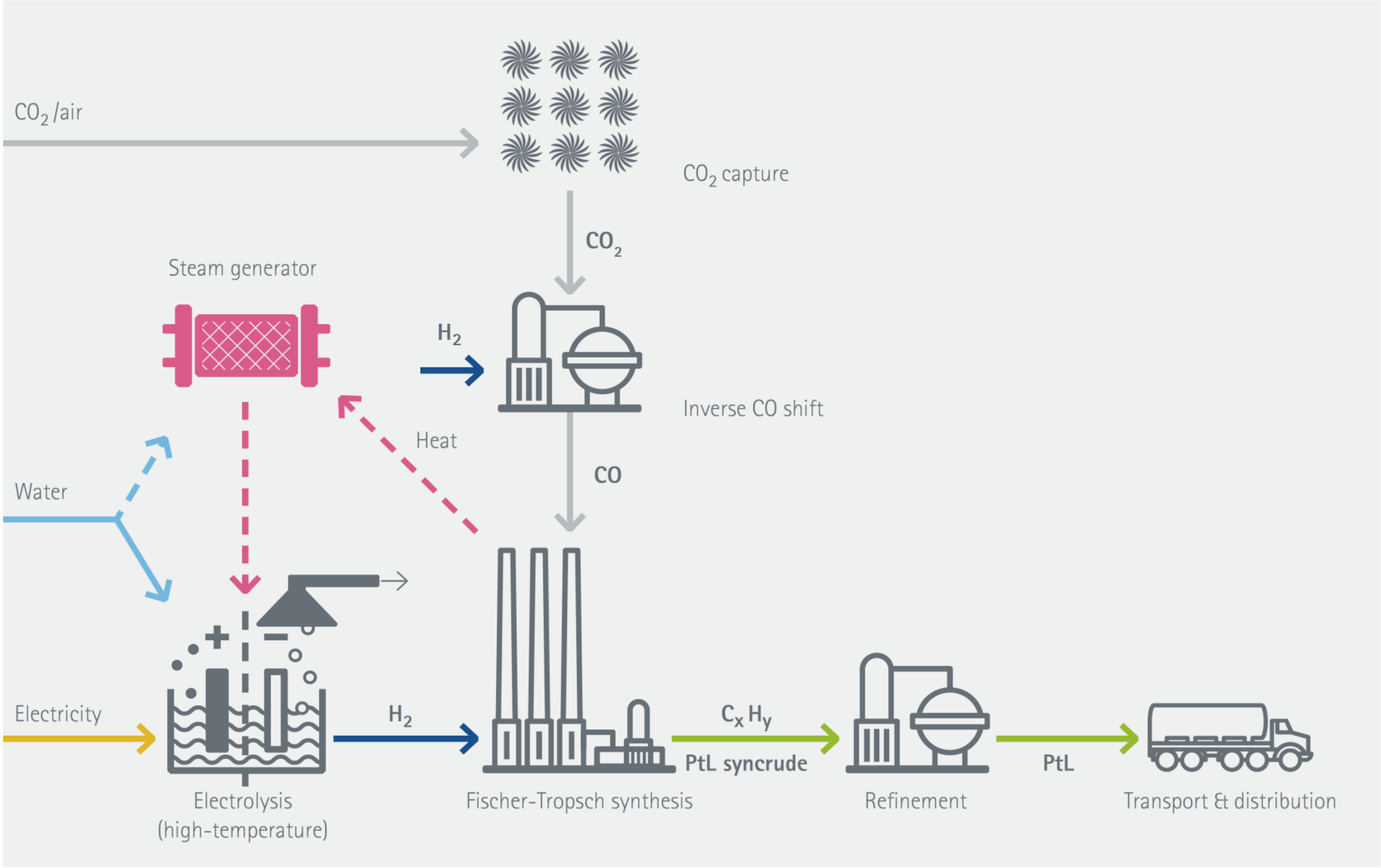
Schematic Diagram of the Fischer-Tropsch Process



Prerequisites for Power-to-Liquid production

- Low cost renewable electricity production
- In particular: wind and photovoltaic energy
- Land surface, technology
- Capital, stable overall conditions
- Advantage for countries with existing oil- and gas infrastructure

→ Investigated regions for production in this study:
MENA* und Kazakhstan

→ Distance < 5000 km

* MENA: Middle-East and North Africa

In 2050 PtL can be produced at costs of 1,33 €/litre (at an interest rate 7 %)

