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Work in Progress

74rd SEMI-ANNUAL ETSAP MEETING
7 November 2018 at IER Stuttgart University

Implication of Transport Policies when meeting Swedish Climate Goals

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AGENDA

- Background: Why
- Background: Swedish Energy System
- HOW: Energy system optimisation modelling using TIMES-Sweden
- HOW: Transportations in TIMES-Sweden
- Scenario Analysis: Policies & Framing
- Some results: Vehicle types
- Some results: Biofuel produces
- Insights (results analysis are in progress)

BACKGROUND-WHY: Climate Act

A climate policy framework & a climate and clean air strategy for Sweden entered into force Jan 2018

1. **A long-term climate goal:** By 2045 - at the latest – Sweden will have no net emissions of greenhouse gases.
2. **Intermediate targets** only for emissions outside the EU Emissions Trading System (known as the non-trading sector/NETS).
   - NETS targets for year 2030 and 2040.
   - Transport sector targets for year 2030.
3. **A clean air strategy** with a focus on reducing air pollutants (NOX, SO2, VOC, NH4 and particles) and thereby improved air quality.

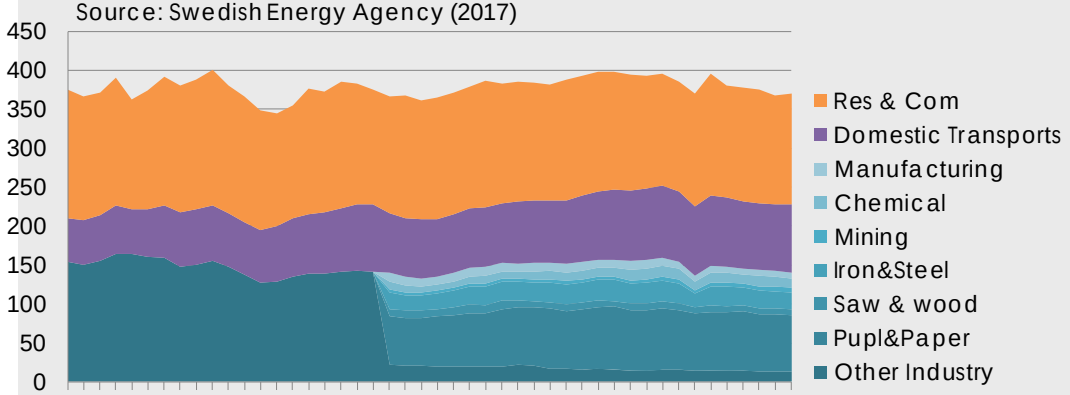
Net-zero means 15% of reduction can be offset by: i)LULUCF, ii)abroad, iii)BECCS

BACKGROUND: Swedish Energy System

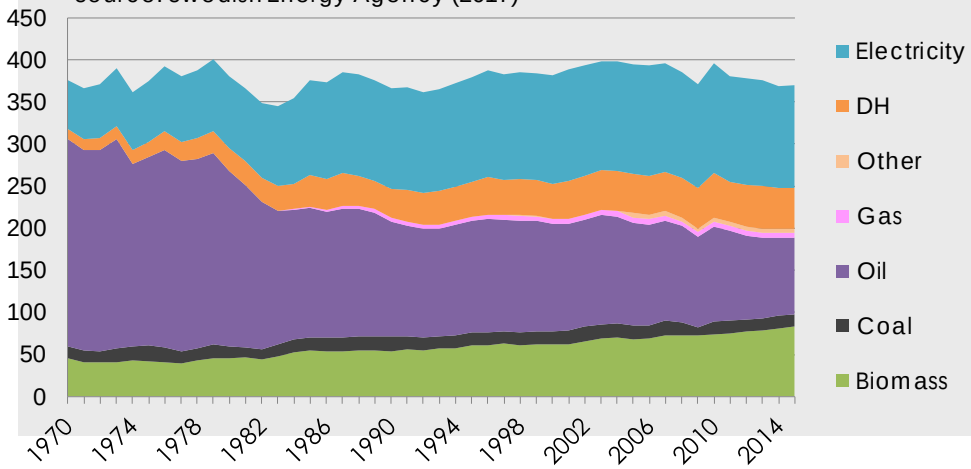
Net Zero GHG in 2045 Almost fossil free space heating **Low carbon electricity and DH production** **Large forestry potential** **High share of biofuels in the transport sector** Energy intensive industry sectors **An increasing transportation demand.**

BACKGROUND: Swedish Energy System

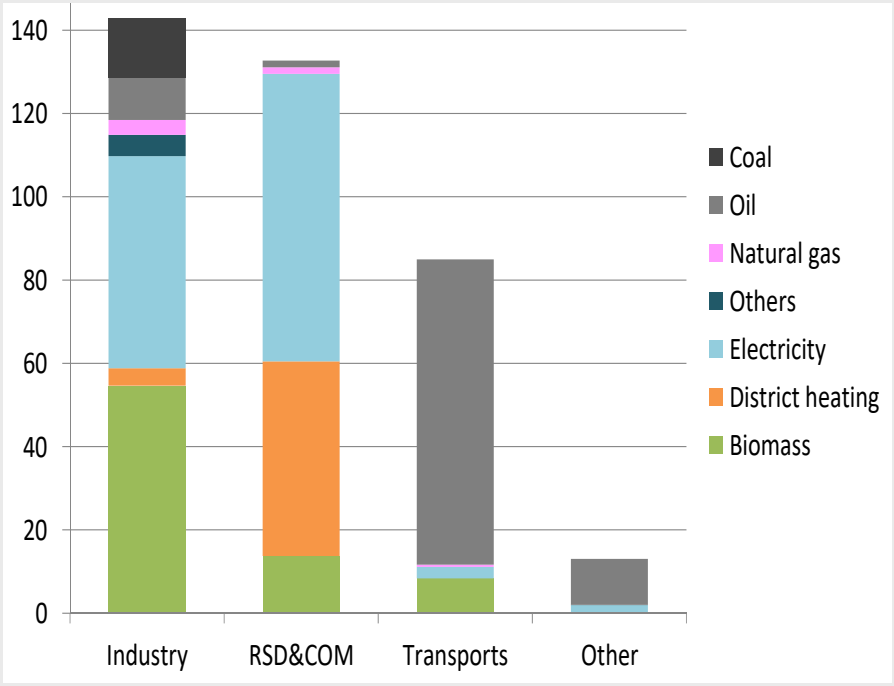
Final use of energy per sector (TWh)
Source: Swedish Energy Agency (2017)



