Vehicle technology and transport fuels

How to reduce emissions of carbon dioxide from transport

(1) Less carbon intensive fuels (life-cycle perspective)

(2) Improved end-use technology *(more energy efficient cars, aircraft etc)*

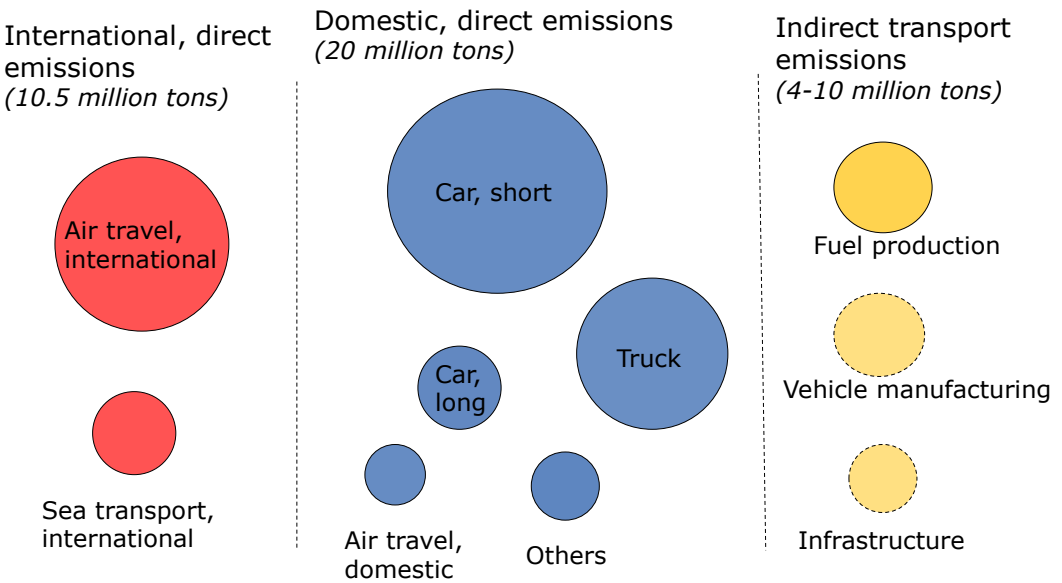
(3) Decrease need for car and air travel and truck transport.
May be achieved by urban planning, modal shift to cycle, rail, bus, IT-communication, local production etc)

Emissions= Activity * Energy efficiency * Carbon intensity* Population

Example: (passenger-km) (kWh/p-km) (kg CO2/kWh)

Life-cycle perspective needed

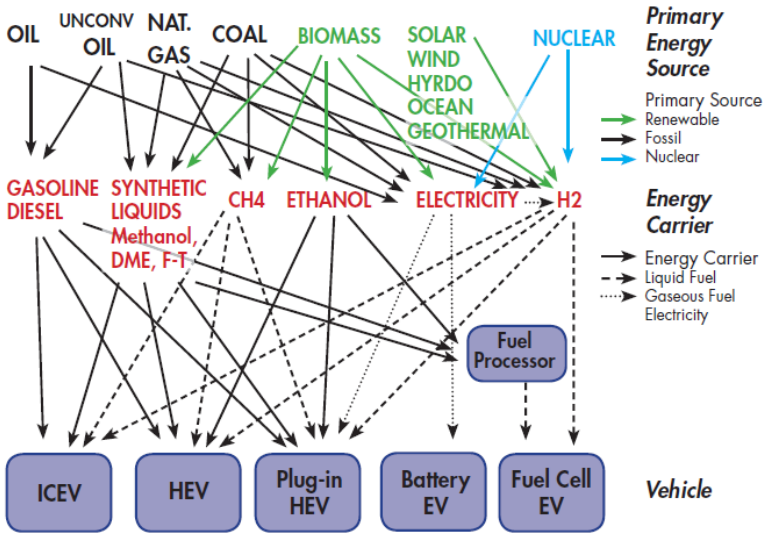
Greenhouse gas emissions from different sub- systems of "Swedish" transport in 2005 (CO_2-equivalents)



Car concepts that may reduce CO2-emissions

- Fuel effective diesel cars emitting less than 95 g CO2/km
- ”Conventional” hybrids (e.g. Toyota Prius)
- Plug-in hybrids (20-80 km *electric* range)
- Fuel cell hybrids
- All-electric cars (around 150 km range)
- Cars running on renewable fuels
- Lighter cars with better aerodynamics

Possible fuel pathways: Primary energy➔ Energy carrier ➔ Vehicle type



Source: Ogden & Anderson, 2011. Sustainable transportation energy pathways

Vehicle/fuel concepts – Which is the best one regarding climate impact?