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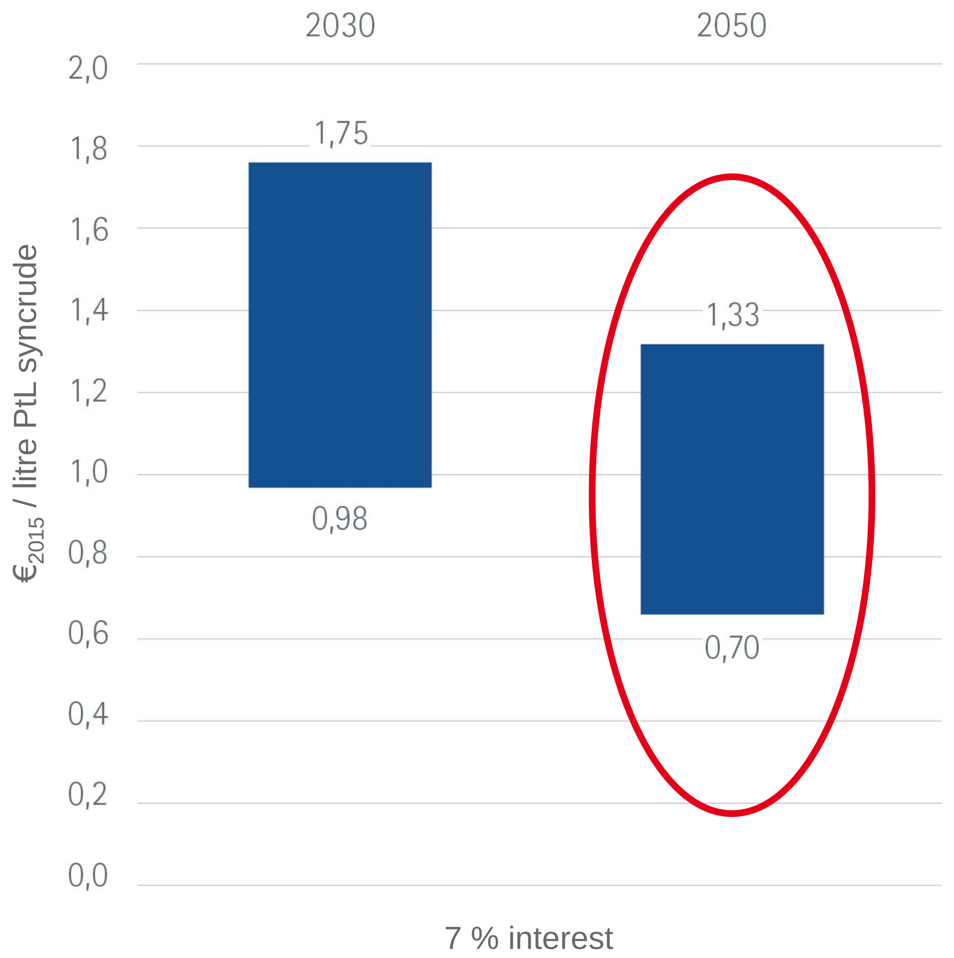
Range for Production Cost of PtL by Fischer-Tropsch Process



PtL: As with any new technology there are risks and chances

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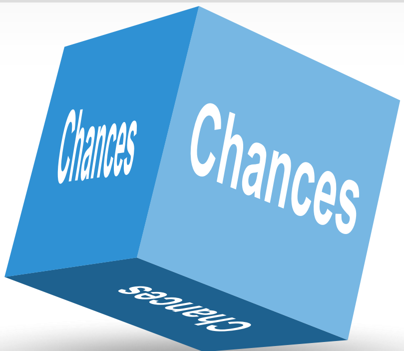
Chances

- Additional option for climate mitigation
- Utilisation of existing infrastructure
- Existing end user applications can be used
- Option for worlwide trade of renewable energy
- Countries of origin can profit from exports

Risks / Challenges

- Very young technology
- Actual costs are uncertain
- High cost degression for production cost will only be achieved if applied in many countries
- Acceptance is also needed in foreign countries
- Investment security in production regions



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The perspective of the consumer

What are Consumer Preferences in the Fields of Application Domestic Heating and Mobility?

Usage

Environment

Economic Efficiency

Comparison of different Technologies

Oil-fired central Heating	⟷	Electric Heat Pump
Internal Combustion Engine	⟷	Battery Electric Vehicle

Consumer‘s perspective: example domestic heating in 2050

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2050		Building type	SFH/DFH/RH	MFH
Utilisation		Space requirement inside the building	Electricity advantage (minor)	Electricity advantage (minor)
		Space requirement outside the building	Liquid advantage (minor)	Liquid advantage (major)
		Space requirement heating element	Liquid advantage (minor)	Liquid advantage (minor)
		Maintenance workload	Electricity advantage (minor)	Electricity advantage (minor)
		Possibili		
		Cost ris		
Economic efficiency with PtL	1.3	Cost of procurement	Liquid advantage (major)	Liquid advantage (major)
		Running cost	Electricity advantage (major)	Electricity advantage (major)
		Total cost	Electricity advantage (major)	Electricity advantage (major)
	0.7	Cost of procurement	Liquid advantage (major)	Liquid advantage (major)
		Running cost	Electricity advantage (minor)	Electricity advantage (minor)
		Total cost	Liquid advantage (minor)	Liquid advantage (minor)
Environment		GHG emissions	Neutral	Neutral
		Air pollution emissions	Electricity advantage (minor)	Electricity advantage (minor)
		Noise emissions	Liquid advantage (minor)	Liquid advantage (minor)