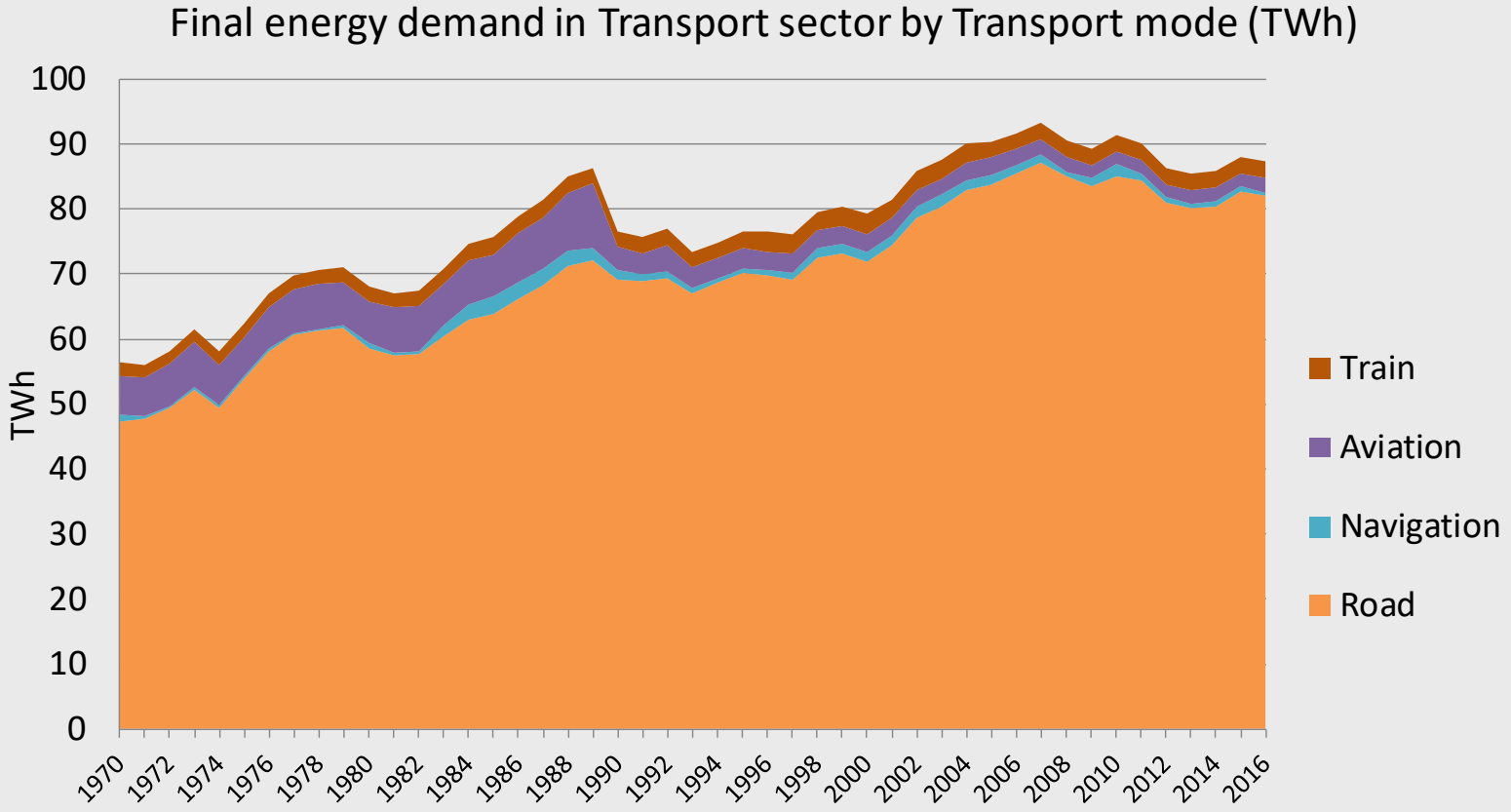
Final Energy Use per Energy Carrier (TWh)
Source: Swedish Energy Agency (2017)



