

# WELL-TO-WHEEL COST FOR FOREST-BASED BIOFUELS

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**Built Environment**  
**Energy and circular economy**



# Aim of study

- The primary aim of this study was to estimate the total **well-to-wheel (WtW) cost** for **forest-based biofuels** for use in different transport segments in **road traffic** and compare these with fossil alternatives in a Swedish context.
- The comparison, based on the cost for the end user, illustrates how different alternative value chains can compete with fossil-based value chains and **under which conditions there is potential for profitable biofuel production.**



# Studied value chains

## Production and integration/localisation

- **SNG** produced via gasification integrated with a chemical pulp and paper mill (PoP).
- **Methanol** produced via gasification of black liquor naturally integrated with a chemical pulp and paper mill (PoP).
- **Ethanol** produced via hydrolysis and fermentation, with **biogas** as a by-product, integrated with a district heating (DH) system.
- **Renewable diesel** and **petrol** produced by first making a bio-oil from extracted lignin at a chemical pulp and paper mill (PoP) and then upgrade the bio-oil at an oil refinery (Ref).

## Distribution and usage

### ■ Car

- CNG
- Liquid



### ■ (Distribution truck)

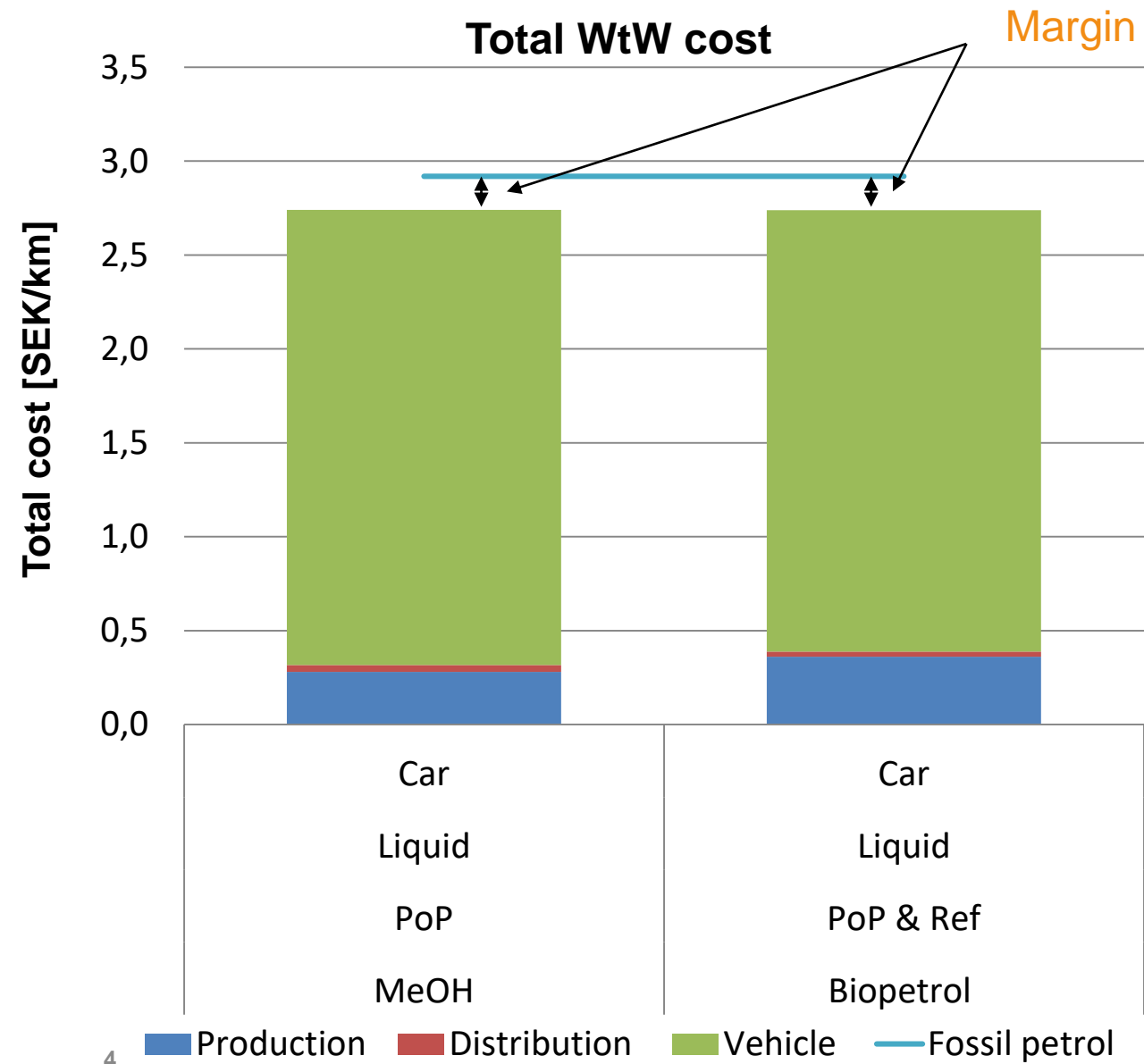
- CNG
- Liquid

### ■ Long-distance truck

- LBG
- Liquid



# Methodology and assumptions

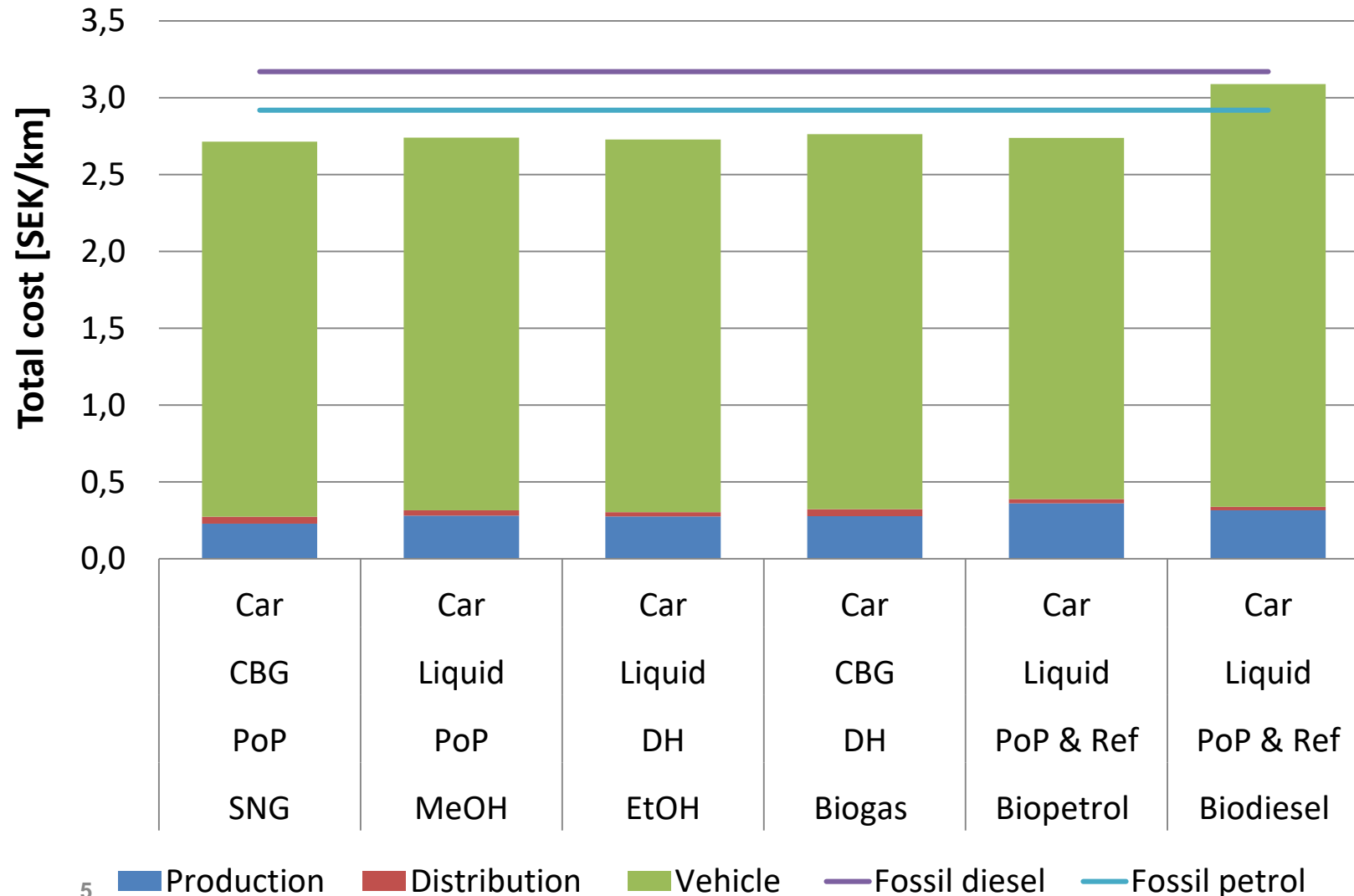


- Margins for fuel producers and distributors were included for the fossil reference chain, while it was not included for the biofuel chains.
- Instead an indicative margin was calculated by comparing the results of the total cost for the renewable alternatives with the total cost for the fossil reference cases (assuming the same cost for the end user).
- Current market prices for energy, as well as current policy instruments, were used as input for the calculations.
- It was assumed that the biofuels are used as high-blended fuels with tax exemption (current policy situation).