- Electricity advantage (major)
- Electricity advantage (minor)
- Neutral
- Liquid advantage (major)
- Liquid advantage (minor)

Source: Prognos AG

Consumer‘s perspective: example mobility in 2050

2050	Mobility	Passenger car [km/day] <50	Passenger car [km/day] >200	LCV ca. 100	HCV >200
Usage	New European Driving Cycle (NEDC)	Neutral	Liquid advantage (minor)	Neutral	Liquid advantage (minor)
	Robustness of range	Neutral	Liquid advantage (major)	Liquid advantage (minor)	Liquid advantage (major)
	Refuelling time	Liquid advantage (minor)	Liquid advantage (major)	Liquid advantage (minor)	Liquid advantage (major)
	Refuelling infrastucture (city/countryside)	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)
	Degradation (cyclic ageing, calendar ageing)	Neutral	Neutral	Neutral	Liquid advantage (minor)
	Driving dynamics (acceleration, maximum speed)	Electricity advantage (minor)	Neutral	Electricity advantage (minor)	Neutral
	Maintenance	Neutral	Neutral	Neutral	Liquid advantage (minor)
Economic efficiency	Cost of procurement	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)
	Resale value	Neutral	Neutral	Neutral	Neutral
	Maintenance	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)
	Running cost	Electricity advantage (major)	Electricity advantage (major)	Electricity advantage (major)	Electricity advantage (major)
	Total cost (PtL 0.7 and PtL 1.3)	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)
	GHG emissions	Neutral	Electricity advantage (minor)	Electricity advantage (minor)	Neutral
Environment	Air pollution emissions: local emissions (tank to wheel)	Neutral	Neutral	Neutral	Neutral
	Noise emissions	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)	Electricity advantage (minor)
	Resource consumption (manufacturing and disposal)	Electricity advantage (minor)	Neutral	Electricity advantage (minor)	Neutral
	Ressourcenverbrauch (Herstellung und Entsorgung)	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)	Liquid advantage (minor)

Source: Prognos AG

Electricity advantage (major) · Neutral · Liquid advantage (major)

Electricity advantage (minor) · Liquid advantage (minor)

Consumer‘s perspective: The results differ depending on point in time and user

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	Domestic Heating		Mobility	
	2030	2050	2030	2050
Usage				
Economic Efficiency				
Environment				

Liquid advantage

Neutral

Electricity advantage

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Scenarios achieving the GHG emission reduction targets

Parameters and important Assumptions in the Scenario Setting (Input)

	Status 2015	Reference 2050	PtX 80 2050	PtX 95 2050
GHG Emissions in Germany based on 1990	- 28 %	- 60 %	- 80 %	~ - 95 %
Renewable Energies installed capacity [GW]	90	224	230	230
Carbon Capture and Storage (CCS)		Nein	Nein	Ja
Energy Intensity [MJ/€$_{2015}$]	4,8	~ 2,2		
Share of electric heat pumps in heating	3,8 %	14 %		
Share of electric vehicles	~ 0 %	~ 33 %		
Crude oil world market price [$2015/bbl.]	51	115	115	50

In the target scenarios the fossil mineral oils and gases are replaced by GHG-neutral synthetic energy sources

