Coupling TIMES-PanEU and NEWAGE: Energy and macroeconomic impacts of decentralization trends in the European electricity sector

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Outline

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   - Decentralization trends in the European electricity sector

2. Methodology
   - TIMES-PanEU
   - NEWAGE
   - Model Interface

3. Scenario analysis and results
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   - Energy system impacts (TIMES-PanEU)
   - Macroeconomic impacts (NEWAGE)

4. Summary and outlook
Decentralisation trends in the European electricity sector

- Increased use of renewable energies for electricity generation
- Renewable energy systems operate at a lower scale than conventional plants
- Large power plant projects face acceptance problems in the society
  → There is a decentralization trend in the European electricity sector

- What consequences does this trend trigger?
  - Impacts on fossil fuels usage and CO$_2$-emissions
  - Impacts on electricity prices
  - Macroeconomic impacts of electricity price increases

- Coupling an European energy system model (TIMES-PanEU) with a global CGE model (NEWAGE) makes it possible to assess these issues
TIMES-PanEU

- 30 region model (EU 28, No, CH, IS)
- Energy system model
  SUPPLY: reserves, resources, exploration and conversion Country specific
  renewable potential and availability (onshore wind, offshore wind, ocean, geothermal, biomass, biogas, hydro)
  Electricity: public electricity plants, CHP plants and heating plants
  Residential and Commercial: End use technologies (space heating, water heating, space cooling and others)
  Industry: Energy intensive industry (Iron and steel, aluminium copper ammonia and chlorine, cement, glass, lime, pulp and paper), food, other industries, autoproducer and boilers
  Transport: Different transport modes (cars, buses, motorcycles, trucks, passenger trains, freight trains), aviation and navigation
- Country specific differences for characterisation of new conversion and end-use technologies
- Electricity Grid, Biofuel and biomass trade
- Time horizon 2010 - 2050
- GHG: CO$_2$, CH$_4$, N$_2$O, SF$_6$ /Others pollutants: SO$_2$, NO$_x$, CO, NMVOC, PM$_{2.5}$, PM$_{10}$
NEWAGE: a global CGE model with hybrid features

Special / hybrid features:

**Imperfect Labor Market:**
Rigid wages, wage curve
Differentiation by qualification (skilled, unskilled)

**Electricity Generation:**
Technology based modeling: portfolio with 18 generation options

Flexible resolution of regions and sectors (current: 19x27)

19 sectors:
- Agriculture
- Energy production (5)
- Energy intensive ind. (5)
- Rest of industry (4)
- Construction
- Transport
- Services

27 regions:
- Germany (2)
- EU-countries (8)
- USA (1)
- BRICS (5)
- Other OECD (4)
- Rest of world (7)

Main data sources:
GTAP8, IEA, et al.

Dynamics:
Recursive-dynamic, 2007-2030, 5-year steps

Technological Change:
Autonomous energy efficiency index (AEEI)

**Electricity Generation:**
Technology based modeling: portfolio with 18 generation options

**Factor markets**
- Capital
- Labor
- Resources
- Carbon

**Production**
- Fossil Fuel Production
- Sectoral Production
- Aggregation Pool (Armington)

**Foreign trade**
- Exports
- Internat. Transport
- Imports

**Investments**
- Savings
- Consumption

**Representative Agent**
- Households and Government
- Tax Revenue

**Implicit tax system**

**Closed circle of income**
Model interface

**Model input data**

- **TIMES-PanEU specific data:**
  - Energy system
  - Exogenous demands

- **NEWAGE specific data**:
  - National accounts (GTAP)
  - Hybrid technology data

- **Common inputs:**
  - Crude oil price paths

**Scenario constraints:**

- Energy and climate policies

**TIMES-PanEU**

**Model output**

**Coupling interface:**

- CO₂-emissions in the EU (ETS + Non-ETS)
- Electricity prices in the EU

**NEWAGE**

**Model output**
## Scenario definition

<table>
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<tr>
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<th>ETS75</th>
<th>C80</th>
<th>C80_DEZ_EU</th>
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<tbody>
<tr>
<td><strong>GHG reduction targets</strong></td>
<td>▪ ETS: -34% until 2030 (w.r.t. 2005)</td>
<td>▪ -80% until 2050</td>
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<tr>
<td></td>
<td>▪ ETS: -75% until 2050 (w.r.t. 2005)</td>
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<td><strong>Investments in large power plant and CCS</strong></td>
<td>▪ Based on economic decisions</td>
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<td>▪ Large power plant restriction in the EU from 2020</td>
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Electricity generation (TIMES-PanEU)

