Regional modelling in Norway
Focusing on transportation sector

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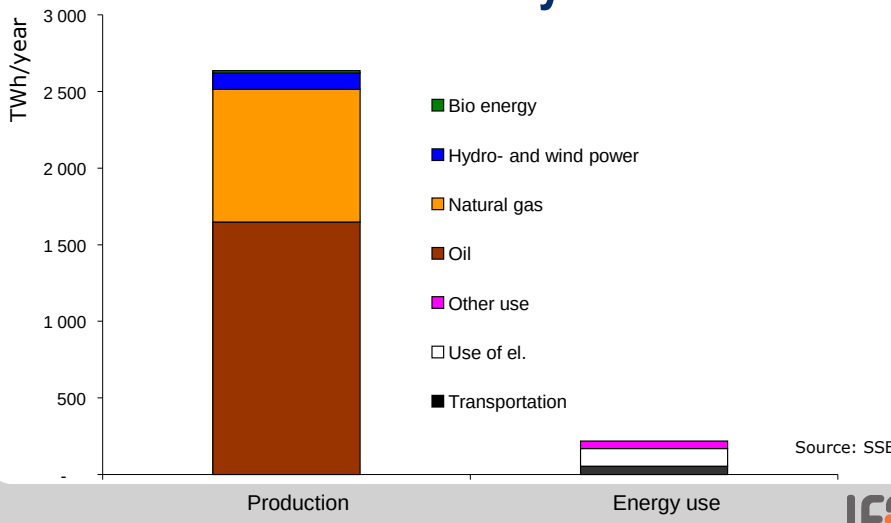
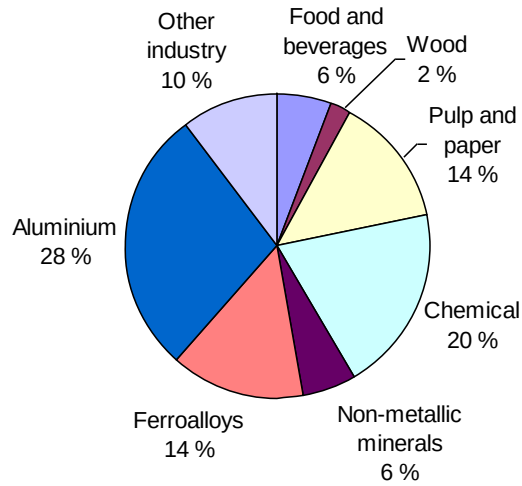
Outline

- The Norwegian energy system
- Regional energy system models in Norway
- MARKAL regional models
  - Selection of regions
  - Scenario analysis
  - Conclusion

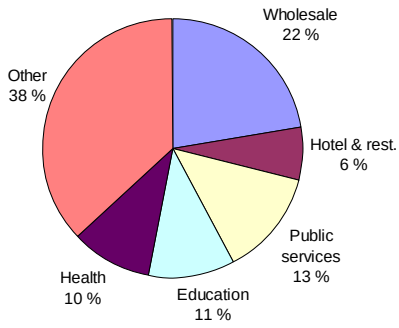
Energy production vs final energy use in Norway



