

# Modelling impacts of policy schemes for increased forest-based biofuel production in the Nordic countries

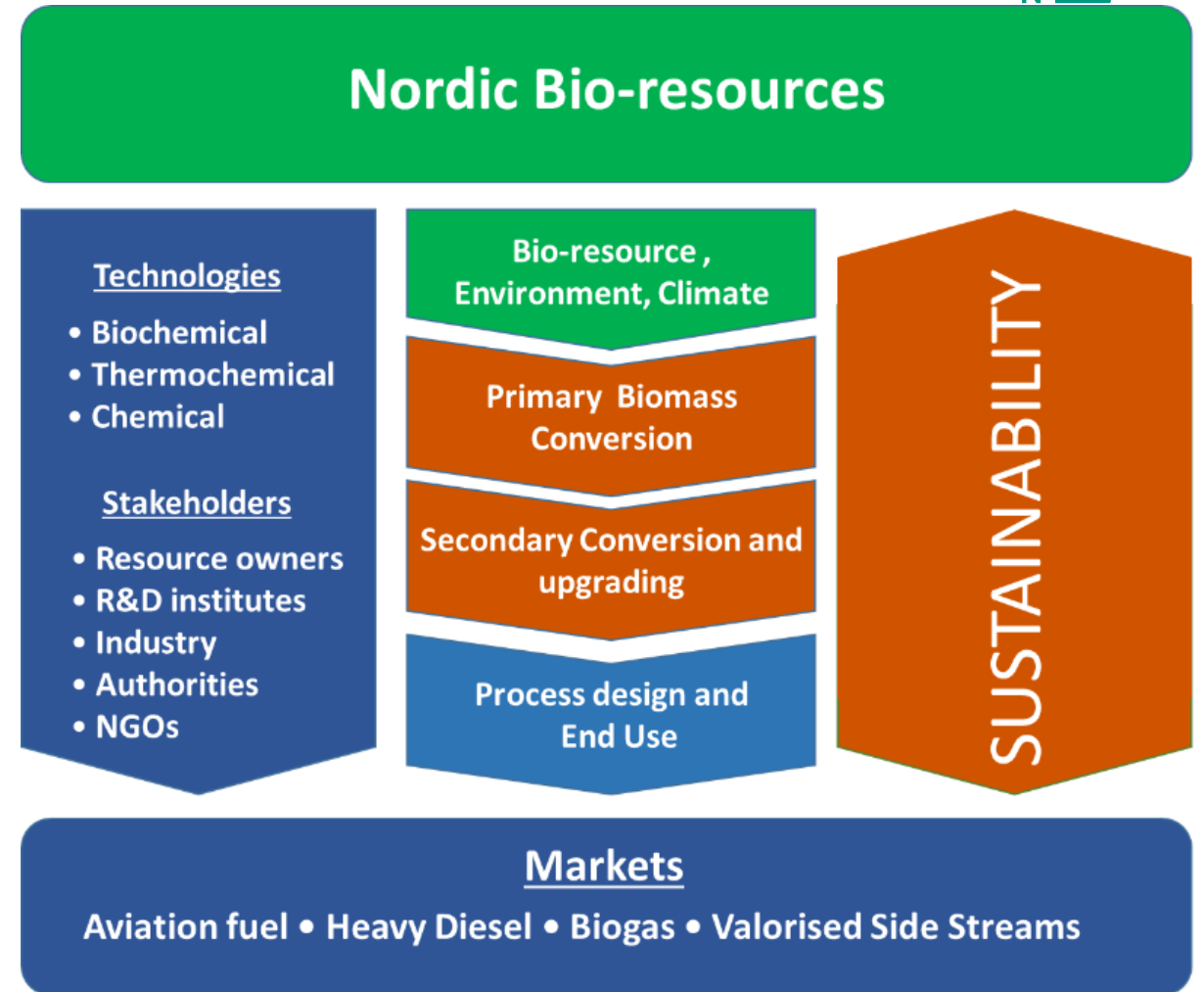
Eirik Ognér Jåstad, Per Kristian Rørstad, Torjus Folsland Bolkesjø