- Efficient diesel car (biodiesel/fossil diesel)
- Ethanol fuelled car (E85/gasoline)
- Gas fuelled car (biogas/natural gas)
- Plug-in hybrid electric car (electricity/gasoline)

What factors are affecting the climate impact of these cars?

- Energy efficiency of the car (kWh per vehicle-km)
- Driving patterns
- What fuel that is filled (for multifuel cars)
- How that fuel is produced (life-cycle)

Two vehicles with two driving (fuelling) patterns

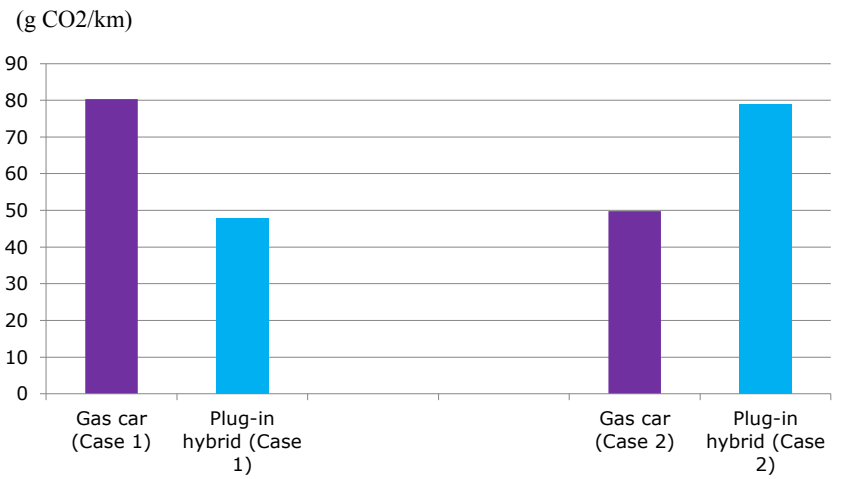
Driving/fuelling pattern, Case 1:

- **Gas car** fuelled by 50% natural gas and 50% biogas
- 70% total mileage for **plug-in hybrid** is driven in electric mode. (trips shorter than 50 km).

Driving/fuelling pattern, Case 2:

- **Gas car** fuelled by 90% biogas
- 40% of total mileage for **plug-in hybrid** is driven in electric mode. (trips shorter than 50 km).

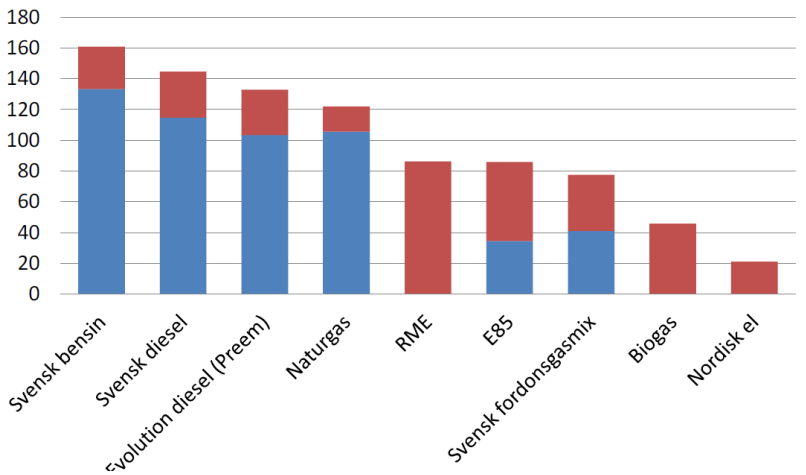
Emissions for gas car and plug-in hybrid in two cases



Possible fuels for transport

- **Diesel/gasoline**
- **Methane** (biogas, natural gas)
- **Ethanol**
- **Synthetic liquids** (methanol, DME, F-T diesel)
- **Hydrogen**
- **Electricity**

Emissions per vehicle-km for a VW Golf class car using different fuels.