# Results Car



## Basic assumptions – total WtW cost

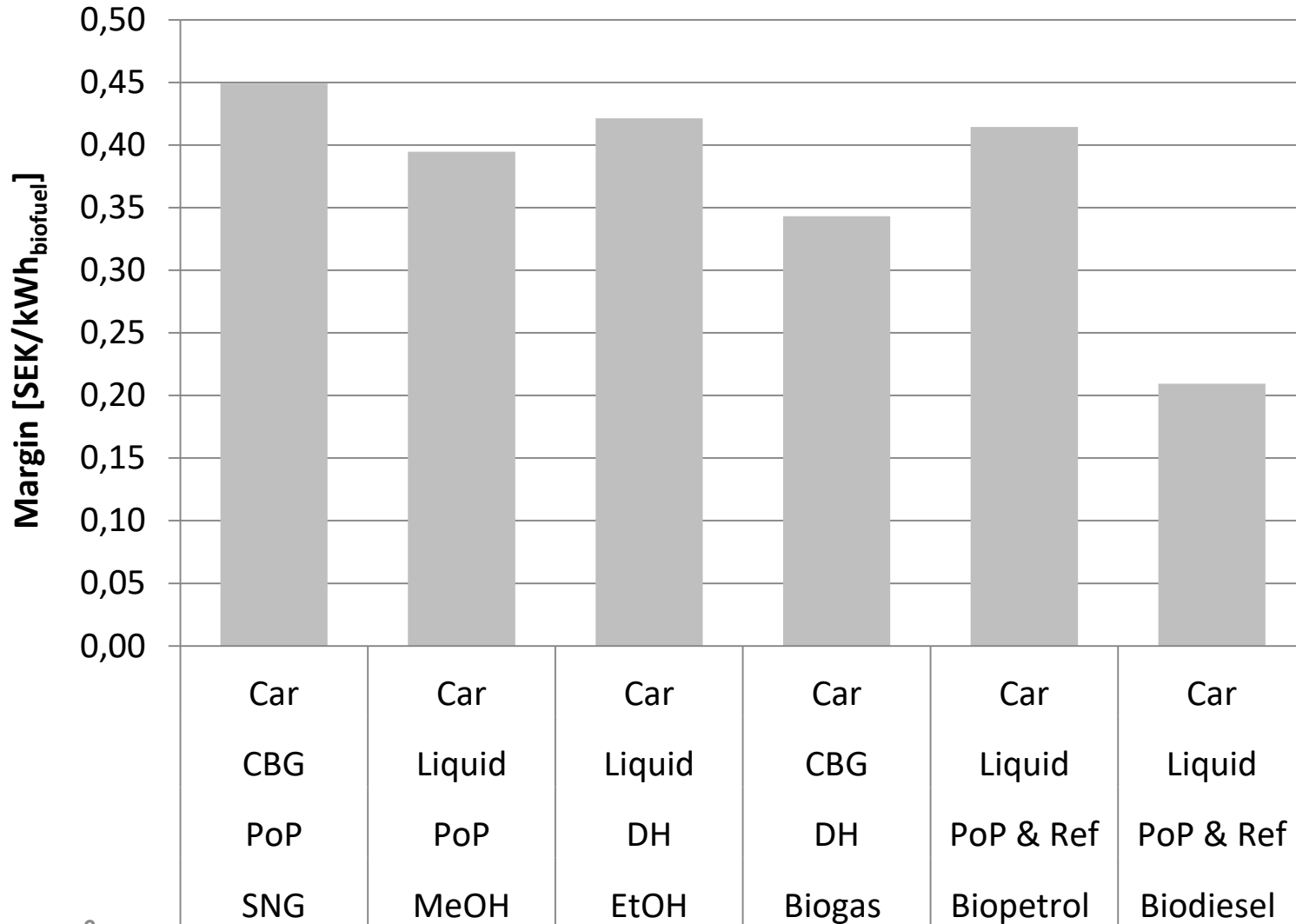


- The dominating cost for the car segment is the vehicle cost.
- All biofuels are competitive with policy instruments, including significant margins for producers and distributors.