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# BIO4 FUELS

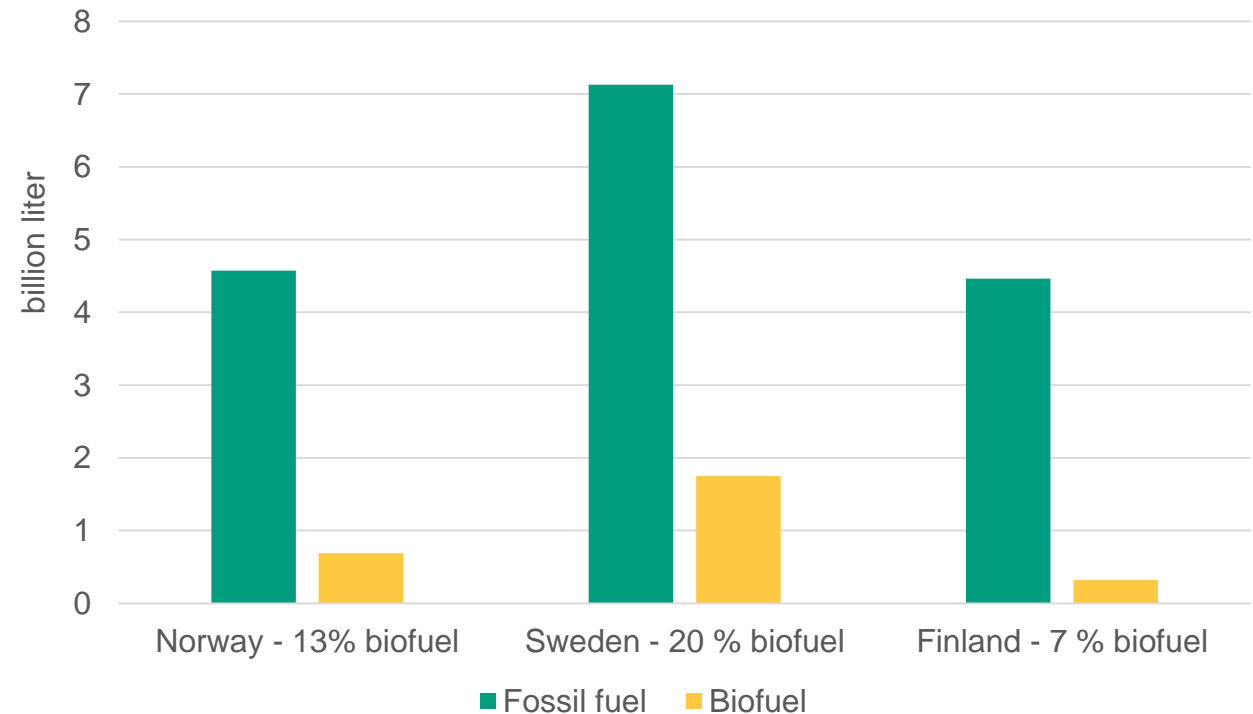
- Norwegian Centre for Sustainable Bio-based Fuels and Energy
- Bio4Fuels aims to contribute to the reduction of emissions from the Norwegian transport sector through coordinated research efforts to establish the basis for sustainable routes to advanced biofuels.



# Biofuels in the Nordic countries

- So far, mainly first-generation biofuel
- Small amount of second-generation raw materials

Actual consumption of fossil fuel and biofuel in Norway, Sweden and Finland – 2017