Final Energy Consumption by sector in year 2015

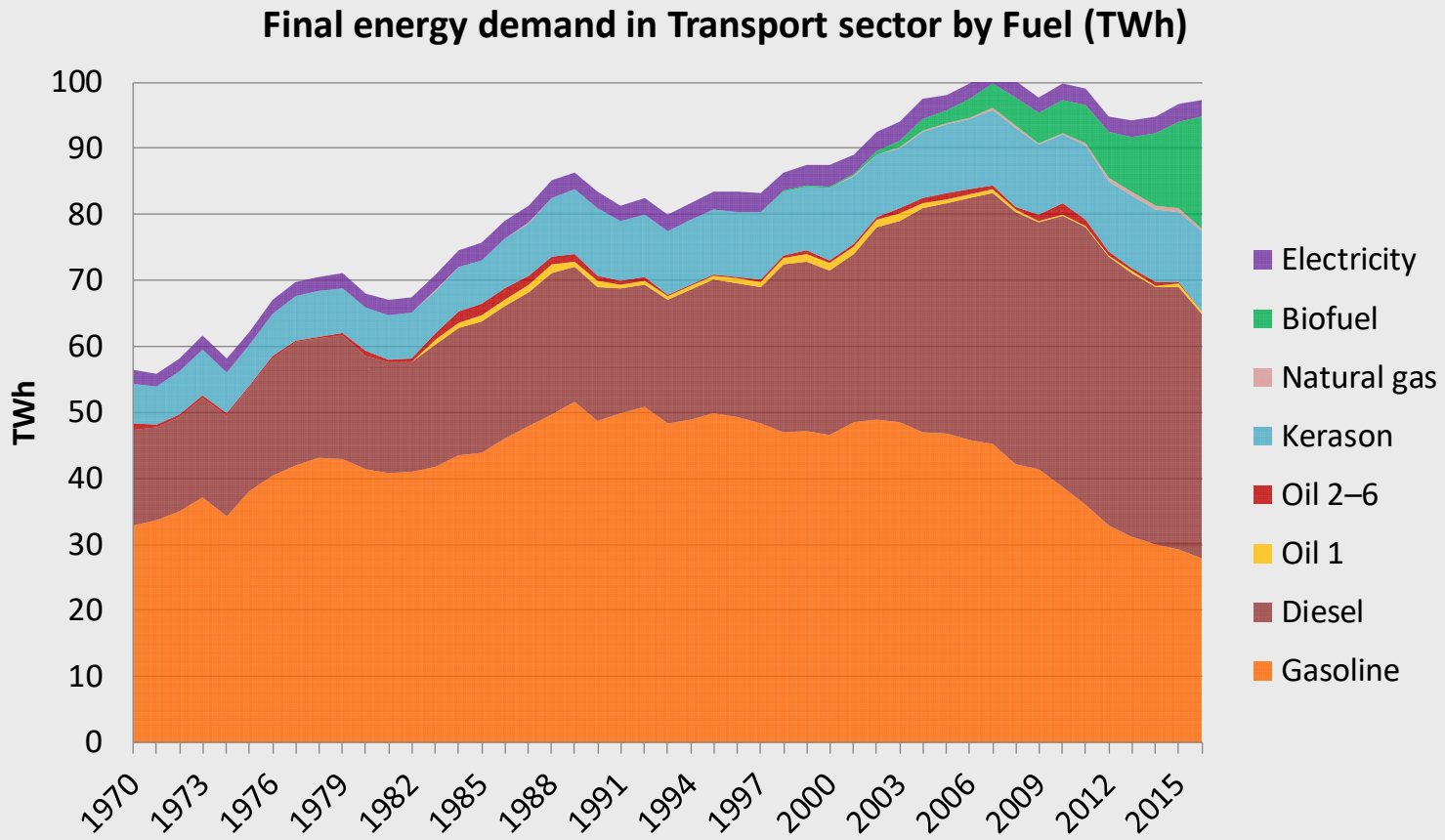


BACKGROUND: Swedish Energy System



Source: The Swedish Energy Agency & Statistics Sweden

BACKGROUND: Swedish Energy System



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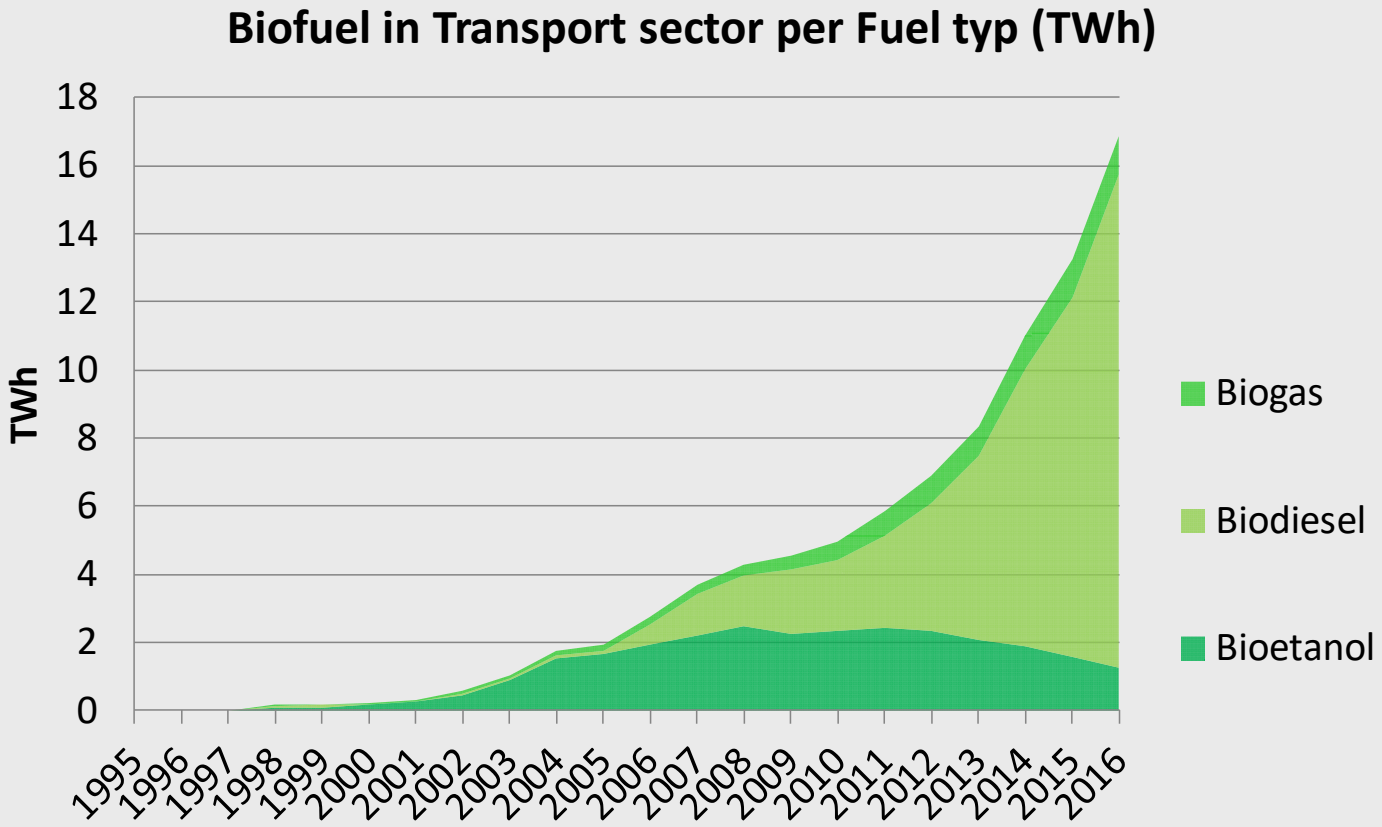
BACKGROUND: Swedish Energy System



Source: The Swedish Energy Agency & Statistics Sweden

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HOW

Energy System Optimisation Modelling using TIMES-Sweden

TIMES-Sweden

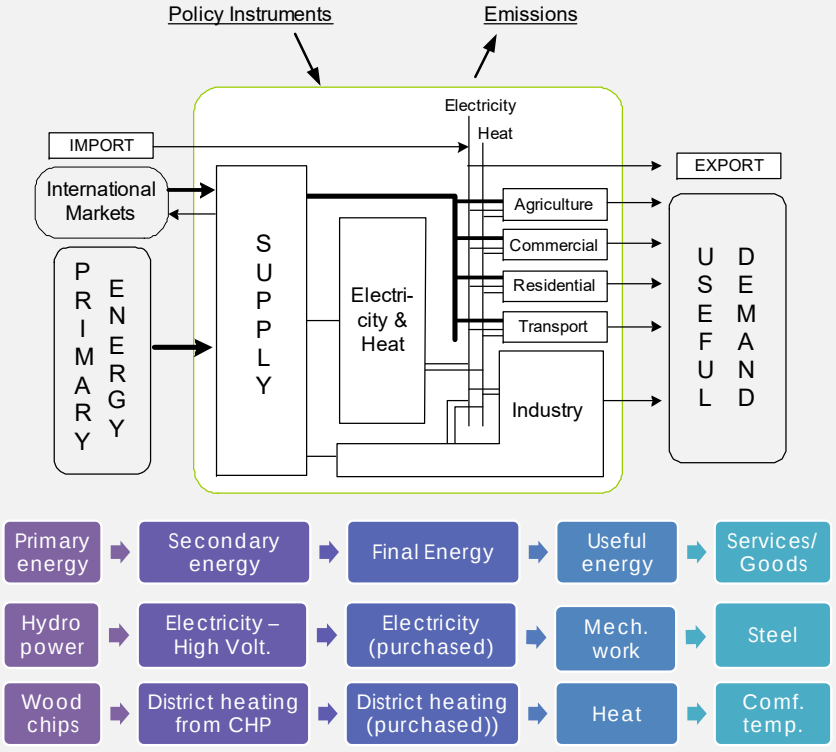
TIMES-Sweden identifies how limited **resources can be allocated** in order to minimize the total system costs.

TIMES-Sweden is a comprehensive energy system model represented by **seven (soon eight) main sectors**: Industries, Residential, Services, Agriculture, Transports, ELC&DH and Energy supply and fuel production. The model is driven by the demand for energy-intensive goods and services.

TIMES-Sweden is based on the TIMES-platform (IEA-ETSAP) and share the main structure with, e.g., JRC-EU-TIMES.

- **Energy system optimisation model**
- **Comprehensive Energy System**
- Dynamic LP-model (12 per/year)
- Long-term Modelling (20-50 years)
- Bottom-up/**Techno-economic model**
- Cost minimisation
- Multi-Partial Equilibrium Model
- **Technology Rich**

