Environmental aspects of inter-city passenger transport

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Inter-city passenger traffic

is a segment of passenger transport where

- aviation,
- cars,
- buses,
- conventional trains, and
- high speed trains

naturally compete for market shares

The task

- The objective is to analyze whether investment in high speed rail infrastructure is justified when the goal is to reduce the environmental impact of inter-city passenger transport
- The potential benefits from travelling at average speeds below 100 km/h are disregarded in the choice of alternatives

Analyzing long-term effects

- Ideally the benefits should be calculated year-by-year and discounted into present value
- However, no expert can tell us what vehicles and engines may look like 30-40 years from now
- In this paper therefore the expected best new vehicle and fuel technologies of 2025 are used as a proxy for the entire depreciation period

Focusing on greenhouse gases

- By 2025 all tailpipe emissions from **new** vessels and vehicles are assumed to have been reduced to sustainable levels
- All power plant emissions are also assumed to have been reduced to sustainable levels
- Noise, land use and intrusion are disregarded as they are to a large extent site-specific
- Greenhouse gas emissions are studied in a tank-to wheels or grid-to-wheels perspective

The electricity consumption per train seat kilometer depends on

- Train length
- Number of seats per length meter
- Aerodynamics
- Weight
- Tunnel length and tunnel diameter
- Average speed and top speed
- Number of stops and accelerations/decelerations
- Engine efficiency and degree of regenerative braking

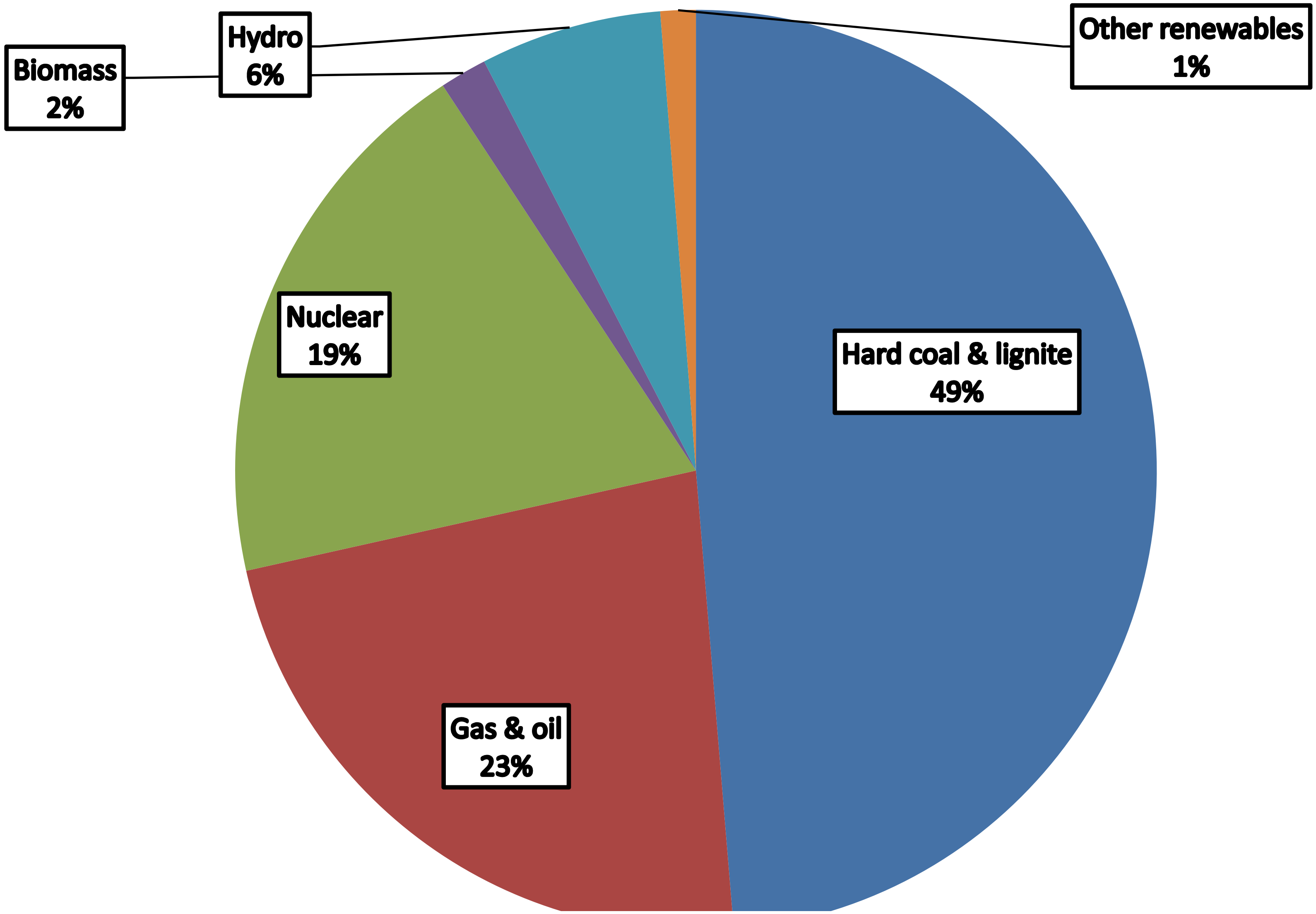
No marginal cost-curves for efficiency improvement in high speed rail