# Nordic targets and policies

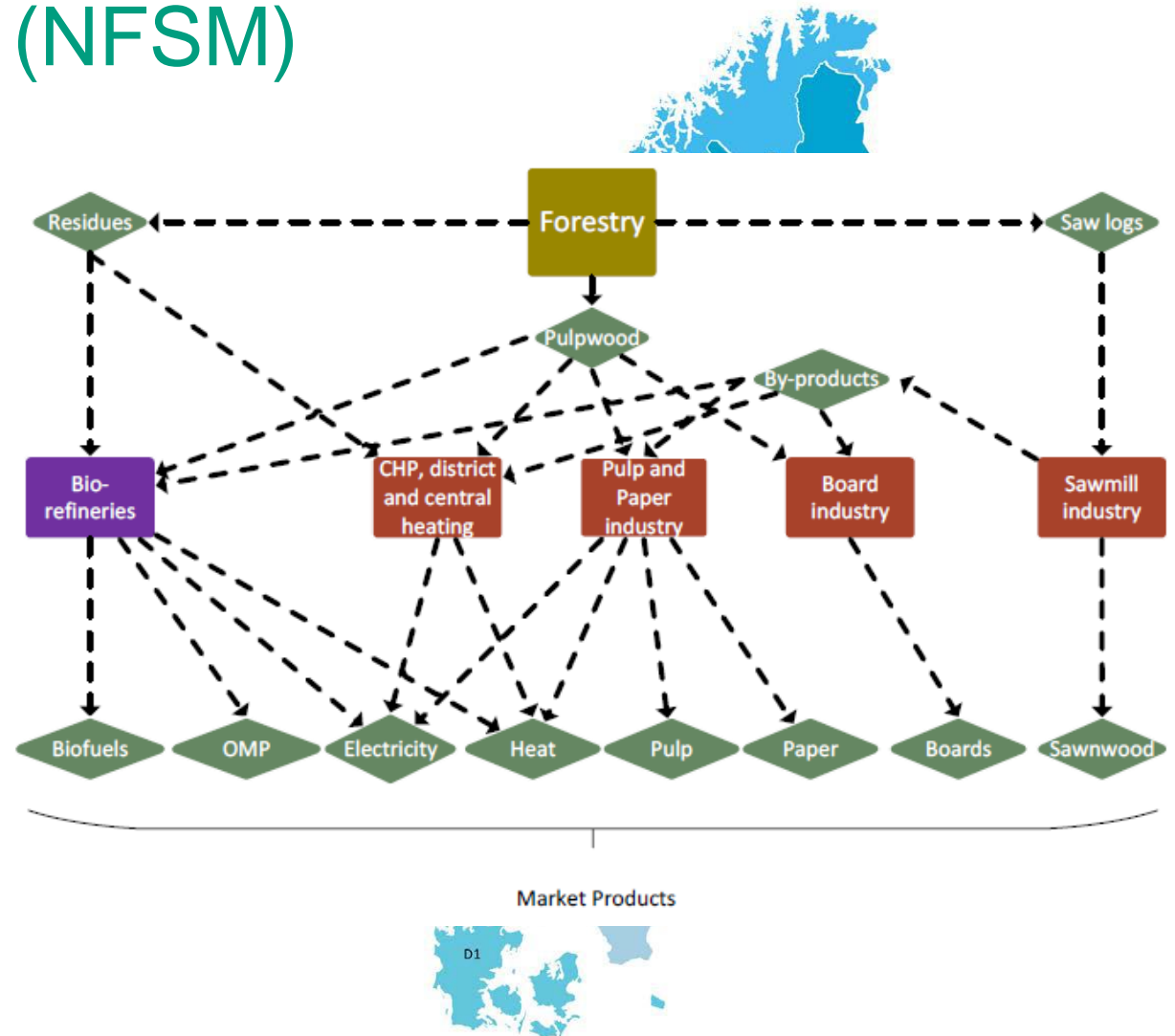
- Norway
  - Quota obligation
    - At least 3.5% (2018), 8% (2020), 16% (2030) advanced biofuel with doublet counting
- Sweden
  - Reduction obligation
    - CO2 reduction
- Finland
  - Quota obligation
- Denmark
  - Quota obligation
- EU
  - Double counting
  - GHG emission reduction
  - Max 7 % food-based biofuel

Targets for biofuel in the liquid fuel mix

	2018	2020	2030
Norway	10%	20%	40%
Sweden – diesel	19.3%	21.0%	70%
Sweden - gasoline	2.6%	4.2%	70%
Finland	15%	20%	30%
Denmark	5.75%	10%	
European Union		10%	14%