# Results Car



## Basic assumptions – margin for biofuel producers

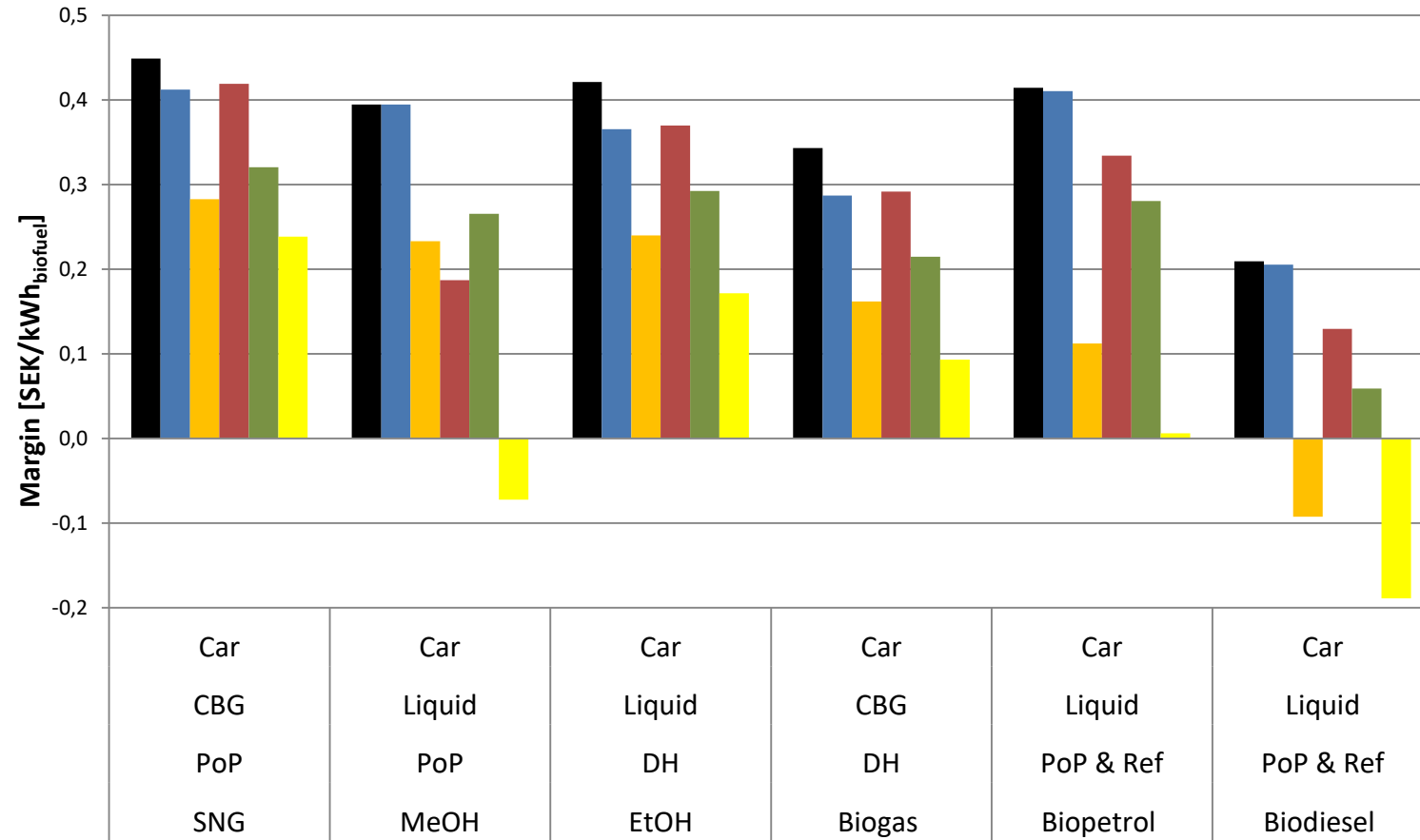


- The margin is between approximately 0.20-0.45 SEK/kWh.
- The tax exemption on biofuels are the single most important policy instrument, adding a cost of around
  - 0.7 SEK/kWh for petrol
  - 0.5 SEK/kWh for diesel