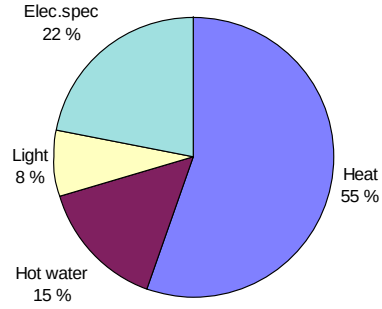
End use – Industry



Buildings - end use

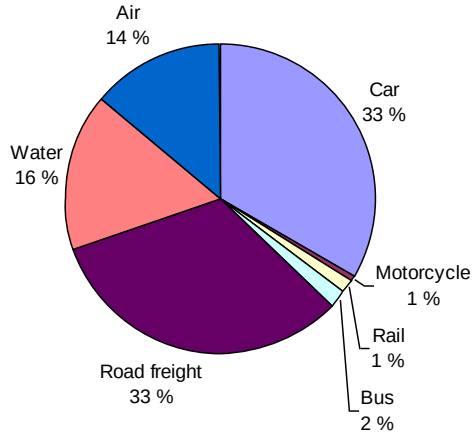


Tertiary sector



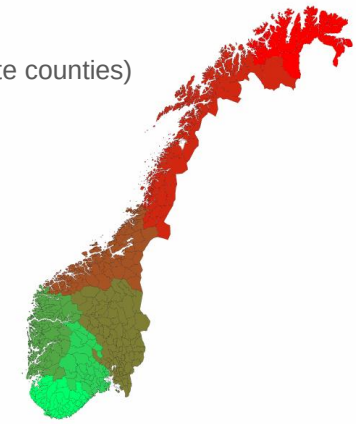
Households

Transport - end use



Regional energy system models in Norway

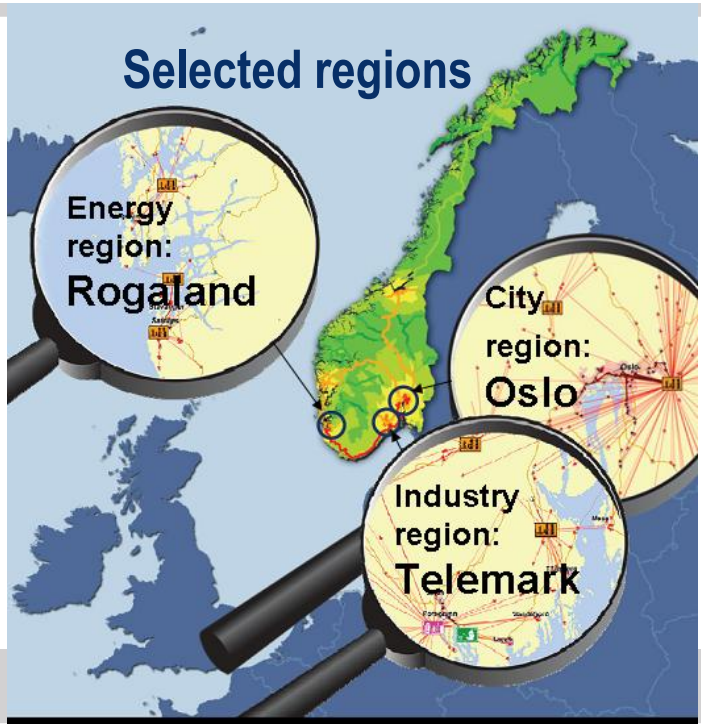
- MARKAL
  - 3 regional models (for 3 separate counties)
  - no interconnections
- TIMES
  - 1 model for Norway
  - divided in 7 regions
  - interconnection



Selecting regions for MARKAL analysis

- Variations in the local energy resources and energy end use demand were emphasised
- Large potential of wind power - possible to produce zero-emission hydrogen based on electricity from wind
- Access to natural gas pipeline (and CCS) – possible to produce hydrogen from natural gas

➢ Assess how resource availability and energy end-use demand might influence the introduction new technologies



City region - Oslo

- Oslo is the capital of Norway with approximately 580 000 inhabitants
- There are no major industries or energy resources

Industry region - Telemark

Telemark is an industry region

- heavy chemical industry - hydrogen available as a by-product
- large hydro power production
- no potential for wind power or other renewable energy resources