- All else equal, energy consumption increases with the square of speed
- High speed trains should therefore be able to afford to invest more in reducing the drag than conventional fast trains
- However, the marginal cost-curve may be rather flat
- Longer trains and more seats per train meter may also reduce specific consumption

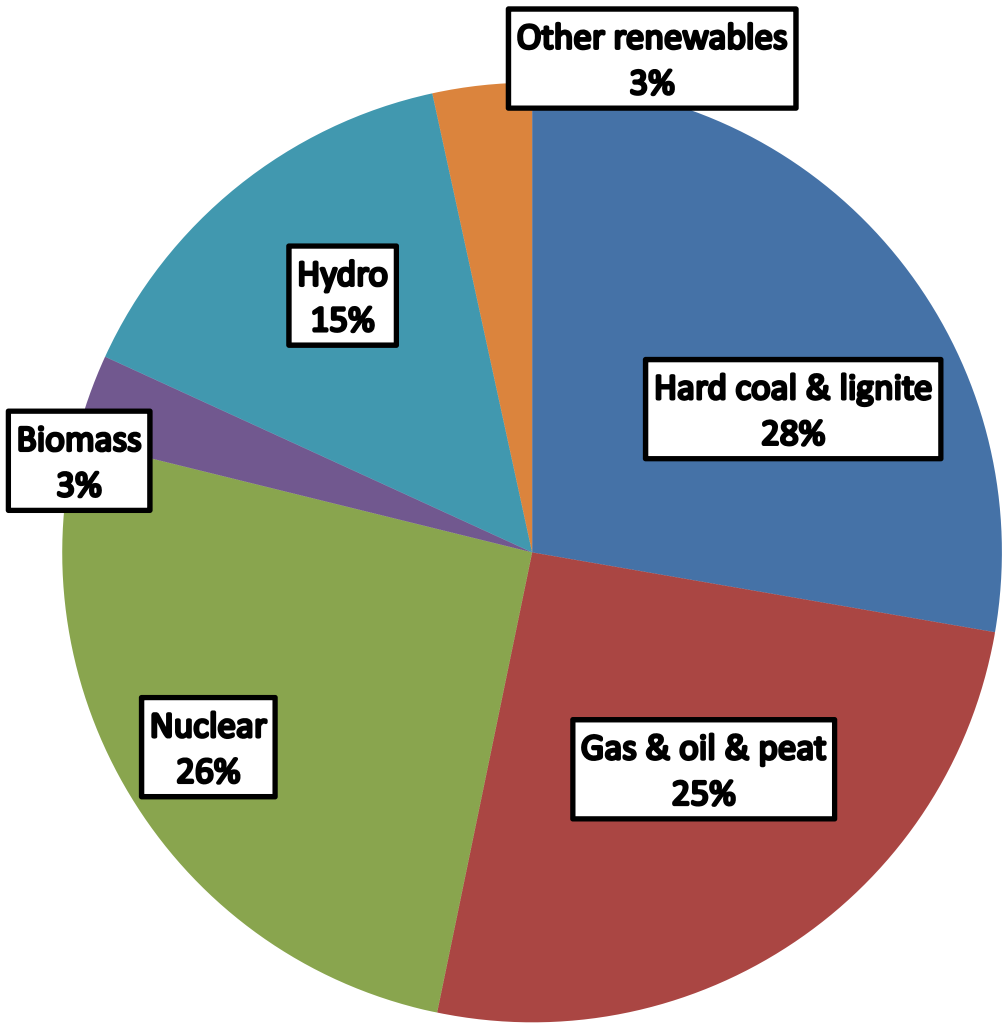
Marginal effects

- When studying change, marginal effects is what matters
- The paper assumes that the marginal electricity is produced in power plants that use hard coal during the first two decades, followed by natural gas during the next three
- The 2025 cars and buses with IC engines are assumed marginally to run on a mix of 80% diesel/gasoline and 20% biofuel