# Results Car



## Sensitivity analysis – margin for biofuel producers

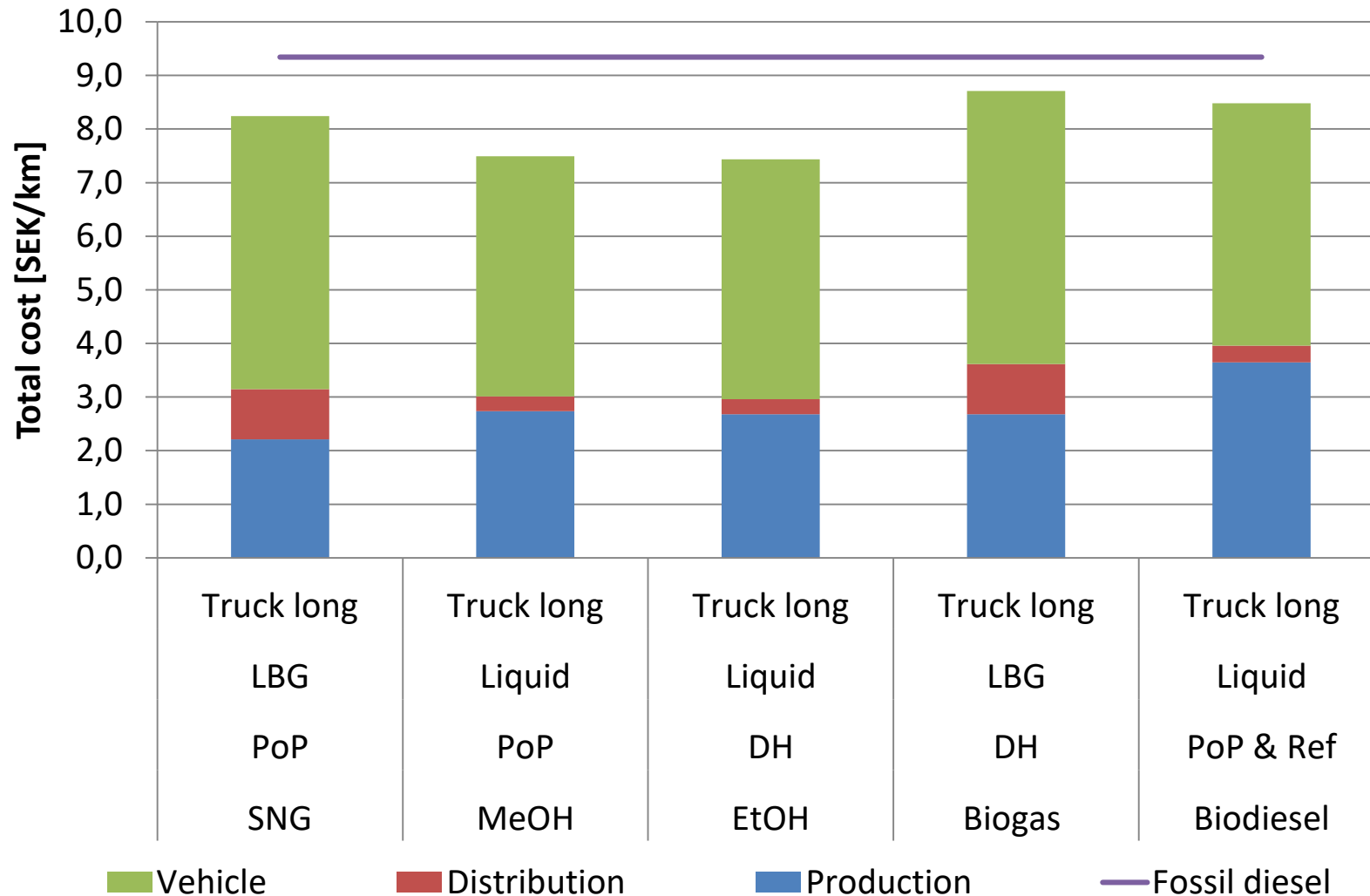


- In addition to illustrating the effect of different policy instruments, the influence of a number of different parameters were investigated – the ones shown here have the largest impact on the results and include
  - the biomass price
  - the crude oil price
  - the price of excess heat
- However, most alternatives are still competitive, showing a significant potential margin, when these parameters are changed individually in an unfavorable direction.
- For a sensitivity analysis where a number of parameters are combined, most cases still has a positive margin.

# Results Long-distance truck



## Basic assumptions – total WtW cost



- The vehicle costs are less dominant in this segment compared to personal cars since the trucks travels a longer distance each year and hence variable costs constitutes a larger share of the total cost.
- All biofuels are competitive compared with fossil diesel.
- Methanol and ethanol have the lowest total cost in this segment.