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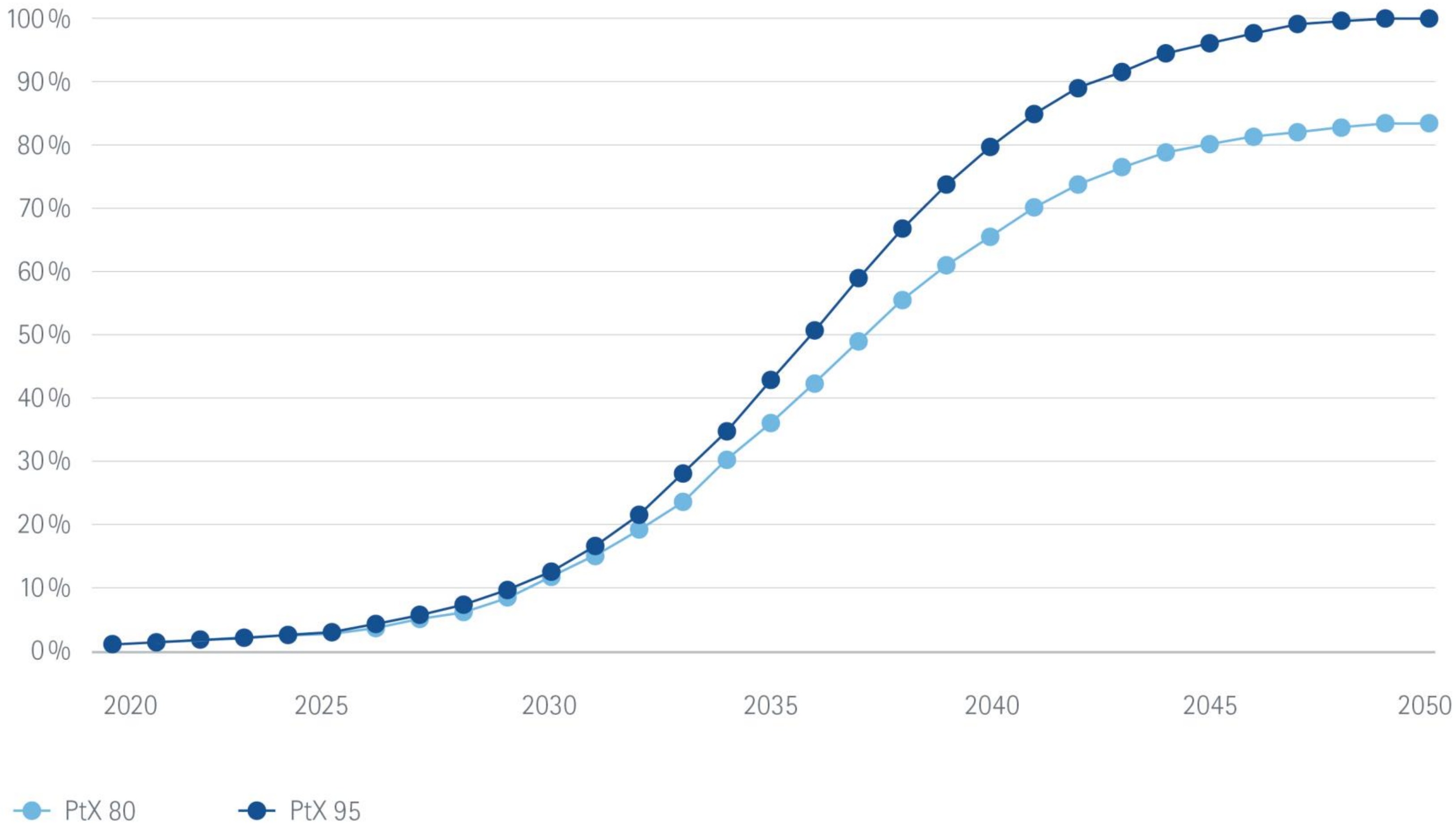
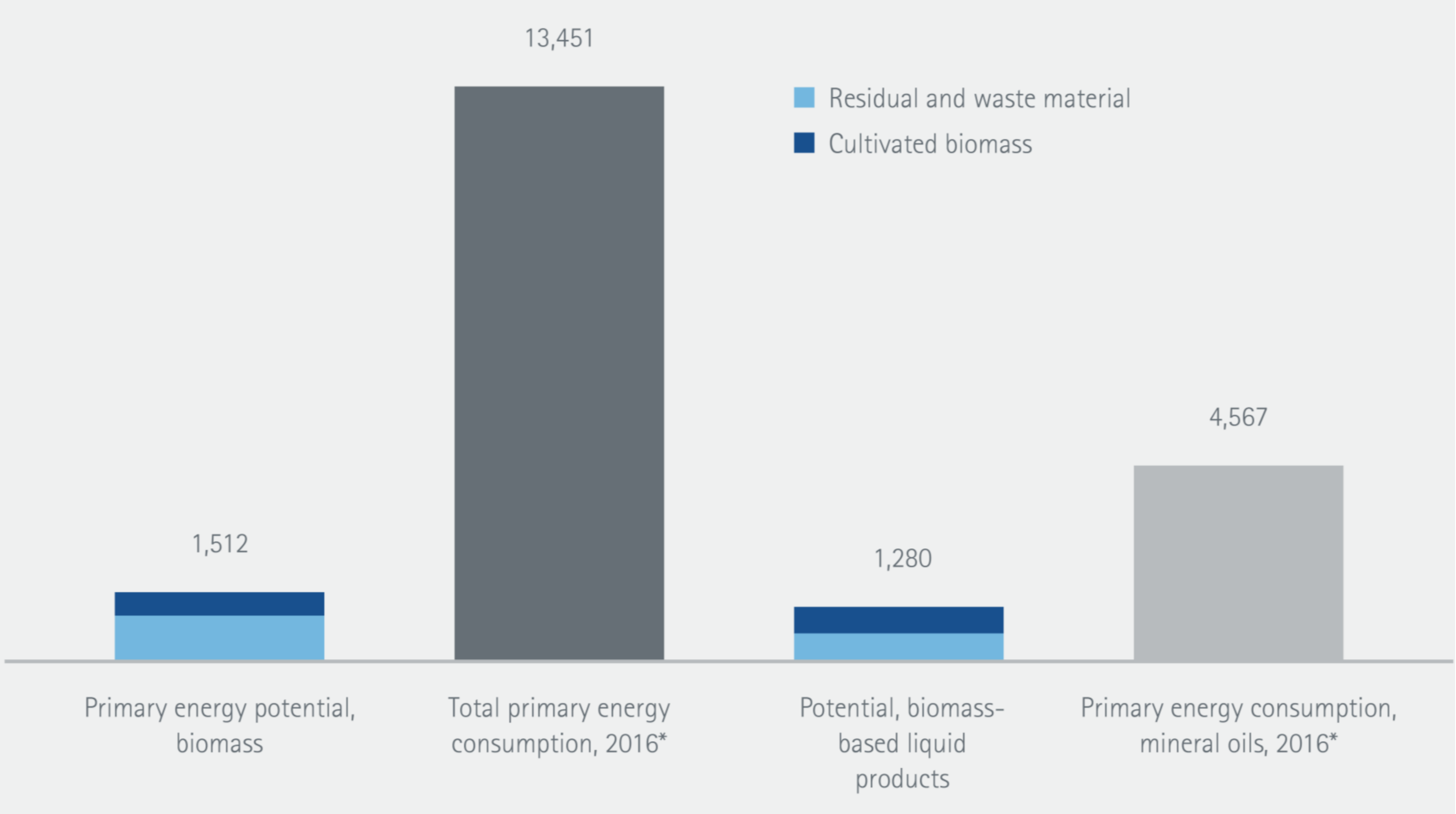
Blending Proportions for synthetic Fuels in the PtX 80 and PtX 95 Scenarios



