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Electric vehicles or use of hydrogen in the Norwegian transport sector in 2050?

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DTU Management Engineering

Department of Management Engineering

Agenda



- Research motivation
- STREAM model
- 2050 scenarios reference, EV and H₂
- Scenario results
 - In a Nordic content



Research motivation Norway



- highest number of electric vehicles per capita in the world
 - 43,442 EV per December 2014

Radical restructuring of fuel use and vehicle stock

System integration with the electricity market

- A significant share of the electricity demand will come from the transport sector - directly or in-directly via H2 production
- Larger share of wind in the power supply in the future
- Limited domestic biomass resources
- Need for a flexible demand?
- EV or H₂?
 Which costs?
 Interaction with the energy sectors?





STREAM model



INDUTS

Flow Model Inputs

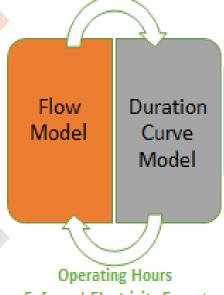
- Energy Demand
- Production
- Conversion Factors
- Technological Development
- Fuel Prices
- Costs
- Emission Factors

Duration Curve Model Inputs

- Time Series (heat, wind, solar, electricity consumption)
- Flexibility of Electricity Consumption
- Heat Storage
- Priority of dispatch into the grid and the DH network

MODEL CALCULATIONS

Demand and Production



OUTPUTS

- Energy balance
- Fuel Consumption
- Import/Export (Fuels)
- Emissions
- Costs (Capital, Fuel, O&M, Energy Savings, CO₂)

Operating Hours
Enforced Electricity Export
Heat Surplus



Scenarios for 2050



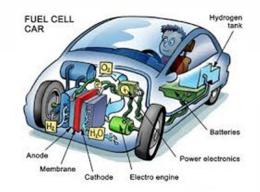
Carbon Neutral Scenario (CNS) from NETP



Electric Vehicles (EV)



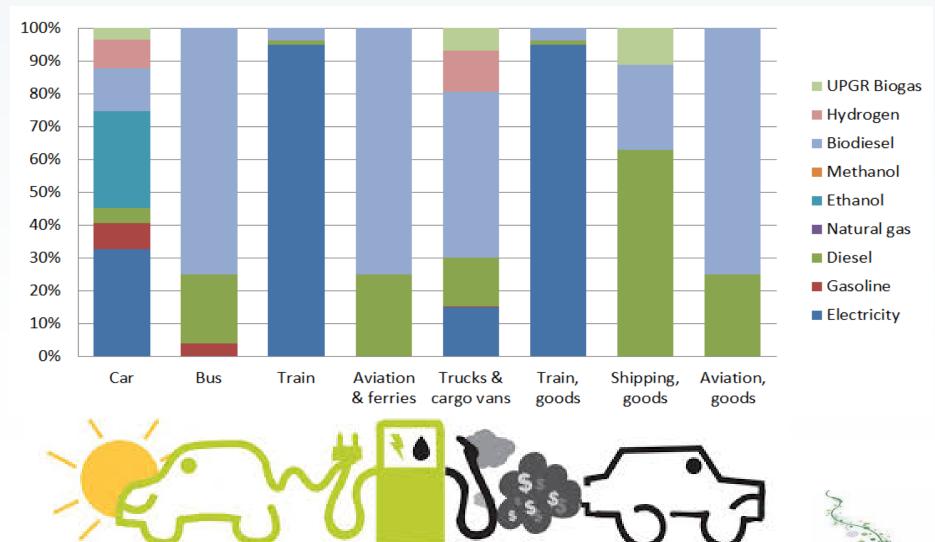
Hydrogen (H₂)