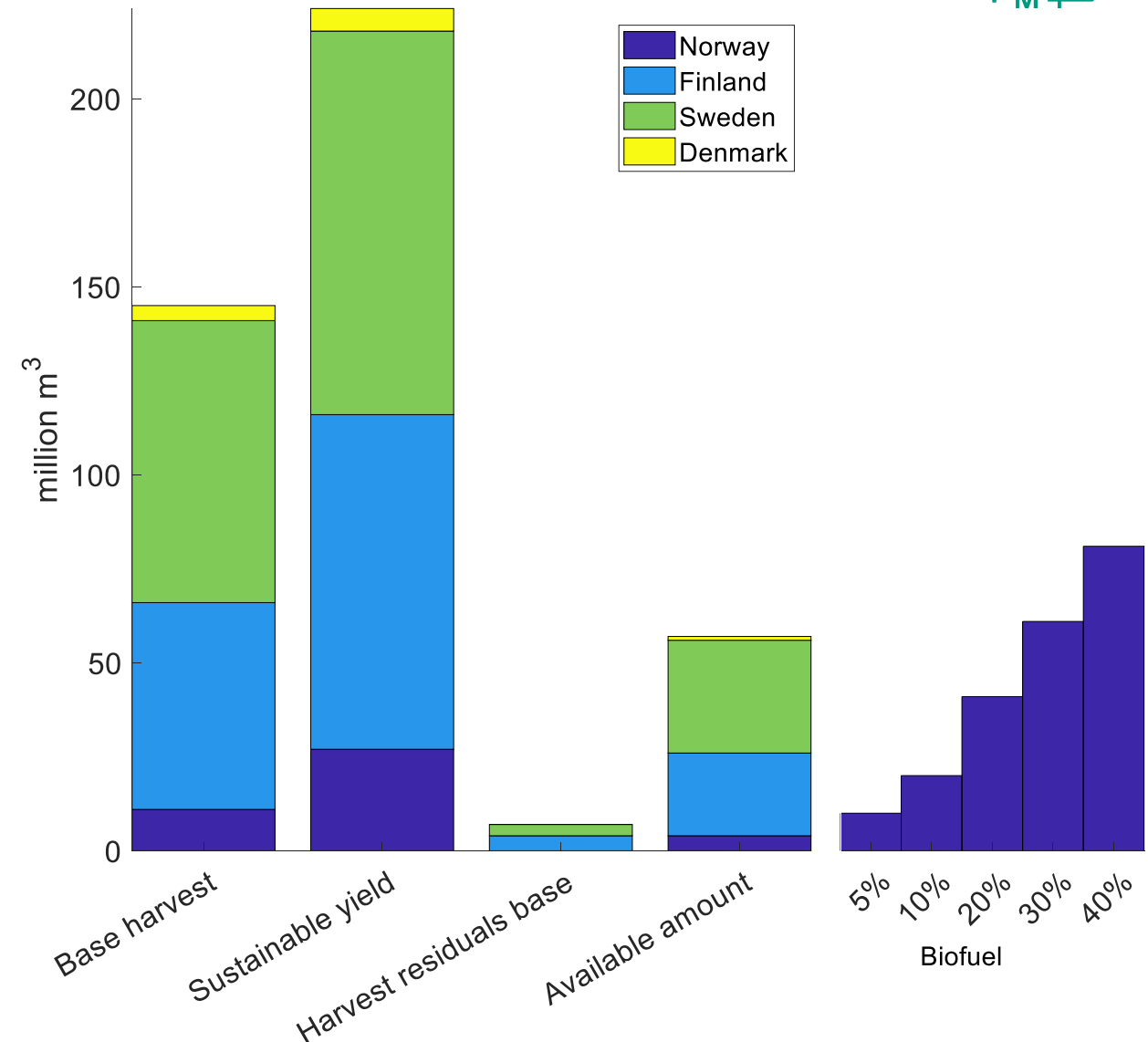
# Nordic Forest Sector Model (NFSM)

- Spatial, partial equilibrium model
- MILP
- Maximising consumer plus producer surplus
- 29 products:
  - Spruce, pine, and non-coniferous sawlogs and pulpwood
  - Harvest residuals
  - 13 final products



# Forest sector

- The Nordic forest sector harvest less roundwood than the growth
- Harvest less harvest residuals than possible
- 40% biofuel production from wood would require about 2/3 of the current harvest



# Biorefineries - assumptions

- 58% efficiency  
=> 1 m<sup>3</sup> pulpwood = 120 L biofuel
- No learning
- Biofuel can be made from:
  - Spruce, pine, and non-conifers pulpwood, residuals from sawmills, harvest residuals, and a mix of them

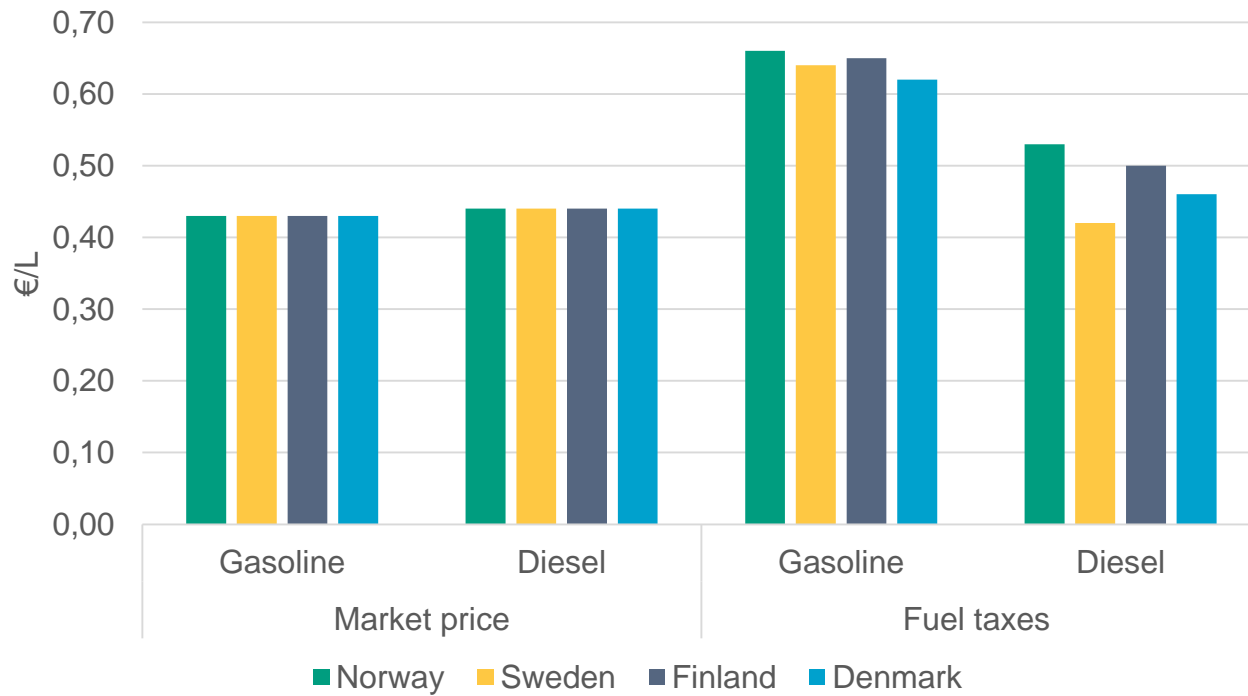
Assumed costs of different production units