Energy sources and raw materials based on biomass are limited

Primary Energy Potential and Primary Energy Consumption in PJ



Fossil sources in the primary energy consumption are mainly replaced by PtX and also renewables and biomass

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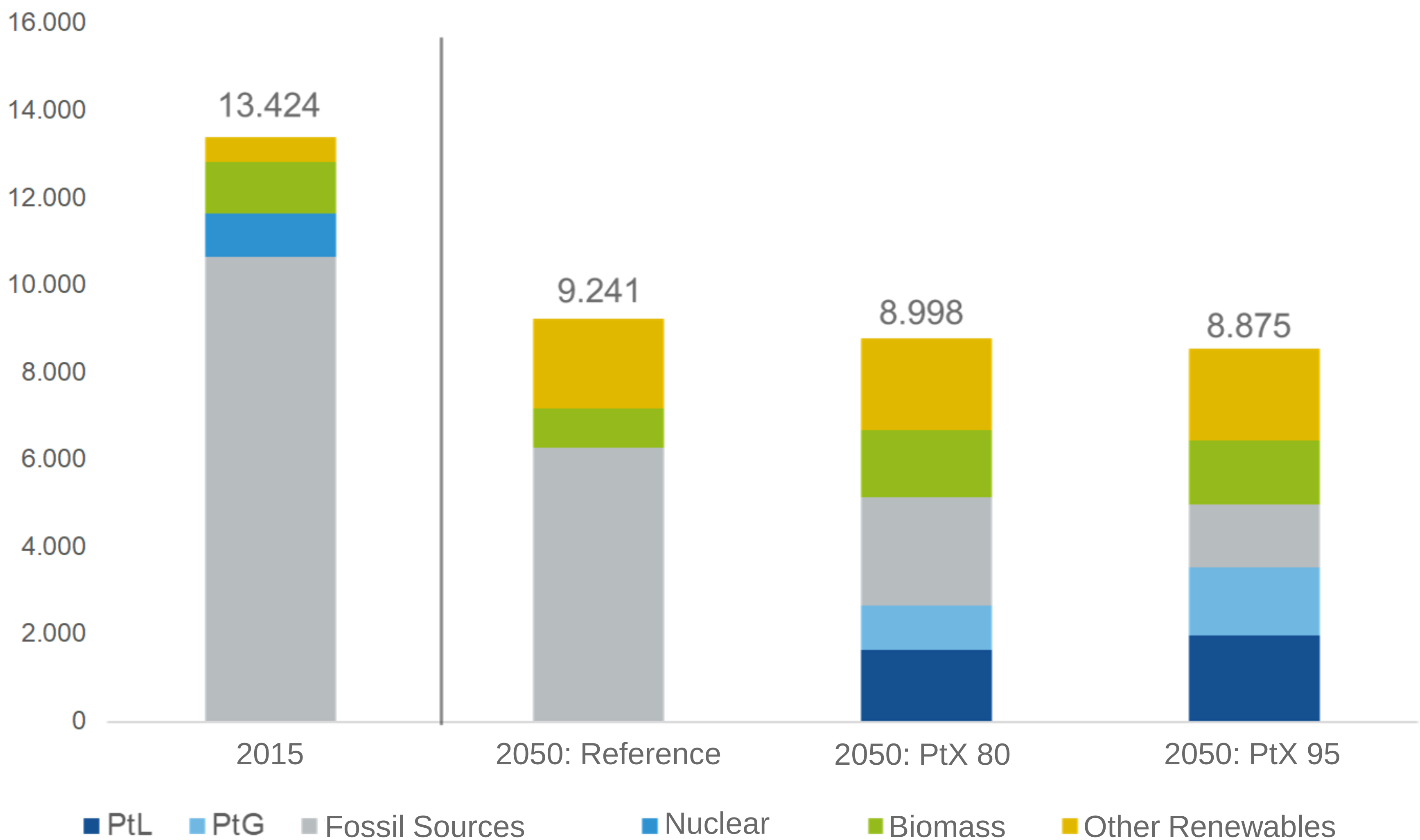
Primary Energy Consumption in PJ by Energy Sources in the Scenarios