TIMES-Sweden a national ESOM



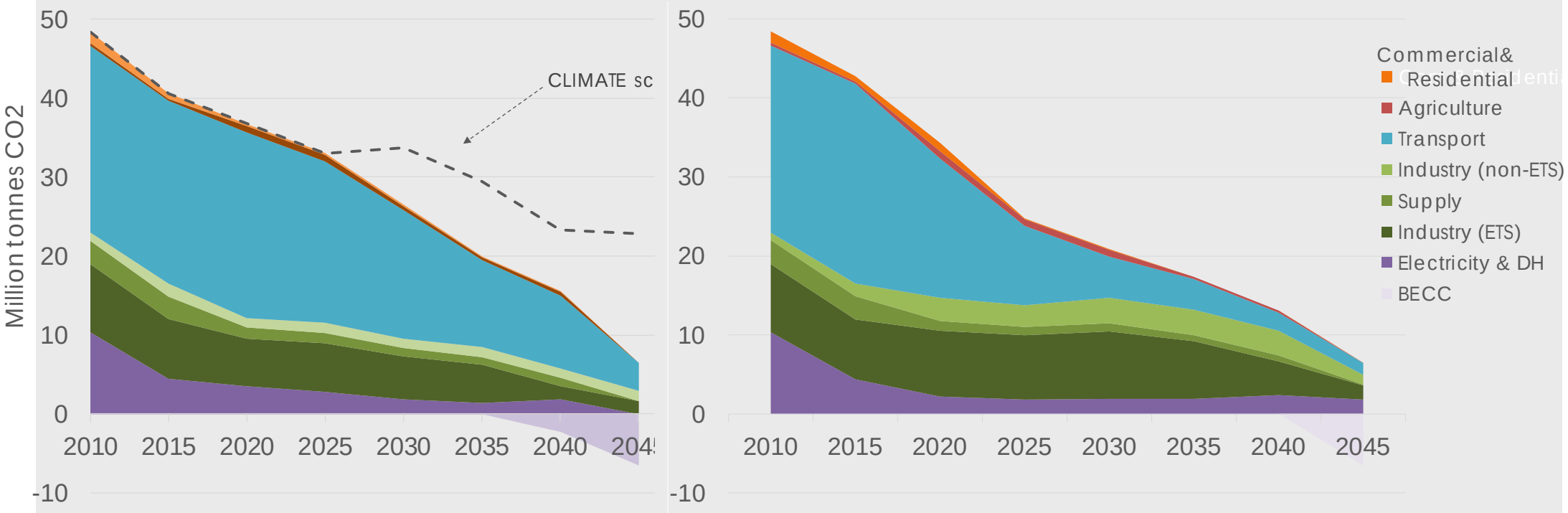
Developments:

- Initially developed as a part of the Pan European TIMES model (**PET model**), within two EU funded projects (**NEEDS** and **RES2020**).
- Emissions-factors/Ancillary benefits (Krook-Riekkola et al. 2011)
- **Iron- and steel industry** (2012)
- District heating (Krook-Riekkola & Söderholm, 2013), (Pädam et al., 2013)
- **Demand** through soft-linking with EMEC (Krook-Riekkola et al. 2013a, 2013b)
- Residential sector (Boverket, 2015)
- **Biomass** (Fjärrsyn project, 2015-2017)
- **Transportation** (on-going PhD project/Jonas Forsberg)
- **Industry sectors** incl CCS (on-going PhD project/Erik Sandberg)

Documentation: TIMES-Sweden is described in Krook-Riekkola (2015). The model is similar to the JRC-EU-TIMES model, documents by Simoes et al. (2013).

New modelling runs with improved biomass description, and included additional biofuel and industrial options.

Comparing resulting CO2-emissions from TIMES-Sweden, before (left) and after (right) implementing a more detailed description of biomass + additional fossil fuel replacement.



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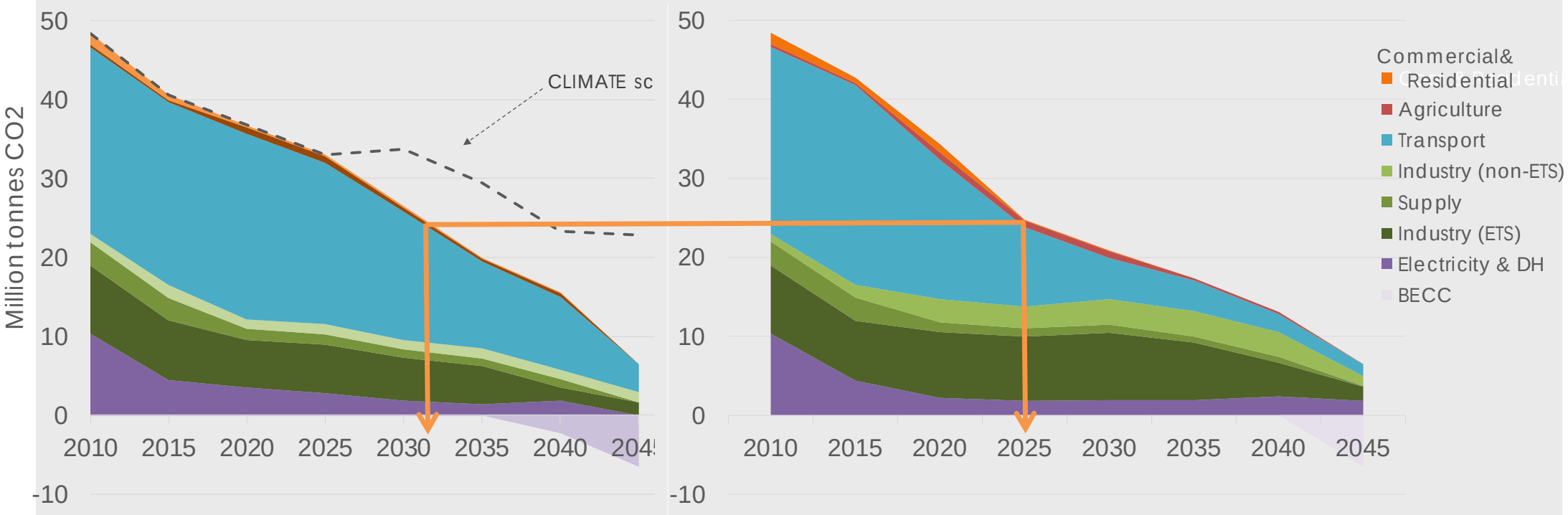
New modelling runs with improved biomass description, and included additional biofuel and industrial options.

→ By improving the **technology representation** → the CO2-emission reduction path differ significant.
→ Fundamental new technologies is entering the arena → important to **update accordingly**.



TIMES-Sweden: How is transportations described?

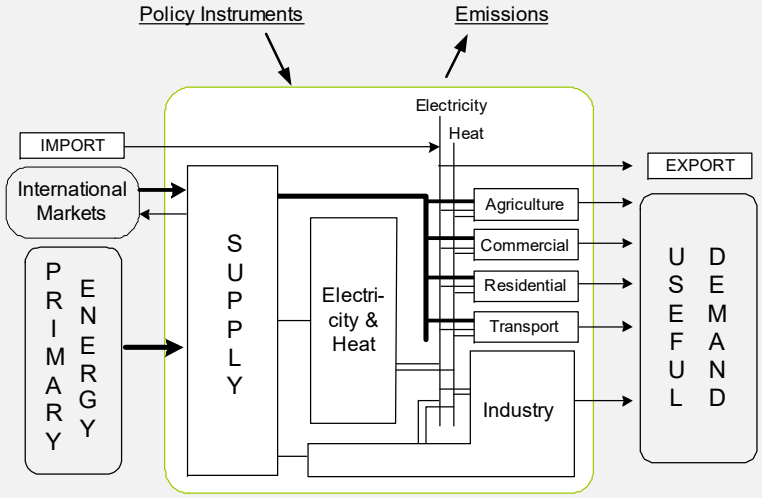
Fuel production

- Refineries (fossil fuels),
- Integrated biofuel prod within old ref,
- Integrated biofuel prod within industries,
- Stand alone biofuel plants.
- Combination of biofuel, district heating and electricity production.
- Electricity generation. (Don't have hydrogen in present model).

Different kinds of biofuels

- Biodiesel (TRA)
- Biogas (TRA)
- Bio DME (TRA)
- Ethanol (TRA)
- Bio FT-diesel (TRA)
- Bio methanol (TRA)
- (H2 for transport gasuous (TRA))
- (H2 for transport liquid (TRA))

TIMES-Sweden a national ESOM



More biofuels compared with average model

Really simple, too simple?