Reference - Carbon Neutral Scenario - CNS

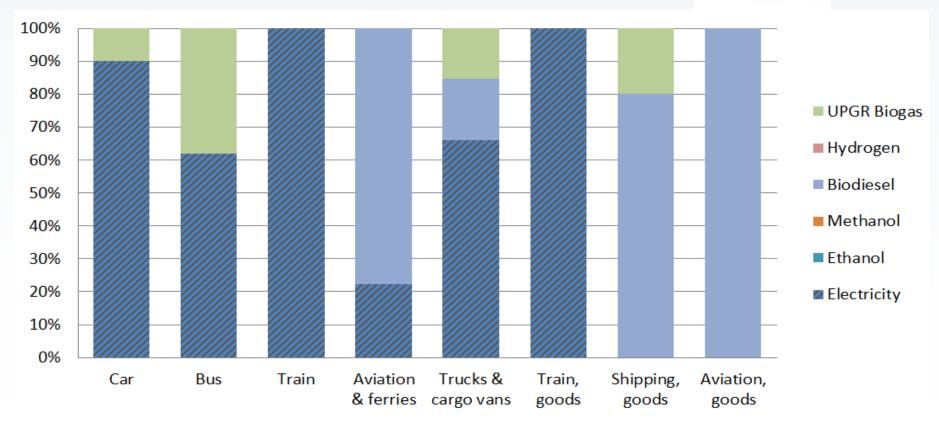




Electric Vehicles Scenario - EV





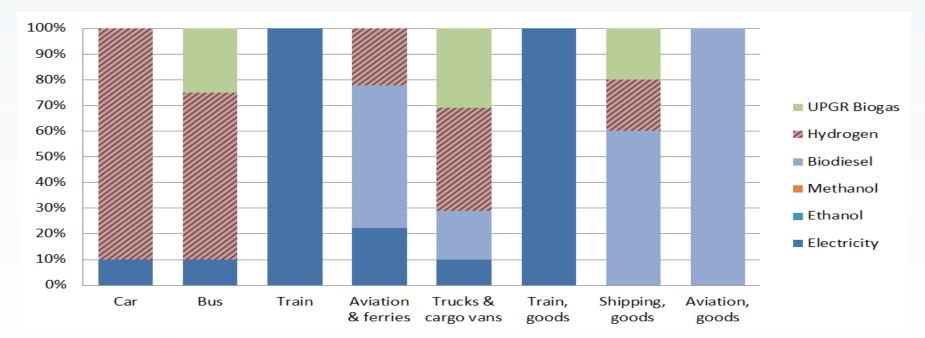


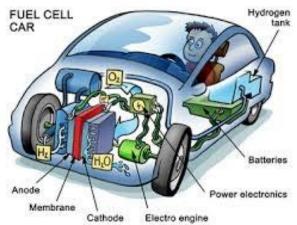




Hydrogen Scenario - H₂









Technology mix in the electricity sector

DTU

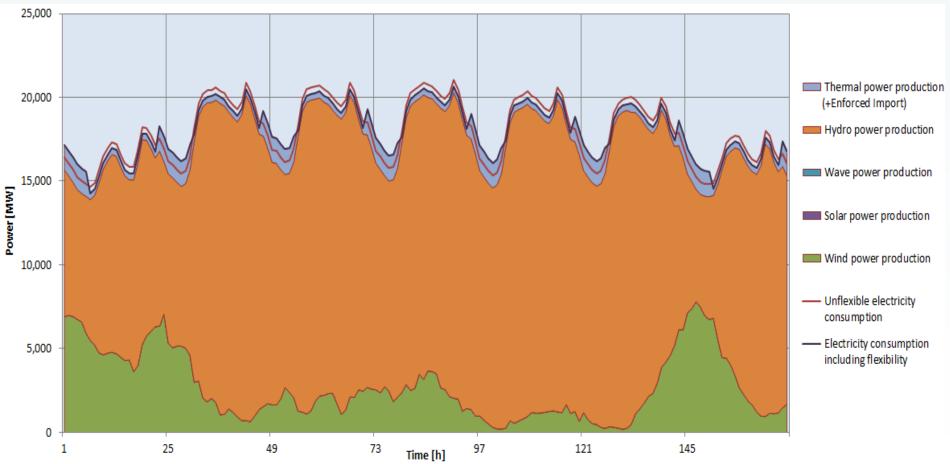
Liectricity production	J	CNC 2050	F \/	1	Dana	CNIC 20E0	5 \/	
	Base	CNS 2050	EV	H ₂	Base	CNS 2050	EV	H ₂
					[TWh]	[TWh]	[TWh]	[TWh]
Coal Plant	0.1%	-	-	-	0.1	-	-	-
Gasturbine	4%	-		· ·	4.8	-		
Wind, offshore	-	5%	5%	10%	-	5.9	7.7	15.1
Wind, onshore	1%	7%	12%	13%	0.9	8.7	16.8	19.7
Biomass	-	0.4%	0.4%	0.4%	0.5	0.5	0.6	0.6
Waste incineration	-	0.4%	0.4%	0.4%	-	0.5	0.6	0.6
Photo voltaic	-	-	-	-	-	-	-	-
Nuclear	-	-	-	-	-	-	-	-
Geothermal	-	-	-	-	-	-	-	-
Coal CCS	-	-	-	-	-	-	-	-
Biomass CCS	-	1%	-	-	-	1.3	-	-
Hydro	94%	87%	82%	76%	117.5	113.9	113.9	114
Electricity imports	1%	-	-	-				
Total production		100%	100%	100%	123.8	130.9	139.5	149.9