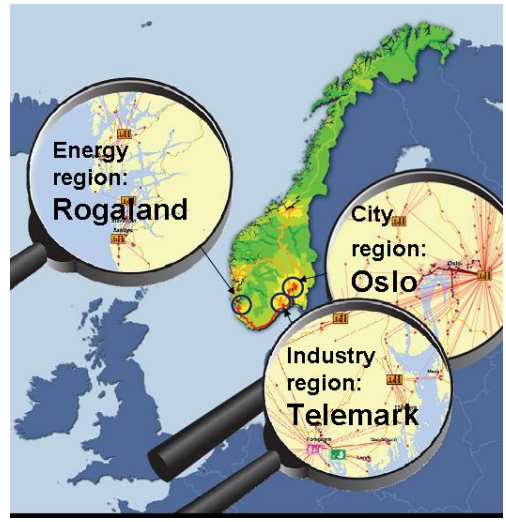
Energy region - Rogaland

the energy region located at the south-west coast

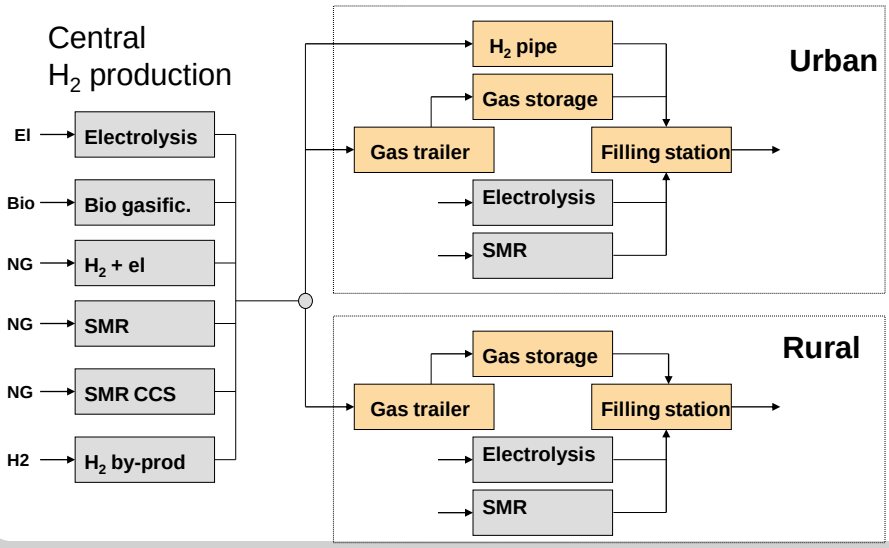
- large hydro power production
- potential for wind power
- landing of natural gas
- the only gas power plant in Norway

Regional MARKAL models

- Regions divided in urban and rural areas
- Regional models with limited import/export possibilities
- Special focus on transport sector
- Variations in drive cycles for vehicles used in urban and rural areas



Modeling hydrogen infrastructure



Car types modelled

- Gasoline car
- Gasoline hybrid car
- Diesel car
- Diesel hybrid car
- NG car
- NG Hybrid car
- Battery electric vehicle (City)
- Battery electric vehicle (Full range)
- Plug-in Hybrid
- H2 ICE
- H2 ICE Hybrid
- H2 FC
- H2 FC Hybrid

Key assumptions for the analyses

- The models includes no possibility to import or export hydrogen into or out of a region or between regions
- The growth from 2005 to 2050 in the transportation sector is in average about 40%

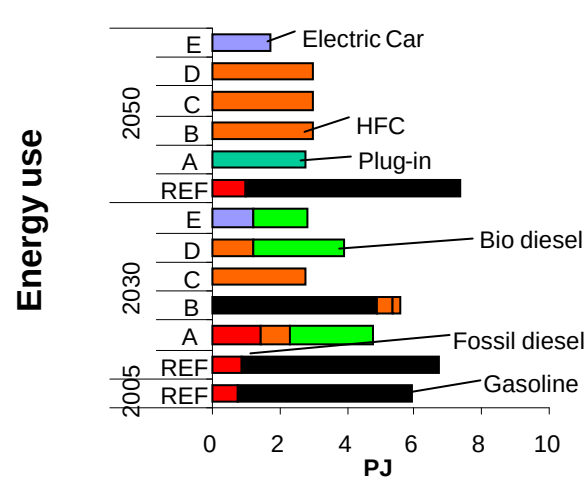
Scenarios

A. HyWays: Basic assumptions with technology costs (H_2) based on results from the European HyWays project
B. No tax: No taxes on transport energy ("revenue neutral")
C. CO_2 reduction: Reduced CO_2 emissions by 75% in 2050
D. Sensitivity on fuel prises
E. Sensitivity on investment costs

C**ompared with a reference case**: Based on the assumptions of World Energy Outlook with no new transport technologies

Results from Oslo – private cars

City region



Scenarios:

E Techn. costs

D Fuel prices

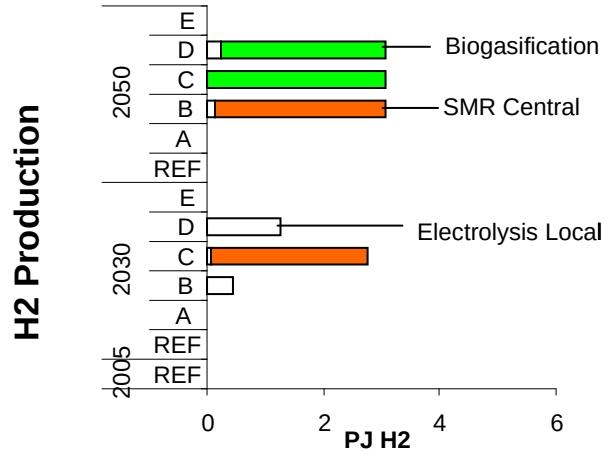
C CO2-red.

B Neutral taxation

A HyWays

REF No new techn.

Results from Oslo – hydrogen production



Scenarios:

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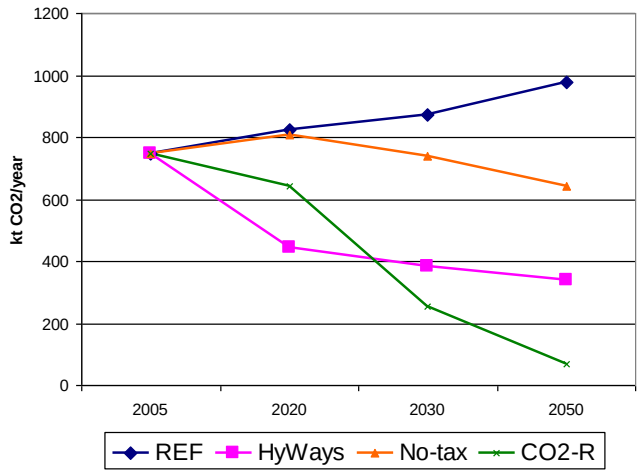
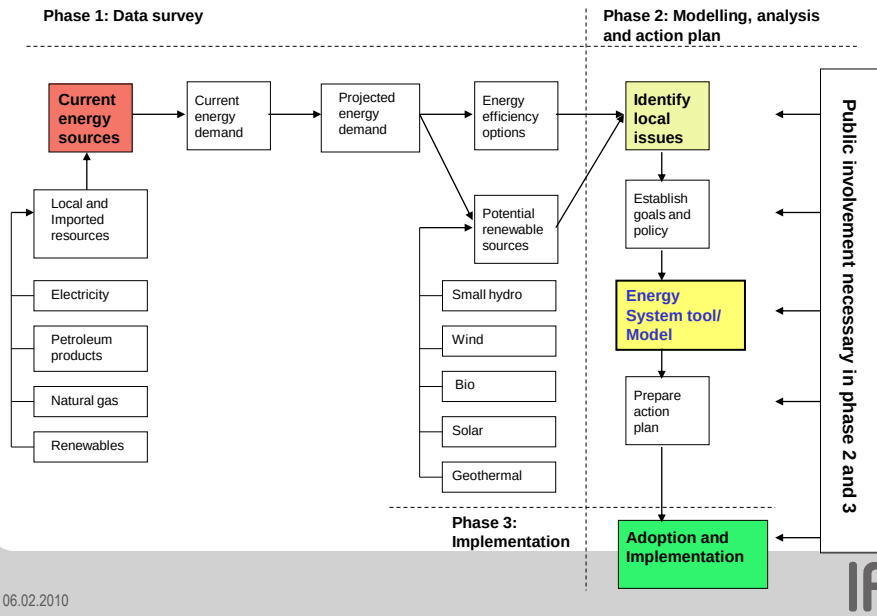
CO_2 emissions in the City Region (Oslo)



Main conclusions – Regional analysis

- The overall efficiency is greatly improved compared with present used technologies (HFC, Plug-in, EV)
- No energy taxes: delayed introduction of hydrogen cars
- CO_2 limitations: Renewable energy is used for hydrogen production (electrolysis or bio gasification)
- Higher electricity price & high hydrogen price → Plug-in hybrids
- Regional differences → **different solutions**
- The challenge: find the right balance between bio fuels, hydrogen and electricity in transport

From modelling to implementation



Thank you!

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