Transportation modes

Aviation International	PJ
Aviation Domestic	PJ
Road.Bus.Intercity.	Million_Pkm
Road.Bus.Urban.	Million_Pkm
Road.Car.Long.Distance	Million_Pkm
Road.Car.Short.Distance	Million_Pkm
Road.Freight.Light	Million_Tkm
Road.Freight.Heavy	Million_Tkm
Road.Moto.	Million_Pkm
Navigation.Generic.	PJ
Navigation.Generic.Bunker	PJ
Rail.Freight.	Million_Tkm
Rail.Passengers.Light.	Million_Pkm
Rail.Passengers.Heavy.	Million_Pkm

No behaviour introduced

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Scenario Analysis & Some Results

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Scenarios: Demand and Prices

	2. Transportarbete efterfrågan			3. Car fleet			7. Fossil fuel prices (imp/export priser)			8. Forest based Biomassa (potential of residuals)	
Scenario	REF: Transport demand in line with official projections (Swedish EPA & Energy agency, 2017)	Extrem-WC: Scenario 'Basprognos' from Trafikverket (2018)	Extrem-BC: Scenario 'Transporteffektivare samhälle' from ÅF (2018)	Modeled endogenously by the model.	Exogenously given for year 2030, according to BM scenario in (Algers, 2017)	Exogenously given for year 2030, according to BM-techup scenario in (Algers, 2017)	High = "Current policies" in table 4 in IEA (2017)	Reference = "New Policies" in table 4 in IEA (2017)	Low = "Sustainable development" in table 4 in IEA (2017)	Reference (High production/harvesting)	Low (Low production/harvesting)
Baseline	X			X				X		X	
Extrem - WC		X		X					X	X	
Extrem - BC			X	X			X				X
Bio 1	X			X				X		X	
Bio 2	X			X				X		X	
Vehicle 1	X			X				X		X	
Vehicle 2	X				X			X		X	
Vehicle 3	X					X		X		X	

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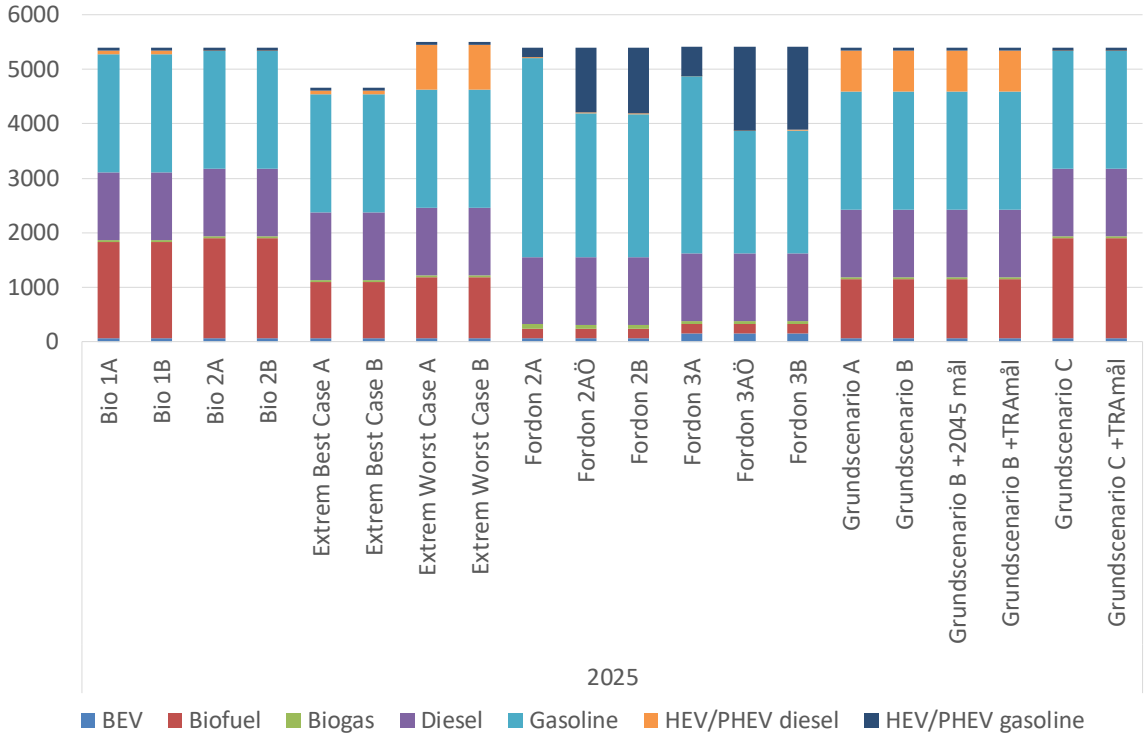
Scenarios: Policies

	1. Climate Targets (CO2-emission targets)						5. Policy: FF-Reduction obligation system (Reduktionsplikt)					
Scenario	**A: Meet the Overall Target (2045) and the Transport target (2030) (=restriction in the model)**	**B: Not necessary meet any of the targets (= no restriction in the models)**	E: Meet the Overall Target (2045) (=restriction in the model)	F: Meet the Transport target (2030) (=restriction in the model)	C: Not necessary meet any of the targets, NO fuel-reduction-system	D: Meet the targets, NO fuel-reduction-system	Separate systems for diesel and gasoline	Joint systems for diesel and gasoline	**Only inlcude biofuels in diesel- & gasolin-pumps**	Include all biofuels for road transporations	Target in 2030 (%)	Biogas included in the system
Baseline scenario	**A**	**B**	E	F	C	D	X	-	X		40	
Extrem - WC	**A**	**B**	E	F	C	D	X	-	X		40	
Extrem - BC	**A**	**B**	E	F	C	D	X	-	X		40	
Bio 1	**A**	**B**	E	F	C	D	X	-	X		30	
Bio 2	**A**	**B**	E	F	C	D	X	-		X	40	
Vehicle 1	**A**	**B**	E	F	C	D	X	-	X		40	
Vehicle 2	**A**	**B**	E	F	C	D	X	-	X		40	
Vehicle 3	**A**	**B**	E	F	C	D	X	-	X		40	