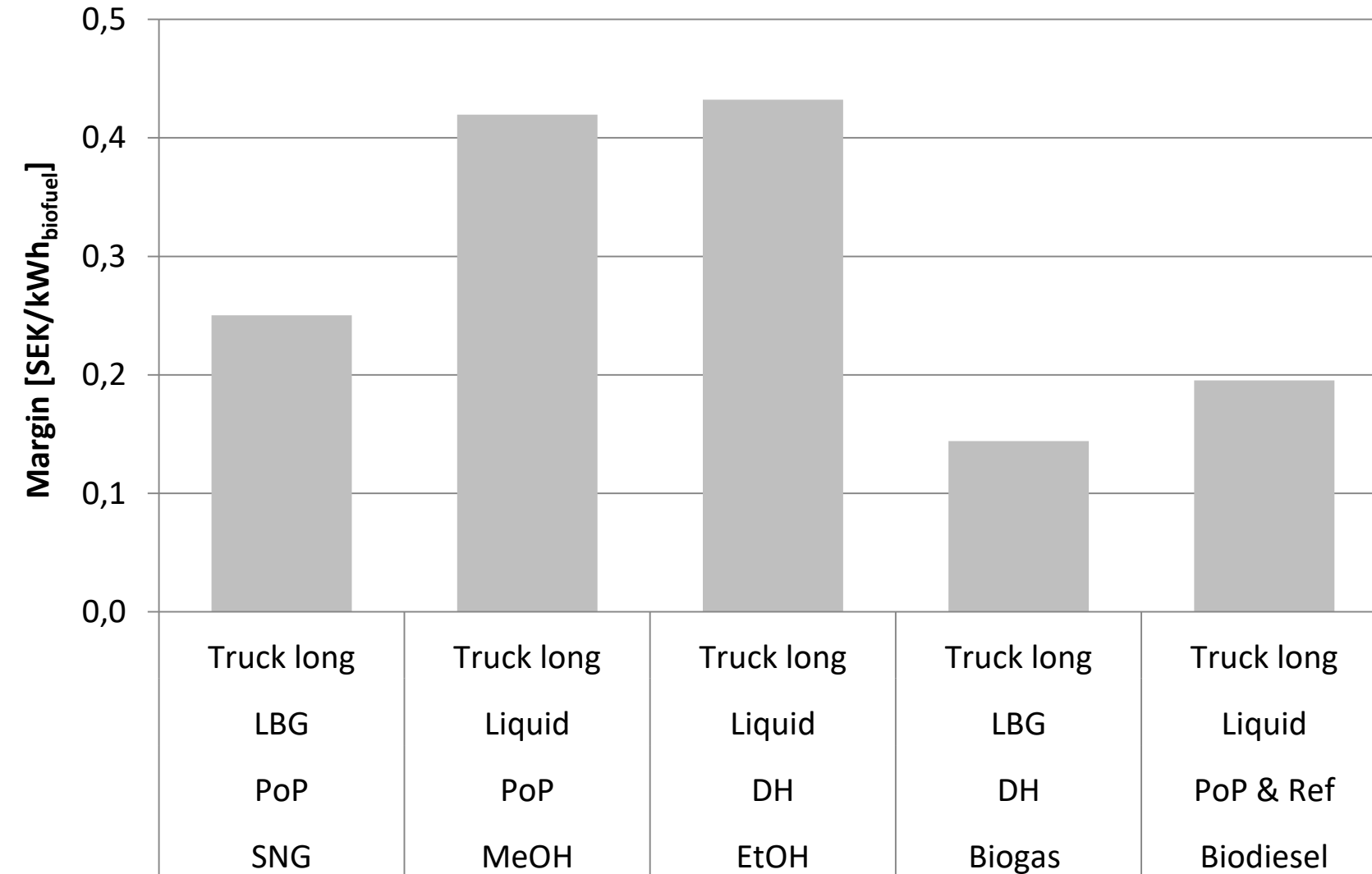


# Results Long-distance truck



## Basic assumptions – margin for biofuel