Net electricity supply [TWh]

Share of renewable electricity generation of total gross electricity consumption

- Electricity storage (excl. pump storage)
- Electricity Imports Desertec
- Net Imports w/o Desertec
- Others / Waste non-ren.
- Other Renewables
- Biomass / Waste ren.
- Solar
- Wind offshore
- Wind onshore
- Hydro (incl. pump storage)
- Nuclear
- Gas CCS
- Gas w/o CCS
- Oil
- Lignite CCS
- Lignite w/o CCS
- Coal CCS
- Coal w/o CCS
- Share of renewable energies

2010 | ETS75 | C80 | Œko | ETS75 | C80 | C80_DEZ_EU | ETS75 | C80 | C80_DEZ_EU | ETS75 | C80 | C80_DEZ_EU
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
2020
2030
2040
2050
Model interface: results as inputs

- CO₂ emissions and electricity prices of the C80 and C80_DEZ_EU scenarios compared to the reference scenario ETS75

CO₂ emissions of scenario C80 (in % of ETS75)

CO₂ emissions of scenario C80_DEZ_EU (in % of ETS75)

Electricity prices in the EU in scenario C80 (in % of ETS75)

Electricity prices in the EU in scenario C80_DEZ_EU (in % of ETS75)
Output activity of different industries (NEWAGE)

Iron & Steel

- 2020: C80, C80_DEZ_EU
- 2030: C80, C80_DEZ_EU

Chemicals

- 2020: C80, C80_DEZ_EU
- 2030: C80, C80_DEZ_EU

Machinery

- 2020: C80, C80_DEZ_EU
- 2030: C80, C80_DEZ_EU
GDP and employment (NEWAGE)

GDP (real) in the EU in scenario C80 (in % of ETS75)

GDP (real) in the EU in scenario C80_DEZ_EU (in % of ETS75)

Employment in the EU in scenario C80 (in % of ETS75)

Employment in the EU in scenario C80_DEZ_EU (in % of ETS75)
Summary and Outlook

- Decentralisation is connected with an increase in renewable electricity generation and induces higher (net) electricity imports
  - This leads to a decreased use of fossil fuels (incl. CCS) and lower CO$_2$-emissions
- Decentralisation leads to electricity price increases, especially in Eastern Europe
  - Energy intensive industries reduce their output activity, especially in the iron & steel sector
  - This leads to negative GDP and employment impacts, especially in Eastern Europe with minor changes in the rest of the EU
- Further research with TIMES-PanEU an NEWAGE
  - Further improvement of the interface (iterative procedures)
  - Technologically disaggregated modelling of household energy demand in NEWAGE (implementation of cars & buildings)
Thank you for your attention!
Back up
General coupling of TIMES-PanEU and NEWAGE

Exogenous input assumptions
(Policy interventions; Fossil fuel prices; technical progress; economic growth)

Soft-link iteration procedure
- Energy demands (%-changes)
- Sectoral CO₂ emissions (indices)
- Energy prices (indices)

Adjust model inputs

Constrain the model

TIMES-PanEU

Technology-rich bottom-up European energy system model

Output (quantities + prices):
- Primary energy demand
- Technology mix
- GHG emissions
- Final energy prices

Possibility of adding a macro module (TIMES-Macro)

NEWAGE

Output (values + indices):
- Production and consumption activities, relative prices, Income levels (variables)
- Employment, Trade, Investments, etc. (indicators)

Possibility of adding more technologies (e.g. vehicles, buildings, heating systems)

Global top-down CGE model with hybrid features:
- Imperfect labor market (unemployment, skills)
- Electricity generation (18 different generation technologies)

Additional technology information

Possibility of adjusting model inputs

Possibility of constraining the model
CO$_2$ emissions