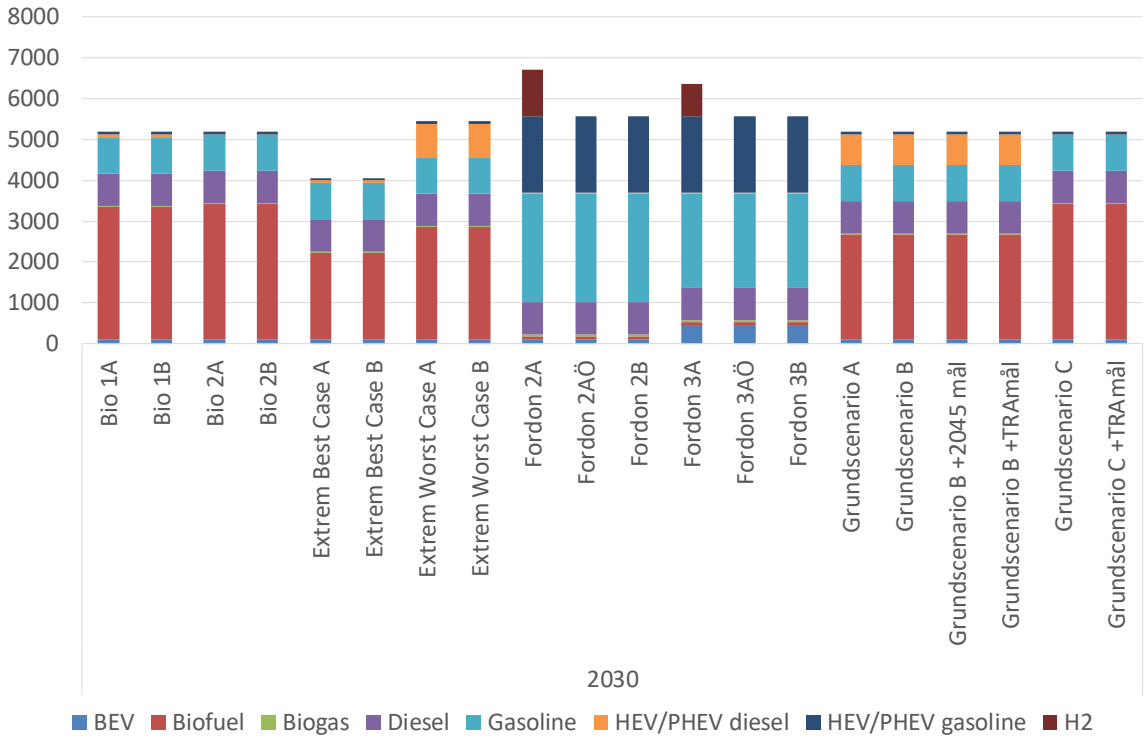
Key assumption

- Assume present taxes, electric certificate system and EU-ETS
- Main biomass is forest residuals and bi-products from the industry (biomass potential derived from forest models).
- No import of biofuels after 2020 (at present >80% import, even though large resources exist, but this rely on newer technologies)
- BECCS <6.5 M ton CO_2

The car fleet in 2025 (1000s vehicles)

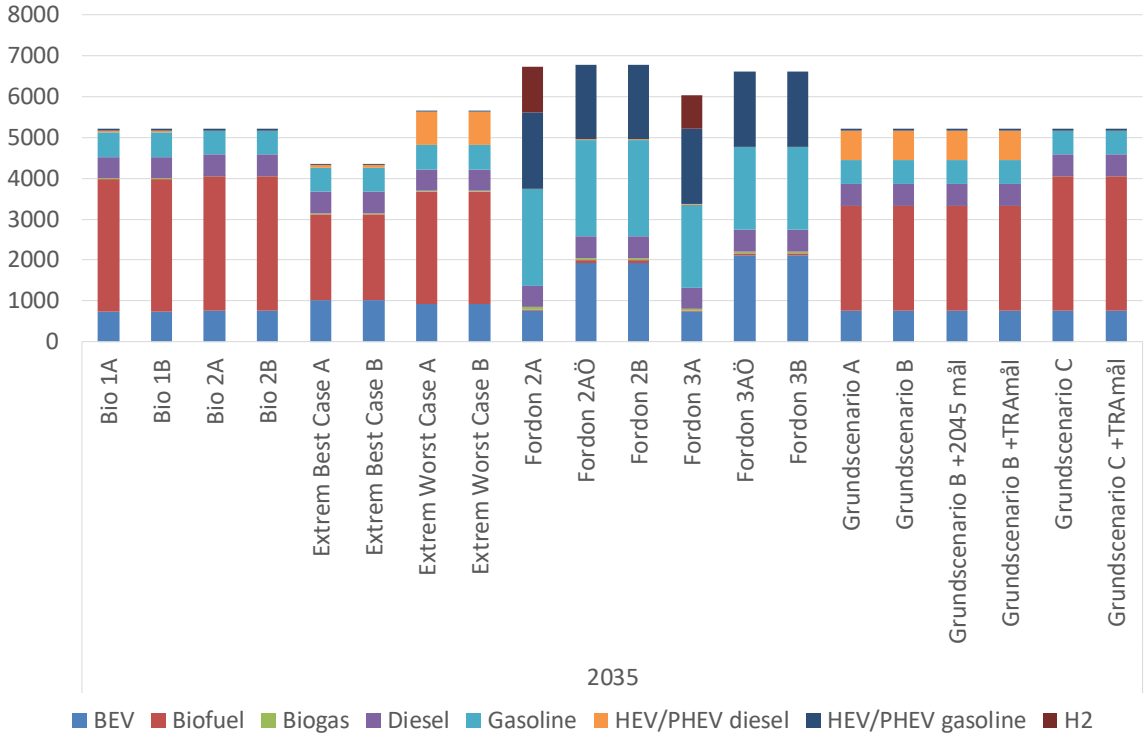


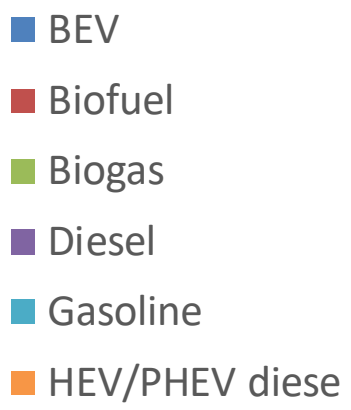
The car fleet in 2030 (1000s vehicles)



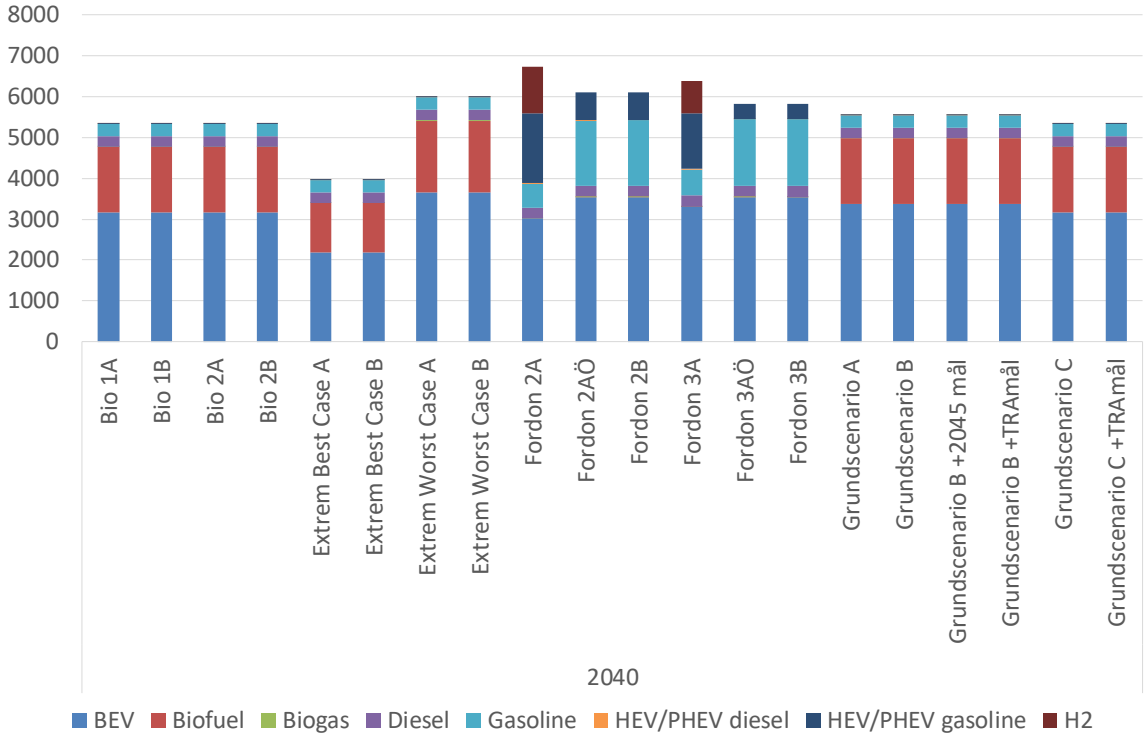
BEV
Biofuel
Biogas
Diesel
Gasoline
HEV/PHEV diese