Electricity production in the US 2007

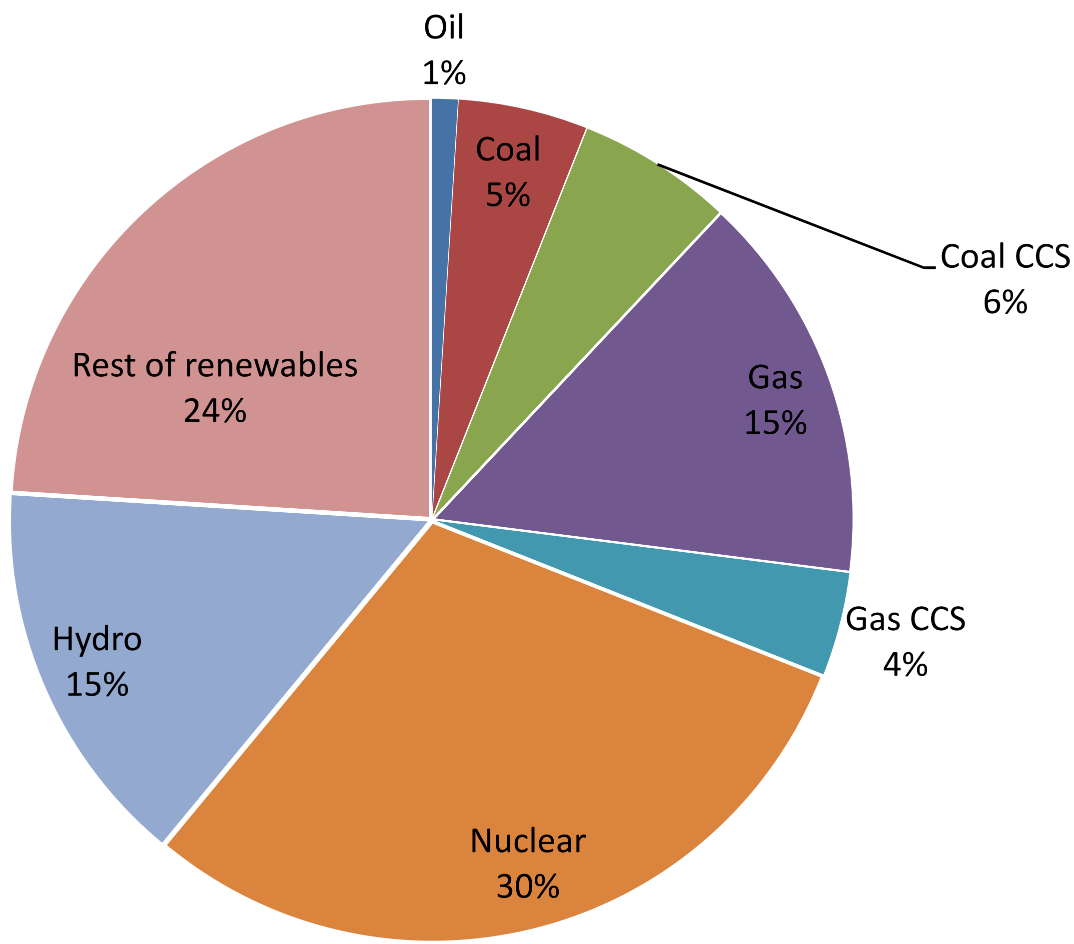


Electricity production in OECD Europe



Electricity consumption by fuel in the OECD+ 2030 scenario 450

(World Energy Outlook, 2008)



Effects of cap-and-trade

- In Europe it has been argued that emissions caused by trains may be disregarded as the total emissions from electricity production is subject to cap-and-trade and cannot rise
- However, emissions from all modes may be subject to a cap as proposed in the US
- Rising demand will make the price of allowances increase, and a high price may make politicians hesitate about future reduction targets

Other greenhouse gases than CO_2

- The total radiative forcing from short range commercial aviation is assumed to amount to 1.5 of the emission of CO_2 (alone)
- GHG emissions other than CO_2 from road fuels and electricity production are assumed to be small and are therefore disregarded

Gram $CO_{2equiv.}$ per seat km

Mode	Emission
Cars with IC engines	18.3
All-electric cars	21.2
Long-distance buses	10.5
Fast trains (average 150 km/h)	9.5
High speed trains (average 280 km/h)	15.4
Short range aircraft	93.8

Assumed average load factors

Mode	Factor
Cars with IC engines	0.40
All-electric cars	0.40
Long-distance buses	0.55
Fast trains (average 150 km/h)	0.65
High speed trains (average 280 km/h)	0.75
Short range aircraft	0.80

Gram $CO_{2equiv.}$ per passenger km

Mode	Emission
Cars with IC engines	45.8
All-electric cars	53.0
Long-distance buses	19.1
Fast trains (average 150 km/h)	14.6
High speed trains (average 280 km/h)	20.6
Short range aircraft	117.2

Traffic generated by investment in high speed rail line, an example

	Share of traffic %
Diverted from aviation	20
Diverted from cars	20
Diverted from buses	5
Total shift	**45**
Generated new traffic	25
Total increase in train traffic	**70**
Pre-existing train passengers	**30**