The development of the Power-to-Liquid-technology is a no-regret measure for climate-mitigation

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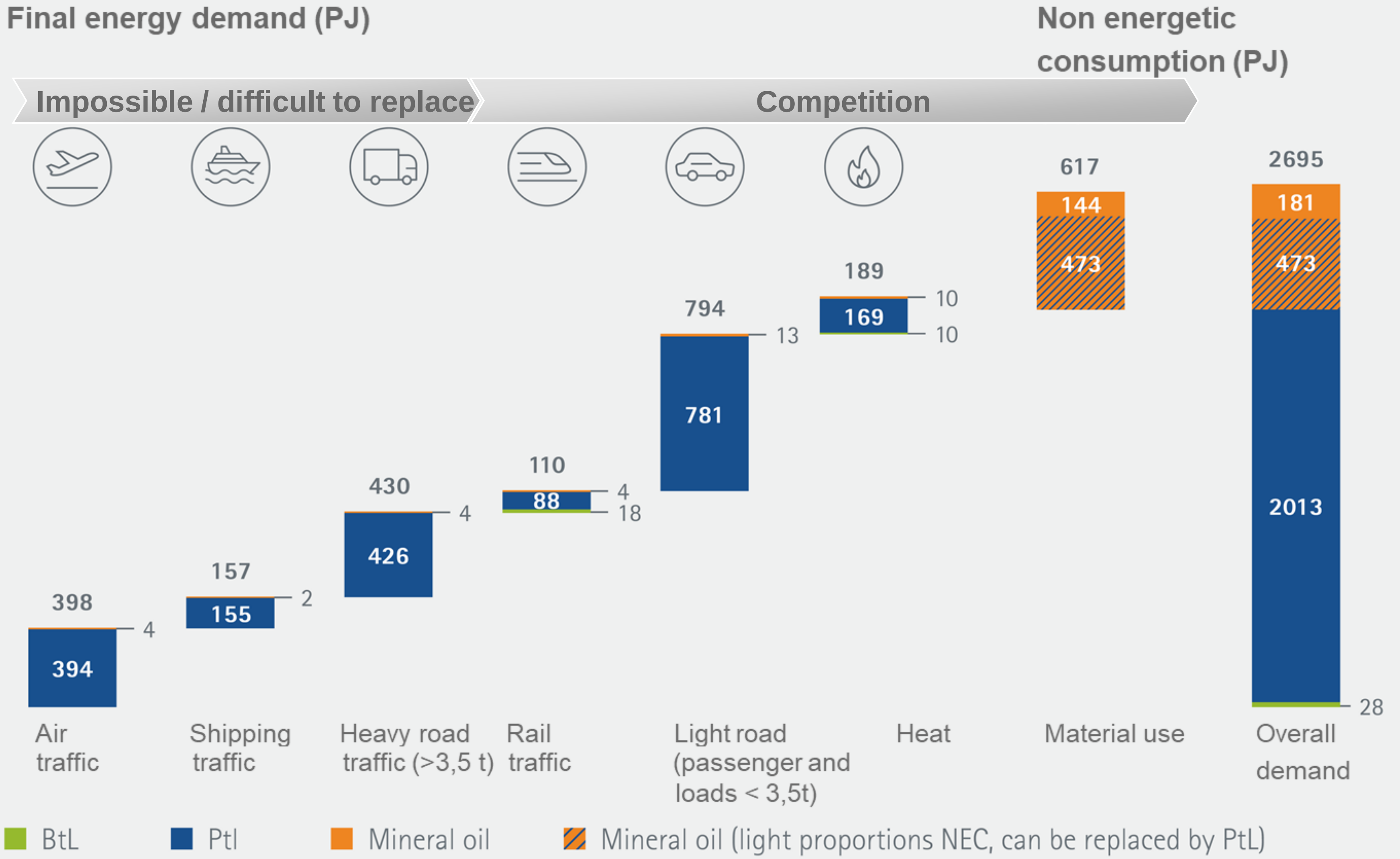
The use of liquid Energy Sources in Germany in 2050 in the PtX 95 Scenario



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In Germany additional costs will arise mainly from energy Imports. Additional domestic investments are low