Criteria for ”good” renewable fuels

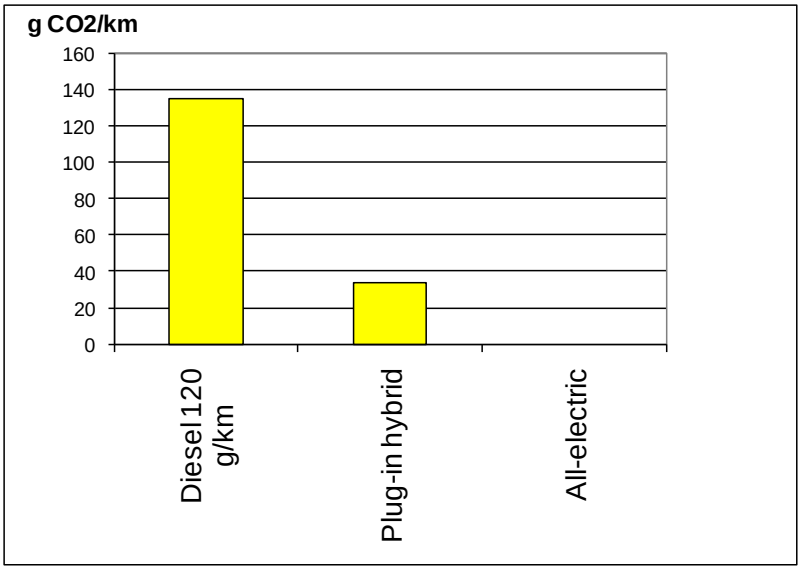
Criteria *Renewable fuels*	Reduction of GHG	Resource base	Mature technology	Cost	Applicable to many transport modes
Biogas	Great	Small	Yes	Medium	yes
Ethanol from sugarcane	Medium	Medium	Yes	Medium	In between
Biofuels from gasified biomass	Medium	Medium-Large	No	Uncertain	Yes
Hydrogen	Possibly great	Large	No	High	Yes
Electricity	Possibly great	Large	No	High	No

Conclusion on fuels

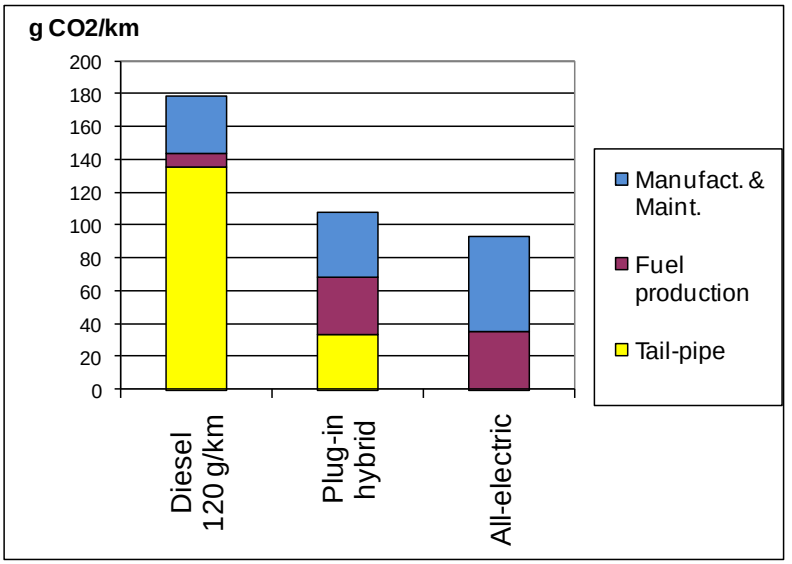
- There will not be a single fuel that will replace fossil fuels in the future.
- We will probably see a combination of fuels such as electricity, biogas, ethanol, synthetic diesel etc (and hydrogen in fuel cells in the longer term)

Electric cars

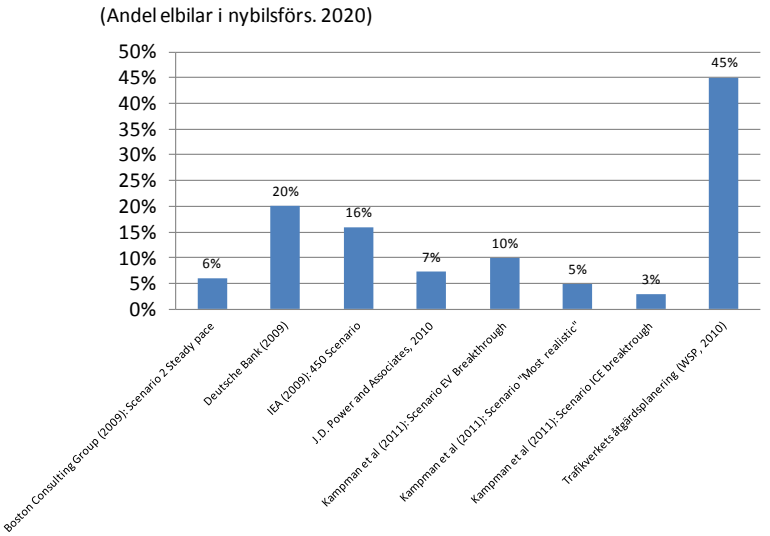
Tail-pipe emissions:



Life-cycle emissions



Forecasts of share for electric cars in car sales 2020



Battery electric cars

Advantages:

- Low energy use and low emissions

Obstacles:

- Limited range (often around 150 km, but up to 400 km)
- Batteries need more development
- High cost >10 000 Euro extra
- Energy/emissions for vehicle manufacturing increases