Total traffic by train	**100**

Effects on CO_2 emissions per 1 million 500 km trips

	Tons
Diverted from aviation	-9,660
Diverted from cars	-2,620
Diverted from buses	+38
Generated new traffic	+2,575
Pre-existing train passengers	+900
Total traffic by train	**-8,767**

Sensitivity analysis, an example

Reducing the marginal climate effect from electricity consumption by half compared to the main scenario and raising the share of total traffic that is diverted from aviation to 30% (and reducing the car share to 10%) would in combination reduce emissions from every one million trips by about **16,000 tons**.

GHG emissions from building the line

- Building a 500 km new high speed line usually requires lots of tunnels and bridges
- The GHG-emissions from construction may amount to several million ton CO_2
- Depending on traffic intensity and site-specific circumstances it may take 20-60 years to offset the emissions caused by the construction work

The economic value

- The market price of CO_2 may be about €40 per ton in 2025
- When emissions are reduced by 9,000 tons per 1 million passengers per 500 km, a total number of 10 million trips/year would generate less than €4 million worth of GHG emission benefits (or €200 million over 50 y).
- According to the UIC, the cost of building a 500 km line amounts to €6,000-15,000 million

Conclusions

- The GHG benefit of high speed rail is small and may be negative when account is taken of emissions from building the line
- Fast conventional trains emit substantially less and require sometimes only moderate investment in up-grading of the existing infrastructure
- Numerous opportunities exist to reduce transport GHG by less costly measures
- Other benefits may justify investment in high speed rail but high traffic volumes are required

Thanks for your attention

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