Scenario Results - EV

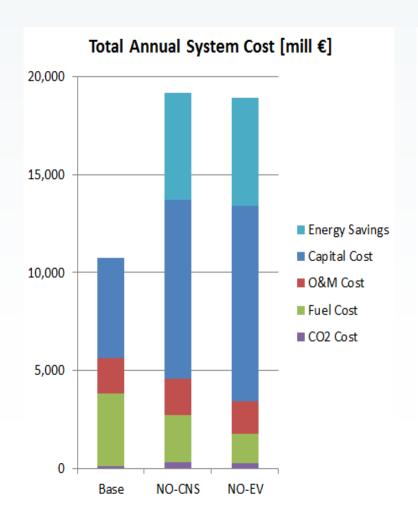


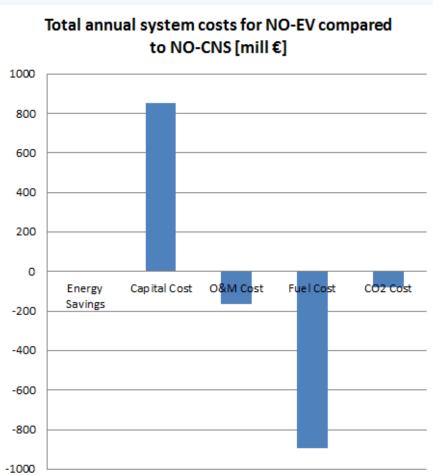


In contrast to the other Nordic countries, there is not a demand for the transport sector to have a flexible fuel demand in order for the Norwegian energy systems to adjust to a larger share of EV or H_2 .

Total annual system costs and the difference between the CNS and the EV scenario (mill €)



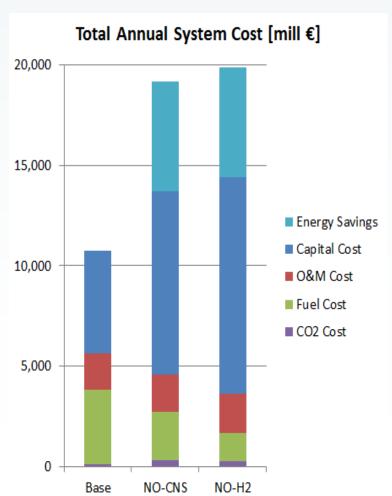


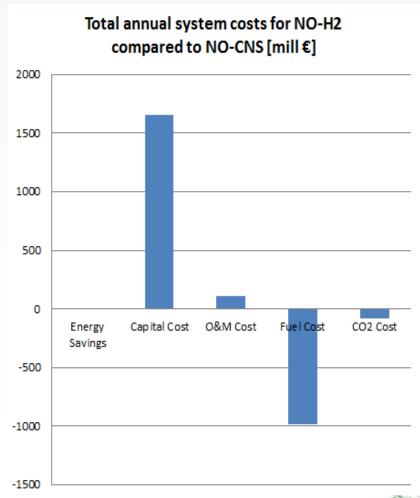




Annual system costs and the difference between the CNS and the H₂ scenario (mill €)



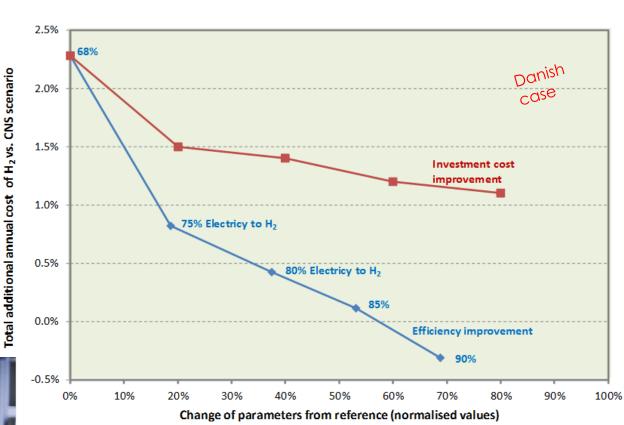






Innovation and technological path - H₂







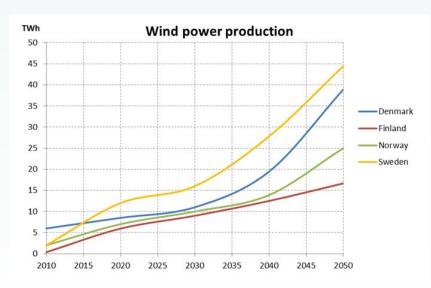
In a Nordic content





- Large deployment of wind
- Need for flexibility especially in DK
 - H₂ generation from electrolysis is more flexible than charging EV

- Hours with excess wind generation which release hydro-power capacity
 - Reduce the need for additional capacity in the H₂ scenario
 - Increase the value of Hydro power



- Biomass resources in Finland and Sweden
 - Bio-fuels cheaper
 - depends on the development of 2nd and 3th generation bio-refineries



Main findings



- EV could reduce the socio-economic cost of the system in 2050
- The Norwegian hydropower supply is very flexible and can therefor easily adjust to the variable electricity generation from wind energy
 - no demand for the transport sector to have a flexible fuel demand in order for the Norwegian energy systems to adjust to a larger share of EV or H₂.
- More Nordic integration and use of excess generation might decrease the cost of the H₂ scenario





Thank you for your interest





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Resources available and used (PJ)