producers

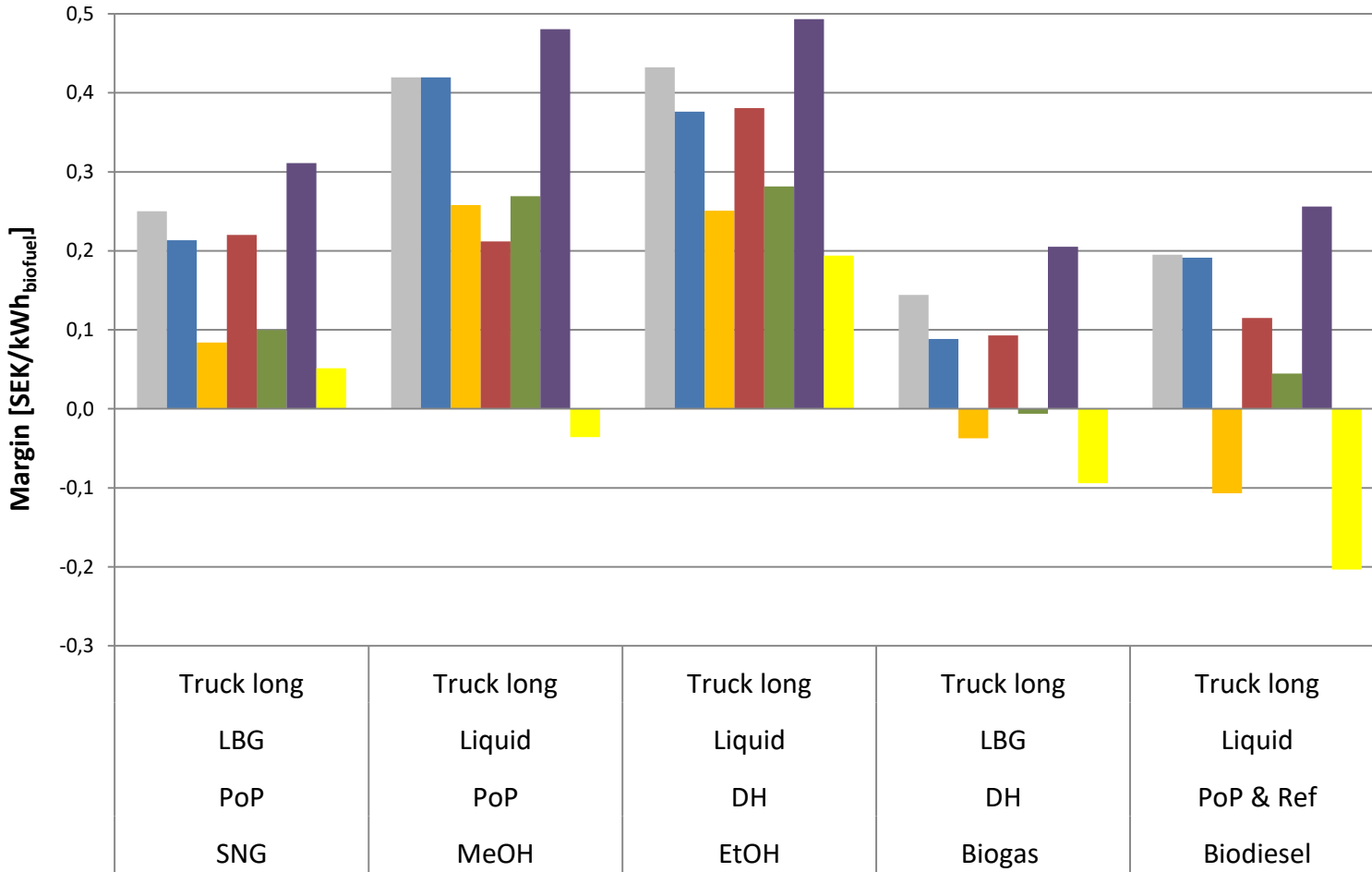
- The margin is approximately between 0.15-0.45 SEK/kWh