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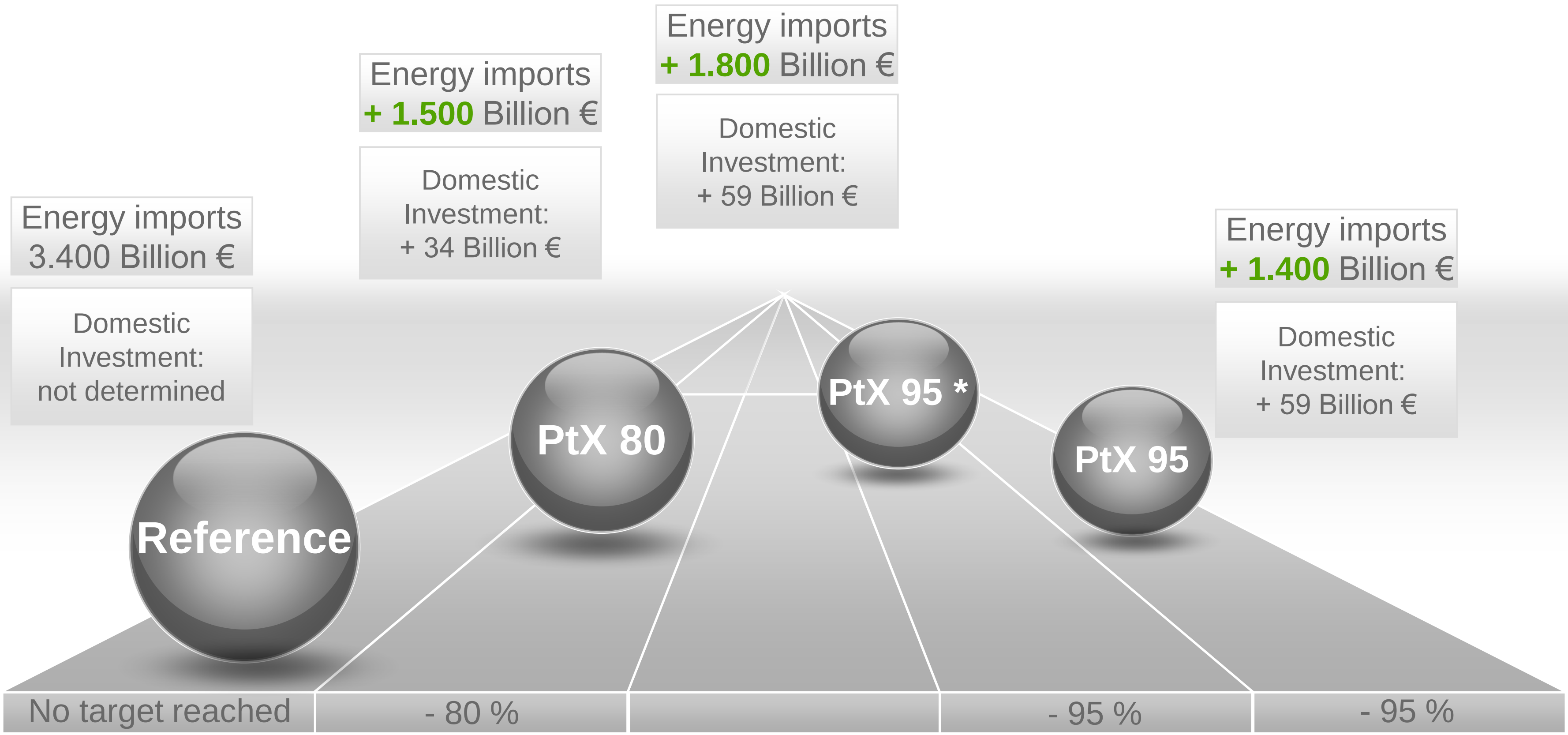
Additional Costs for Energy Imports and Domestic Investments compared to the Reference Scenario



* With the same world market energy prices as in PtX 80

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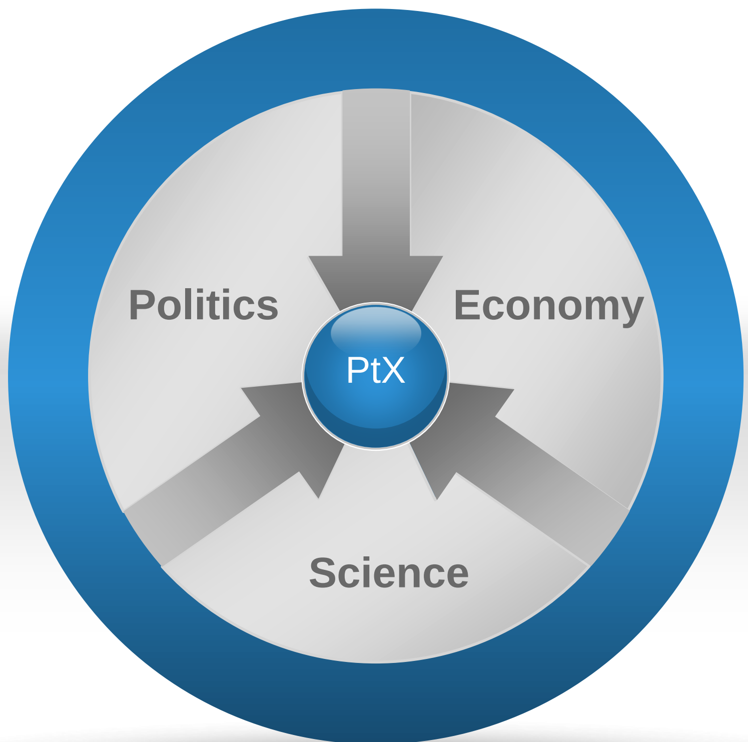
To develop the PtX-option politics, economy and science need to work together



