Modelling of future energy demand in the building sector

Modelling of energy efficiency


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Content

• The Norwegian TIMES model
  • Modelling of renewable energy production

• Modelling of future energy demand
  • Focus on the Norwegian building sector

• Further/on-going work
  • Modelling of energy efficiency
Norwegian TIMES model (2005 -2050)

- Norway is divided into seven regions
- High time resolution (260 per year)
  - Better presentation of intermittent power, storage and trade
  - Each week is divided into:
    - Day 1: 07 – 11
    - Day 2: 11 – 17
    - Day 3: 17 – 23
    - Night: 23 – 07
    - Weekend: 23 Friday to 23 Sunday
- Can be linked with a power market model (EMPS)
  - From EMPS: Electricity prices
  - To EMPS: Electricity demand
TIMES-Norway is linked with our Swedish model

- Basic model features
  - High time resolution (260 time slices a year)
  - Analysis period: 2010 – 2050
  - Developed to analyze the green electricity certificate market

- Norway is divided in 5 regions, and Sweden in 4 regions
  - Exchange of electricity between regions and countries

- Energy demand is exogenous input
  - We use the following demand types:
    - Electricity
    - Heating
    - Cooling
    - Material
    - Vehicle-km
Modeling of power production

- **Hydro power** is the main source (~95% of electricity production)

- Other sources:
  - Wind power
  - Natural Gas
  - Back pressure turbine
  - Waste (CHP)

Hydropower, existing and potential in Norway, 2010 (TWh/year)
Hydropower – inflow and production
Region: western Norway
RNWWIND: Wind power potential

EEWINA0: Existing wind power

EEWINA1: Wind turbine: V > 8 m/s, class I

EEWINA2: Wind turbine: V > 8 m/s, class II

EEWINA3: Wind turbine: V > 8 m/s, class III

EEWINB1: Wind turbine: V > 7 m/s, class I

EEWINB2: Wind turbine: V > 7 m/s, class II

EEWINB3: Wind turbine: V > 7 m/s, class III

EEWINC1: Wind turbine: V > 6 m/s, class I

EEWINC2: Wind turbine: V > 6 m/s, class II

EEWINC3: Wind turbine: V > 6 m/s, class III

EEWINO1: Offshore wind: Near shore, shallow waters

EEWINO2: Offshore wind: Deep sea

EEWINCON: Wind converter

ELC-WP

ELC-HV
Modelling of future energy demand in the building sector

Methodology:

• Service sector
• Households
Population is important...

Population growth scenarios from Statistics Norway
...and floor area is important

- Development in floor area are one of the other important parameters when analyzing future energy demand.
- Heating is a substantial part of the energy use in Norway.
- Different policy measures are in place to support the reduction of heating demand.
- Development of floor area is influenced by population growth, however there is not a "1-to-1" relationship.
Relative development of area per capita
Service, sub-sectors

- Education
- Hospitals
- Hotel
- Office
- Trade
- Total service
Total area = Population * persons/dwelling * (% SFH * m²/SFH + % MFH * m²/MFH)
New area = Total area – existing area
Existing area (year t) = Renovated + unchanged = \( \sum \) existing area *(1- demolishing rate) (base year to year t)
Renovated area (y t) = \( \sum \) existing area * renovation rate (base year to year t)

Energy service demand = Area * (kWh SH/m² + kWh WH/m² + kWh Light/m² + kWh el.spec./m²)
Divided on SFH / MFH and new / renovated / old unchanged
Projection of energy demand
Service sector
«frozen efficiency» and reference path
Using TIMES to analyze the use of technologies / energy carriers
Technologies and energy carriers

Preliminary results:
Residential sector - Heating

- Solar thermal
- Heat pumps (air)
- Heat pumps (ground)
- District heat
- Fossil fuels
- Wood pellets
- Fire wood
- Direct el.
- Total with EE
- Frozen efficiency
Development of technologies and energy carriers in the service sector

Service sector - Heating

Energy use (TWh/year)

- 2010
- 2020
- 2030
- 2040
- 2050

Heat pumps (ground)
District heat
Fossil fuels
Bio energy
Direct el.
Generation and use of electricity
Ongoing / further work

- Modelling of energy efficiency
Modeling of energy demand and efficiency

Projection of drivers / Activity (A)

Energy statistics

Energy by end-use

Statistics of drivers

Indicator (I)
- Base year
- Development

Energy-service demand
\[ E = I \times A \]
- Space heating
- Hot water
- Lighting
- El. for motors
- Melting energy
- etc.

Energy system model
TIMES-Norway

Demand of energy carriers
- Electricity
- Fuel oil
- Fire wood
- Bio diesel
- etc.

& technologies

Energy prices

Energy efficiency

Exist. Regulations
- New Buildings
- Prod. equipment
- Lighting
- etc.

New Reg./Core proc.
- New Buildings
- Prod. equipment
- Retrofit exist. Build.
- Rate
- Windows
- insulation
- etc.

Conservation measures
- More efficient motors, el. appliances etc.
- Additional insulation
- Lighting control
- Time control
- Heat recovery
- CHP waste heat
- etc.

Waste heat for external use
- From industry
  - District heat
  - Other ind.
  - Other use

Technology efficiency
End-use:
- Heat pumps
- Solar thermal
- Integrated PV
- Boiler eff.
- etc.

Energy conversion
- Power plants
- District heating plants
- etc.

Behavioural measures
- Reduced indoor temperature
- Switch off lighting / airing
- Eco drivning
- Modal shifts
- etc.
Modeling of energy demand and efficiency

- Projection of drivers/ activity
- Energy statistics
- Energy by end-use
- Statistics of drivers

Indicator
- Base year
- Development

Energy-service demand
\[ E = I \times A \]

Energy system models
TIMES-Norway

Demand of energy carriers & technologies

Energy prices

Energy efficiency
- Existing Regulations/processes
  - REF
  - New Regulations/Core processes
    - A
- Conservation measures
  - B & C
- Waste heat for external use
  - D
- Technology efficiency
  - E
- Behavioural measures
  - F
Thank you!

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