The car fleet in 2035 (1000s vehicles)





The car fleet in 2040 (1000s vehicles)



BEV
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Diesel
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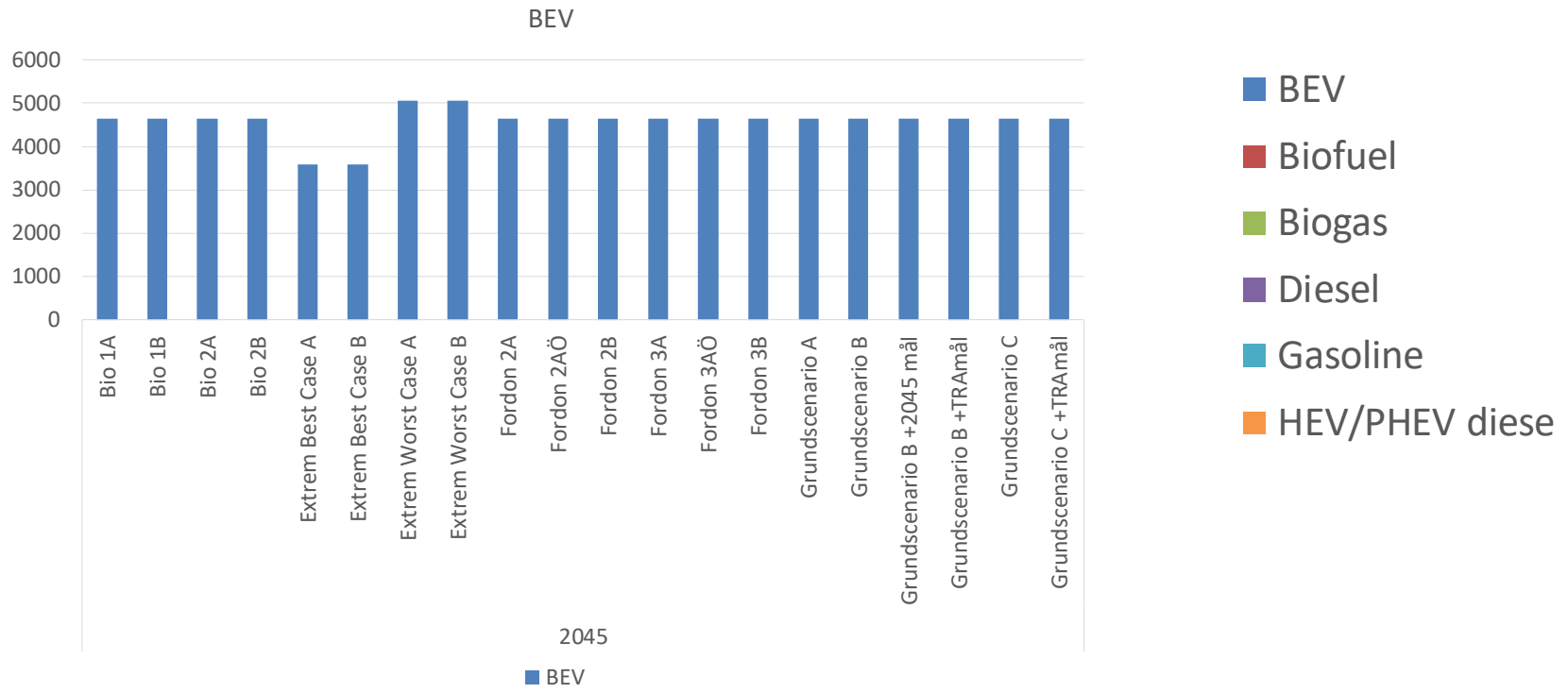
HEV/PHEV diese

The car fleet in 2045 (1000s vehicles)



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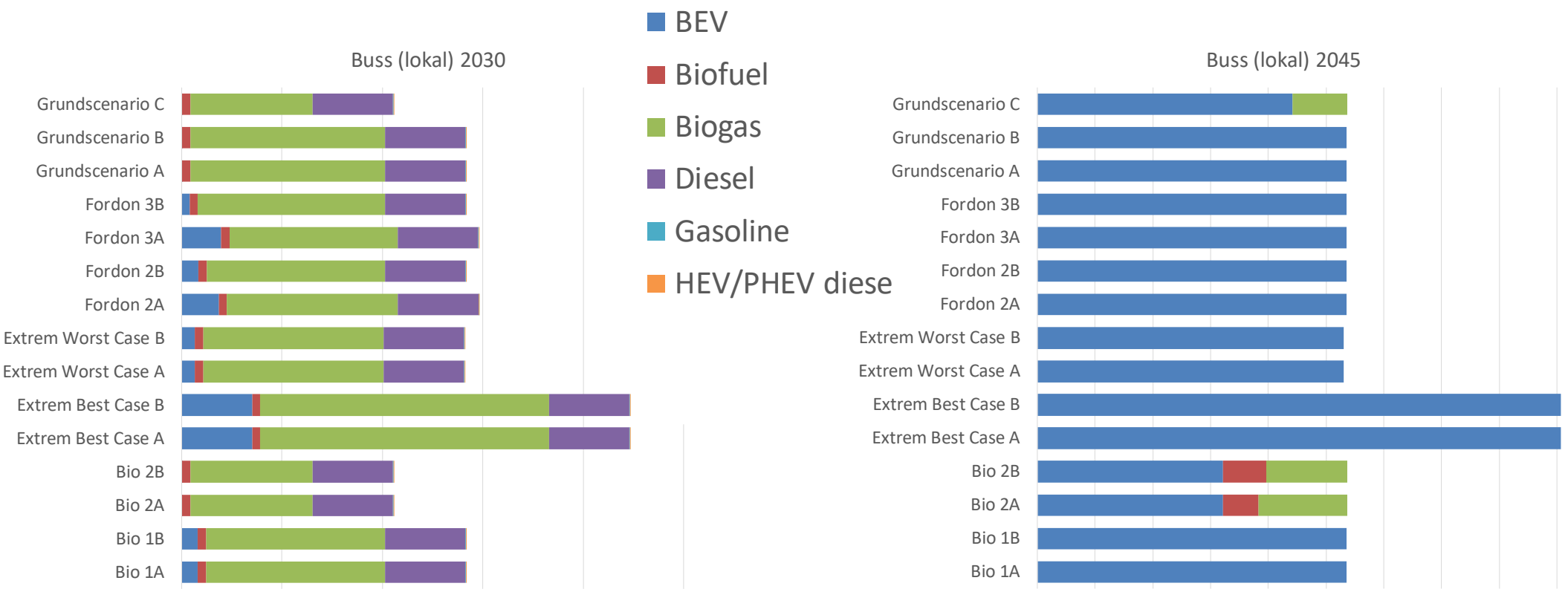
City buses in each scenario 2030 vs 2045