To develop the PtX-option a multi-stage roadmap is needed

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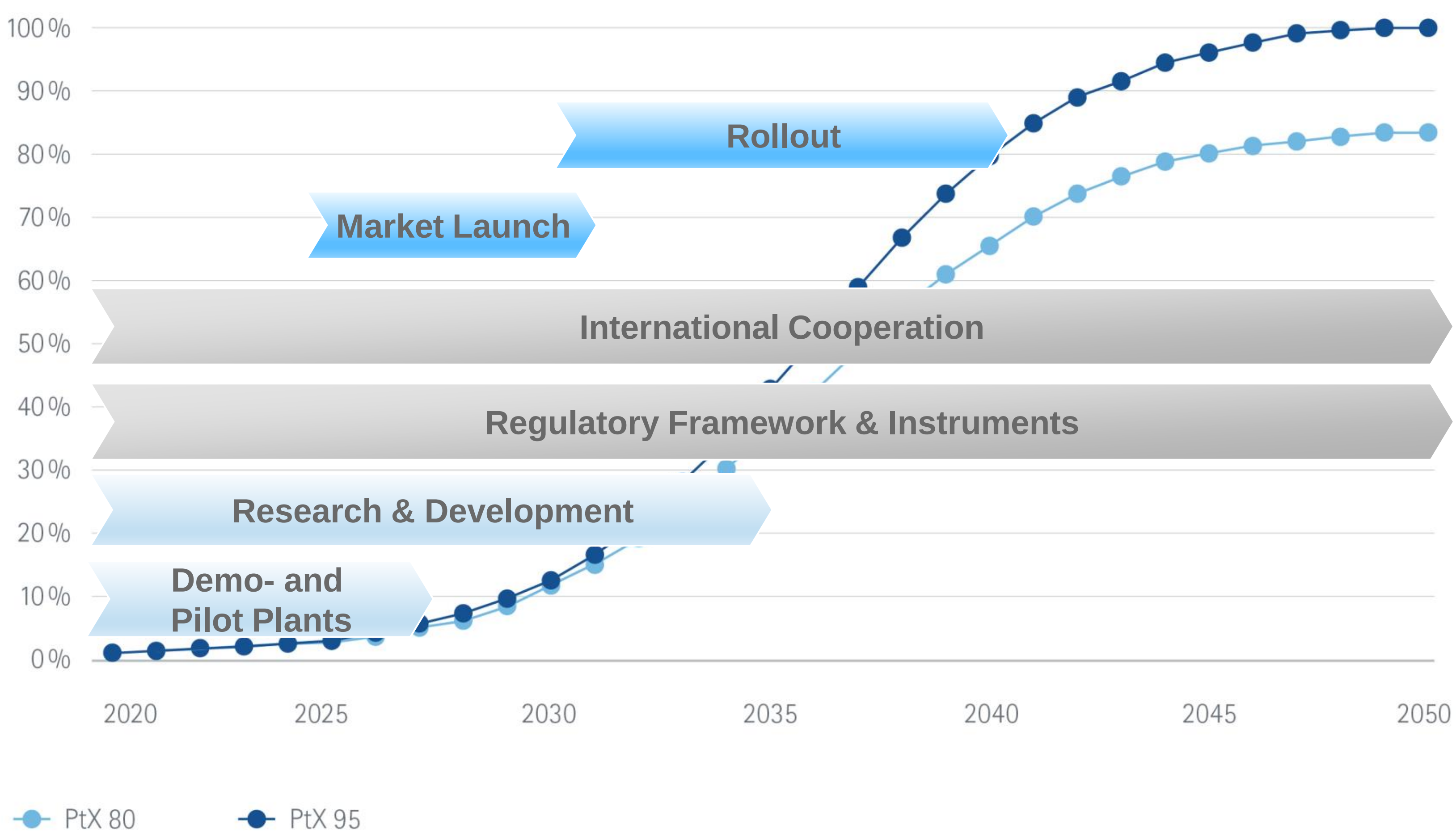
Possible Phases of a market launch of PtX



Liquid energy sources with PtL are essential for a most far-reaching GHG-emission reduction

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- Without renewable energies there is no PtX.
- PtL can be produced at costs around 1,33 €$_{2015}$/Liter in 2050.
- PtL need high international investments. Higher cost of energy.
- Continuous utilisation of existing infrastructure with PtL.
- Liquid energy sources will be needed in the future.
- From today‘s perspective PtL will be essential for climate mitigation (-95 %) .

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