# Results Long-distance truck

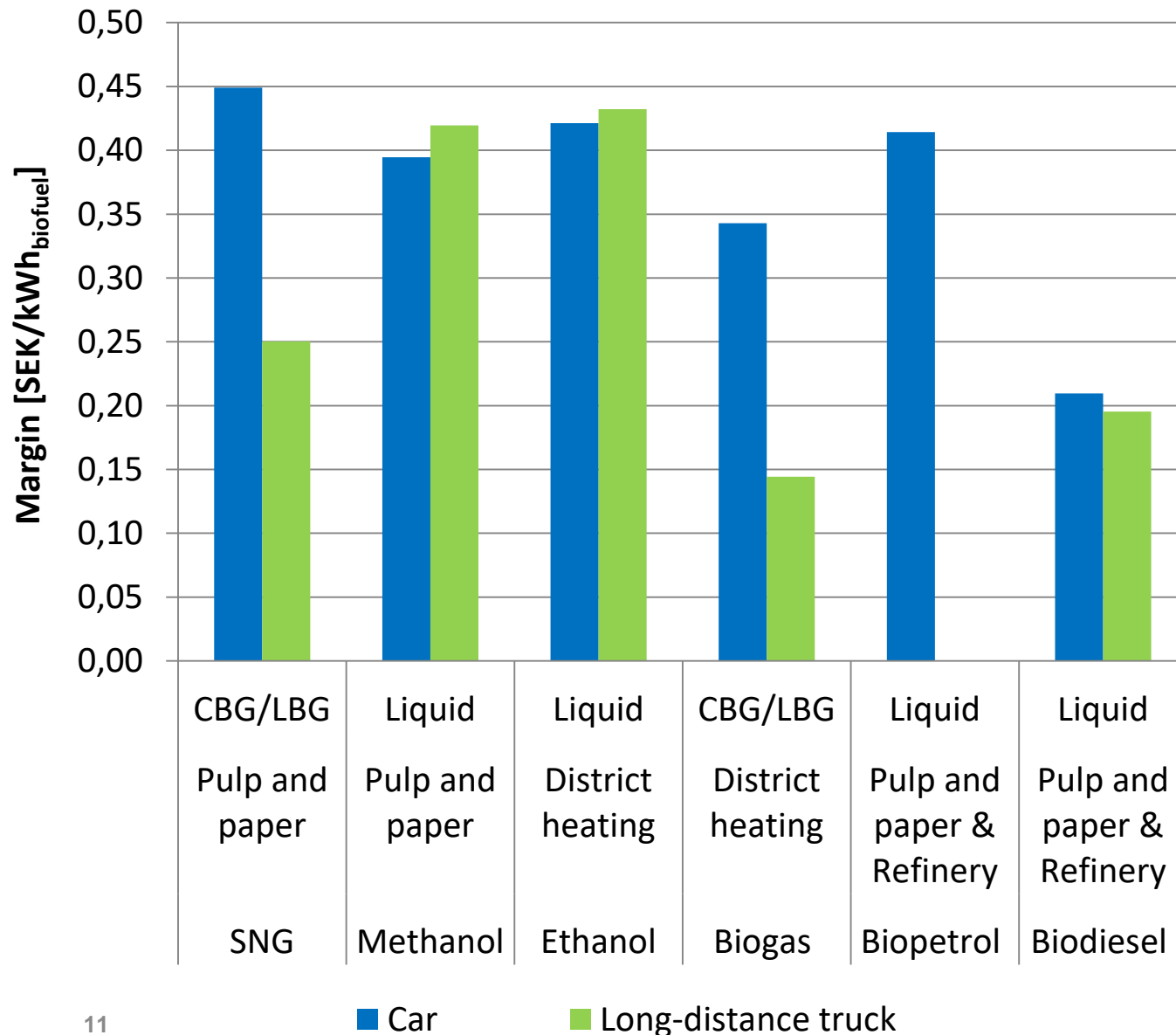


## Sensitivity analysis – margin for biofuel producers



- Since the fuel cost is more significant, changes in fuel related costs have a greater impact than for the car segment.
- For both biogas and renewable diesel, the margin is low or negative when several of the parameters are changed.

# Summary/Conclusions



- All the studied value chains have the opportunity to be profitable given the current policy situation in Sweden (as well as current price levels).
- The value chains with methanol and ethanol show the highest average potential margin for producers and distributors, which is also very stable, looking at the different transport segments.
- Also the SNG and biopetrol value chains have very high potential (average) margin for producers and distributors.
- For biodiesel and biogas the average margin is somewhat lower, but still relatively high. However, when changing certain parameters these value chains have very small or negative margins.
- The production processes with methanol, SNG and ethanol/biogas all have significant margins also when most parameters are changed radically. This is not the case for the biodiesel/biopetrol process.

This project has been carried out within the collaborative research program *Renewable transportation fuels and systems*, with funding from the Swedish Energy Agency and f3 Swedish Knowledge Centre for Renewable Transportation Fuels.

The report can be found here: [https://f3centre.se/app/uploads/P-42404-1\\_Pettersson-et-al-FINAL\\_190429.pdf](https://f3centre.se/app/uploads/P-42404-1_Pettersson-et-al-FINAL_190429.pdf)

In addition to what has been presented here, it contains an additional transport segment (distribution truck), an electricity-based value chain as well as results concerning GHG emissions and energy efficiency for the studied value chains.