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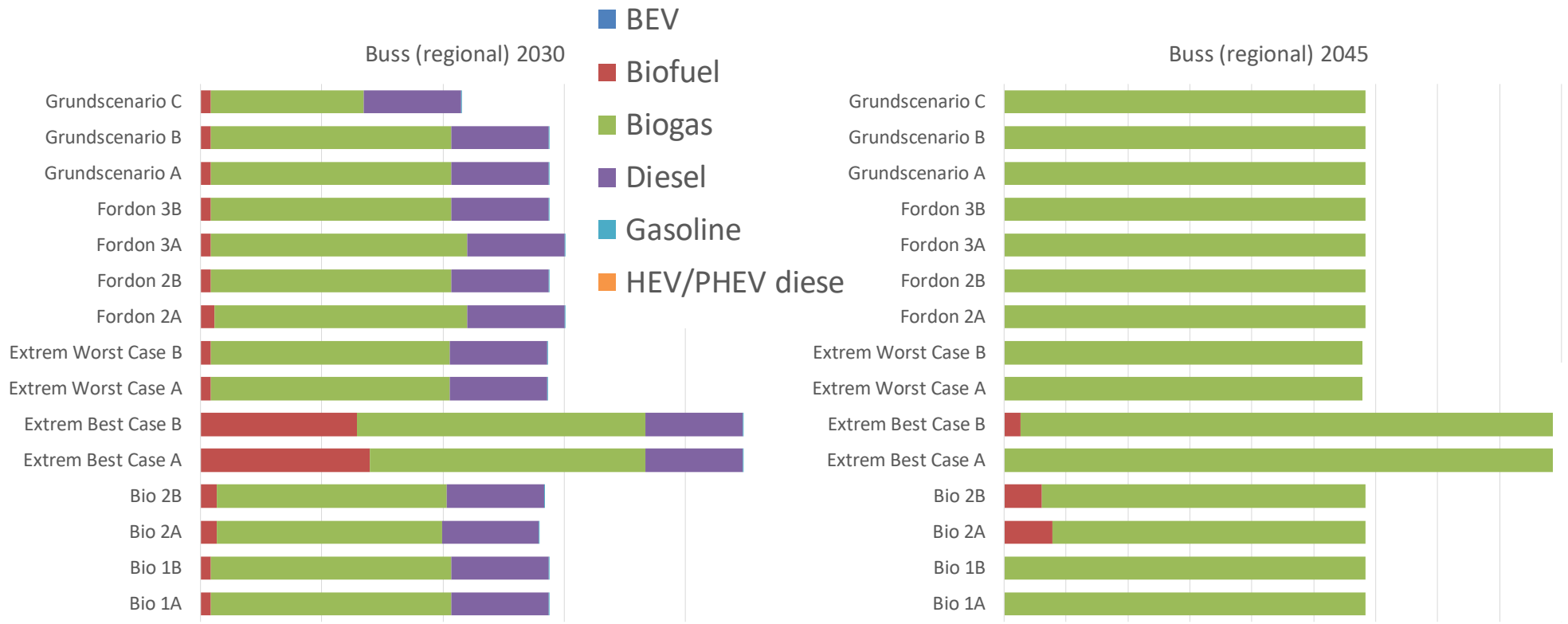
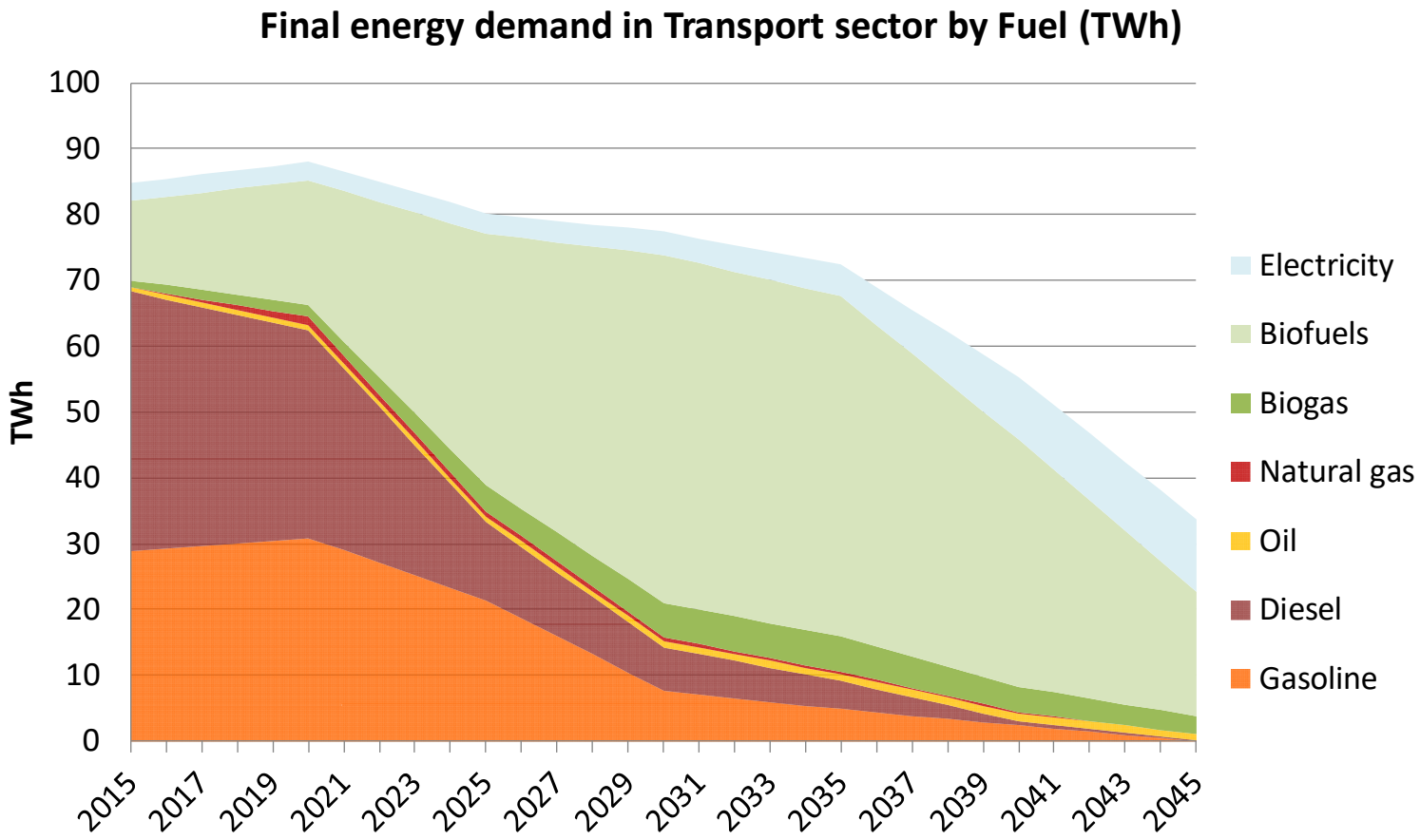
Regional buses in each scenario 2030 vs 2045



Final energy demand by Fuel type



Takeaways

- Useful to create sets of couple-scenarios (with/without climate targets)
- Even a basic TIMES model of the comprehensive national energy system can capture vehicle-shifts in a decant way (of course not fully).
- Biofuels can be produced in many different ways, as well as it can be used for many different purposes (including exporting to other countries). Important to capture the entire biofuel route.
- Extensive interactions with the analysist at the Swedish environmental protection agency.
  - Discussed what should be analysed
  - Discussed what should be presented
  - Scrutinized the result with new eyes

  → Takes time, but provides more robust results and insights

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Thank you for the attention

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