Production unit [million L/year]	79	157	236	315
Labour input [h/1000 L]	0.57	0.44	0.38	0.42
Fix costs [€/L/year]	0.56	0.49	0.45	0.42
Investment cost [€/L/year]	0.40	0.34	0.31	0.29
Input roundwood [million m <sup>3</sup> ]	0.66	1.3	2.0	2.6

# Consumption and taxation



Market price and fuel taxes



VAT and minimum selling price of diesel and gasoline

	Norway	Sweden	Finland	Denmark
VAT [%]	25	25	24	25
Selling price diesel [€/L]	1.21	1.08	1.17	1.13
Selling price gasoline [€/L]	1.36	1.34	1.34	1.31



# Assumed subsidy schemes

- Increase fossil fuel taxation  
– 0 -1.8 €/L
- Feed-in premiums  
– 0-2 €/L
- Quota obligations
- Tax exemptions
- Investment support
- Feed stock support  
– Harvest residuals 0-90 €/MWh  
(0-1.6 €/L)

Tax, market price and consumption of fossil fuel

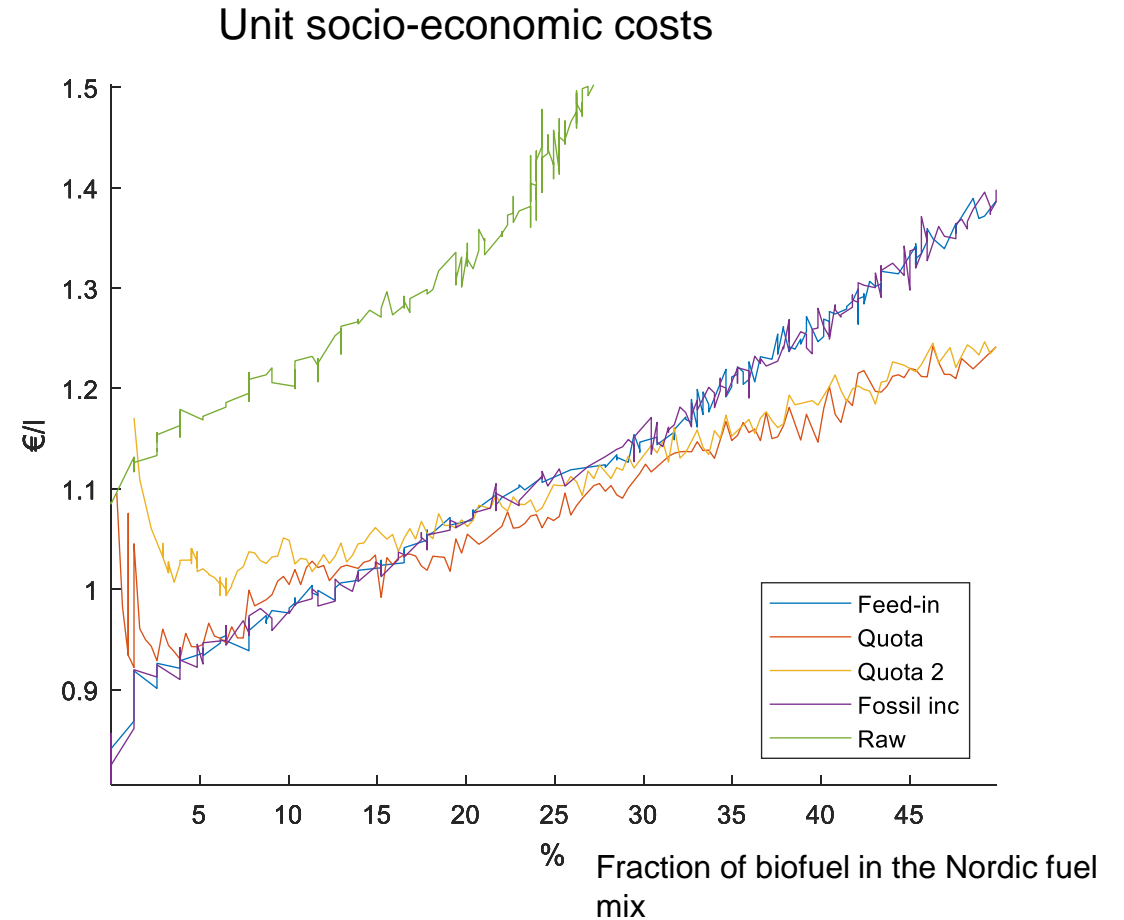
	Norway	Sweden	Finland	Denmark
Market price fossil fuel [€/L]	0.44	0.44	0.44	0.44
VAT [%]	25	25	24	25
Fuel taxes [€/L]	0.63	0.56	0.60	0.56
Consumption of fossil fuel [million L]	4 920	9 597	5 070	4 721