Plug-in hybrids

Advantages:

- Low energy use and low emissions when in electric mode
- No problem with range (20-80 km in electric mode), then switch to e.g. gasoline or diesel)

Obstacles:

- Batteries need more development
- High cost >10 000 Euro extra
- Energy/emissions for vehicle manufacturing increases

Electric cars

- Will probably be an important part of future short-distance transport.
- Plug-in hybrids will probably take a larger market share than all-electric vehicles.
- BUT, expectations presently seem to be too high
  - Environmental benefit will be a bit lower than expected
  - Penetration of electric cars in the fleet will not be as fast as expected

Average occupancy in short distance car travel (<100 km) in EU-countries: about **1.25 persons.**

Average speed in urban commuting is around **50 km/h.**

Mostly cars with 5 seats and a maximum speed of 200 km/h are used....

Small electric vehicles for 1-2 persons

Biofuels

- Biofuels could be used for all transport modes, also aviation and sea transport.
- In the long term the supply of bioenergy may be a limiting factor
- Costs are moderate

Hydrogen (used in fuel cell vehicles)

- The only emission is water
- Technology is at present very expensive
- Need development of network of fuelling stations
- Could be used for most modes, except aviation.

Is it possible to reach climate targets (2-degree target) by improved technology and low carbon fuels?

Technology scenario for 2050 – The example of Sweden

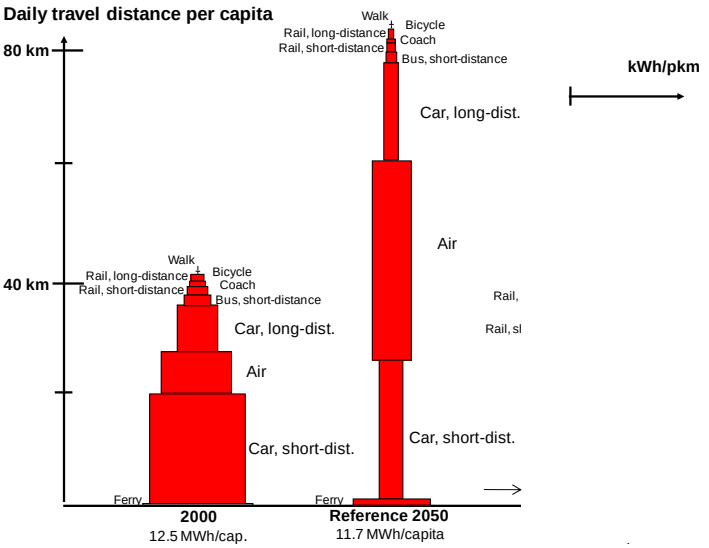
Specific energy use assumed in Technology scenario for 2050

Car	-65% (-85%)	(kWh/person-km)
Aviation	-54%	(kWh/person-km)
Freight transport	-30-70%	(kWh/tonne-km)

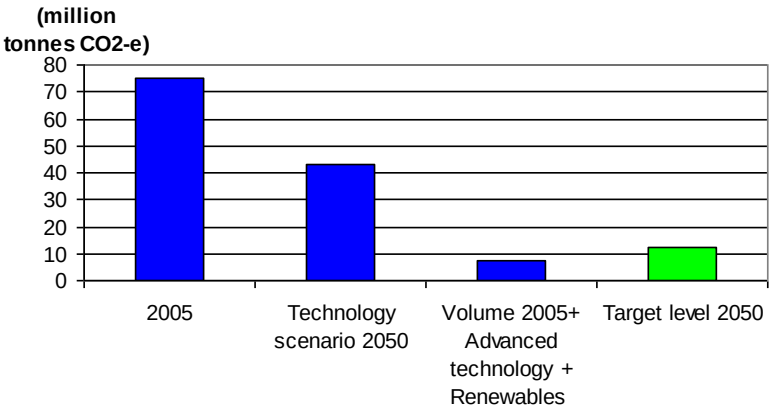
Supply of carbon neutral energy in the Technology scenario 2050

- Bioenergy **200 TWh** (112 Twh)
- Wind power **45 TWh** (15 TWh)
- Hydro power **68 TWh** (65 TWh)
- Fuels with carbon storage **20 TWh** (0 TWh)
- Nucear power phased out until 2050
- For remaining Energy demand fossil fuels are used

Transport image for 2050 with much improved vehicle technology and low carbon fuels but no demand management,



Resulting emissions in the Technology scenario 2050



Conclusion, if the 2-degree target should be met.

New technology and low carbon fuels are important but not sufficient to reach climate targets.

Transport volumes for cars, trucks and aircraft also need to be limited in industrialised countries.

Total travel distance per capita could be as in Sweden around 2005