Cost of different production unit

Production unit [million L]	79	157	236	315
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Fix costs [€/L/year]	0.56	0.49	0.45	0.42
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# Model results: Socio-economic costs

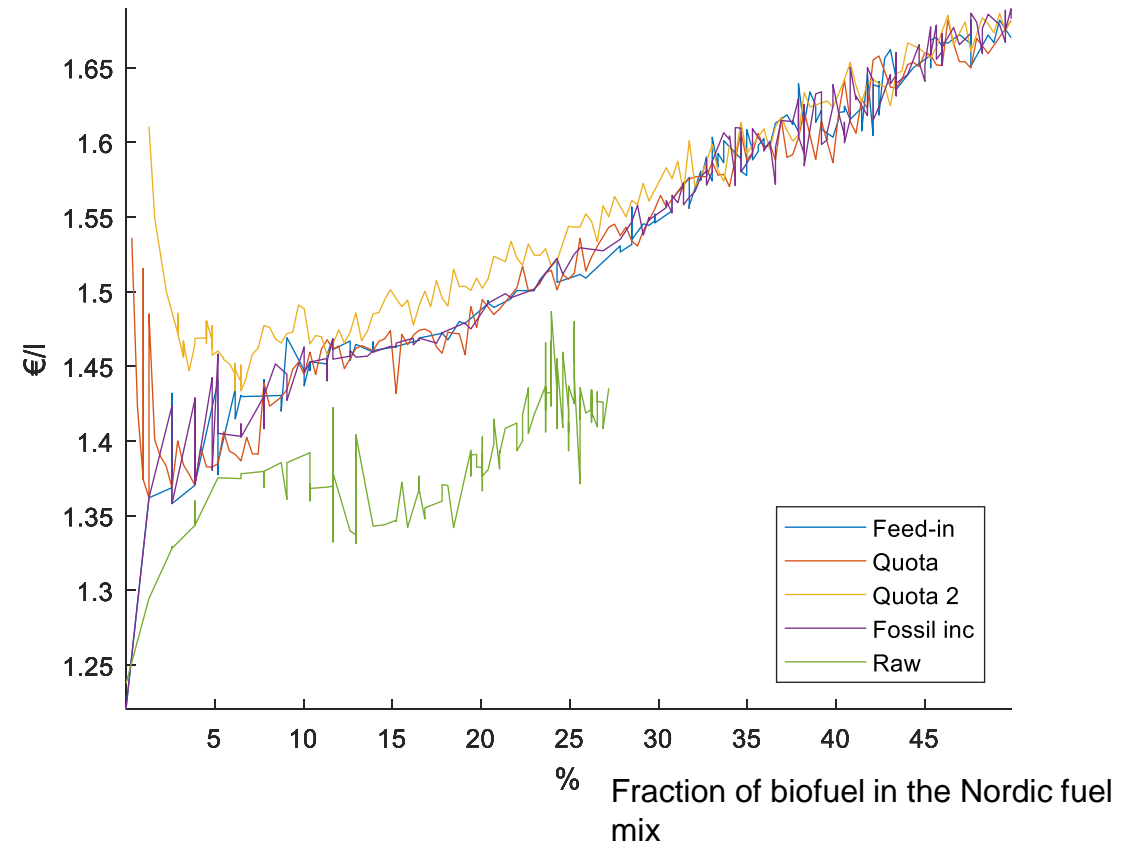
- Feed-in premiums: 0.84 €/L
- Quota obligations total: 1.09 €/L
- Quota obligations country: 1.17 €/L
- Increase in the fossil price: 0.82 €/L
- Support of harvest residuals: 67 €/MWh or 1.08 €/L
- Investment support and tax exemptions did not give any production with the tested subsidy levels



# Model results: Production costs

- Increasing due to increased chips prices
- Highest for national quota obligations, due to higher labour cost and less easy available biomass in Norway and Denmark than in Sweden and Finland
- Lowest unit cost for harvest residues, due to the low demand of harvest residues

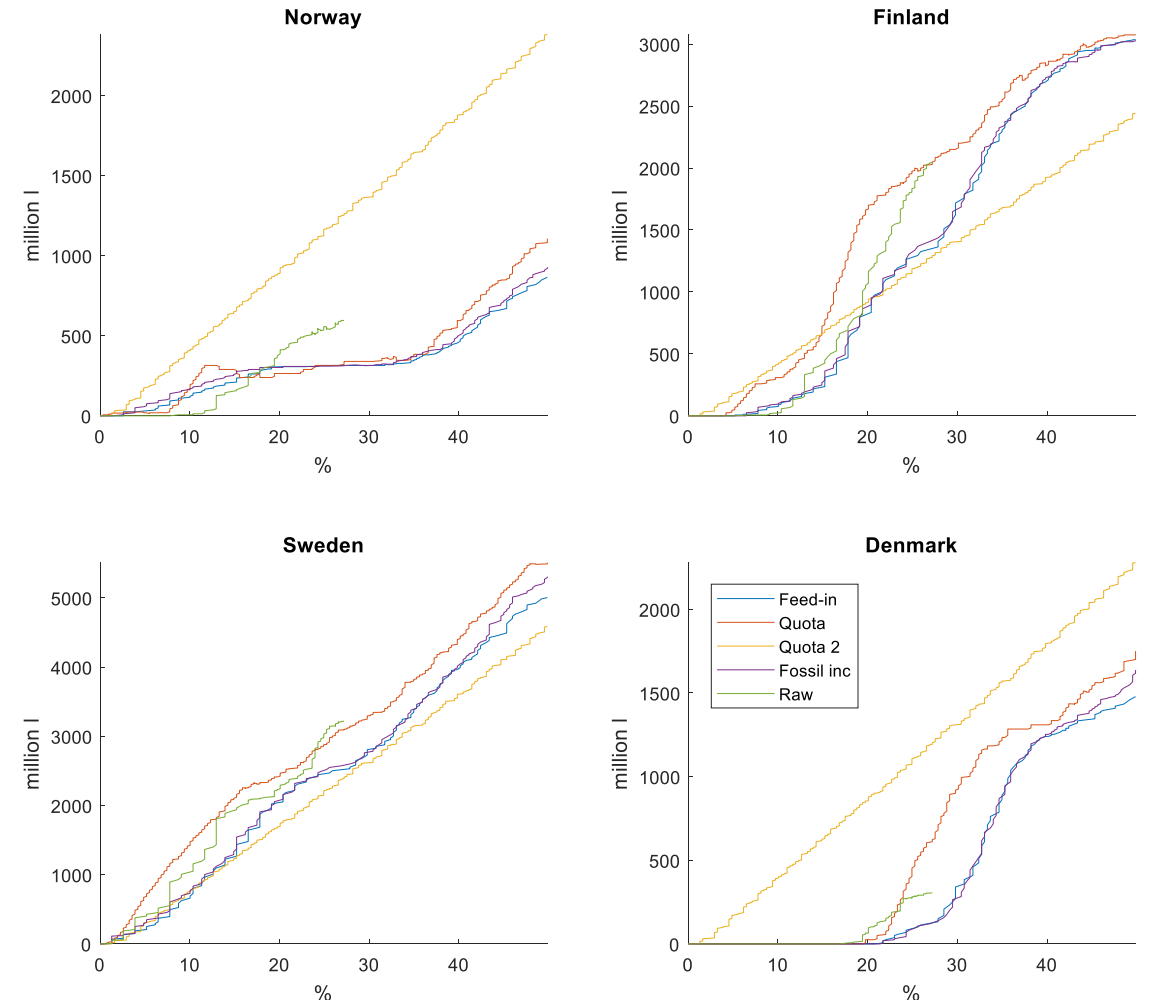
Modelled unit production costs



Fossil fuel reference price: 0.44 €/L

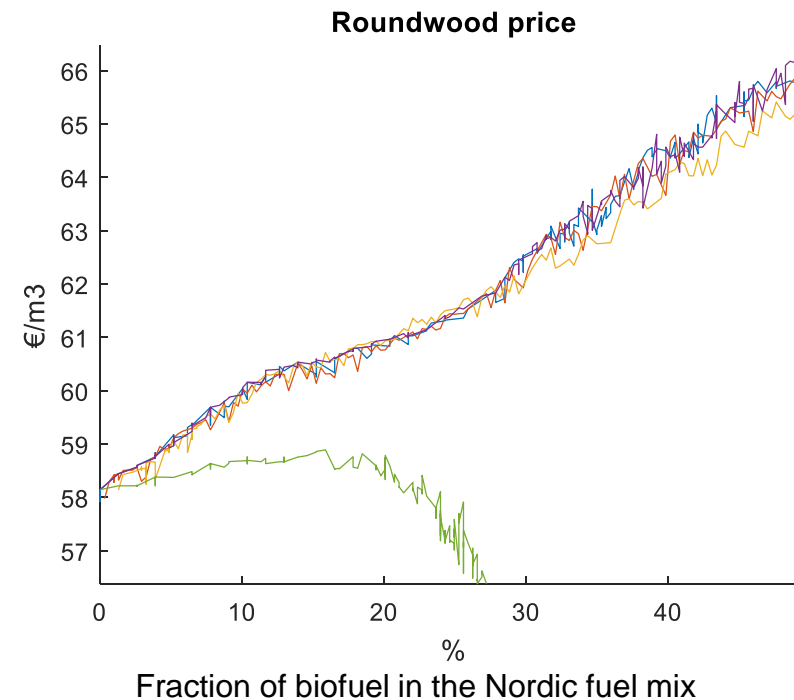
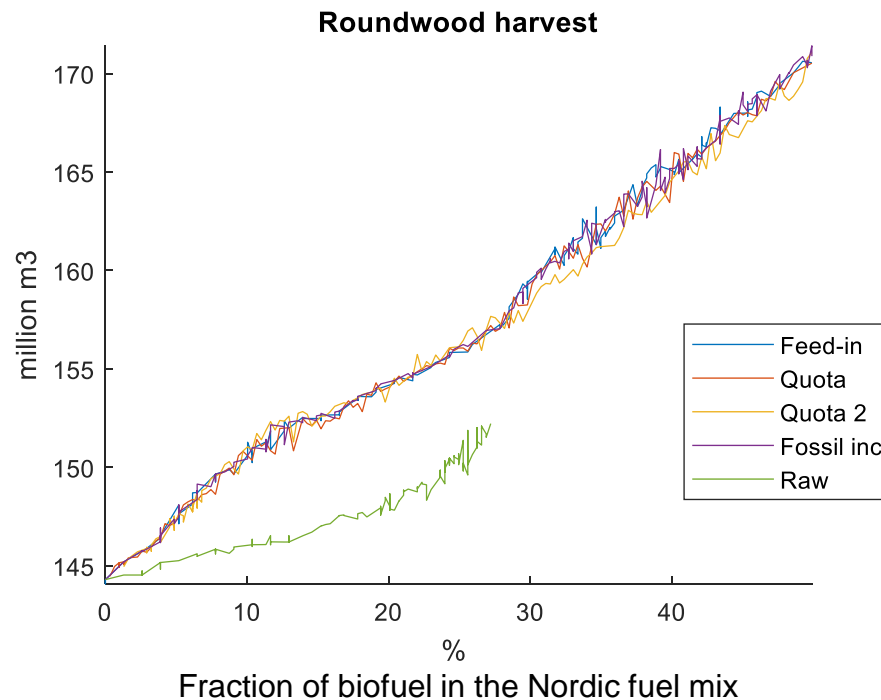
# Model results: Production in different countries

- Norway and Denmark get a lower fraction than they consume
- Increase in fossil fuel price and feed-in premiums are identical



# Model results: Harvest levels and wood prices

- Roundwood increase for both sawlogs and pulpwood, but the increase is largest for pulpwood



# Discussion

- Feed-in premiums
  - Feed-in premiums lower the production cost
- Increased fossil fuel prices
  - Increases the alternative fuel price
  - Stimulate increased use of electrical cars and food-based fuels
  - Implemented as taxation
- Raw material support
  - Has to be in a relatively narrow interval (67-90 €/MWh)
  - Production from harvest residuals can happen without interfering with the traditional forest sector
  - Increase the usage of harvest residuals

# Conclusion

- With the assumed costs of wood-based biofuels production:
  - The socio-economic cost related to wood-based biofuel in the Nordic countries is around 5 billion € for a 20% share
    - Equal to 1.1 €/L assuming a price of fossil fuel of 0.4 €/L
  - It is possible to produce 40% biofuel without closure of the entire pulp and paper industry.
  - There are only minor differences in the modelled impacts of quota obligations, feed-in premium, and fossil fuel tax
  - Supporting biomass supply is less efficient than other measures

