Model Linking

17. November 2021, online
General Approach

Approach

- Link sectoral macroeconomic model & partial model of energy sector
- Following Pan & Köhler 2007 and Köhler 2006
  - Endogenous learning curves → change IO coefficients
  - Hybrid model (economic and energy technology)
  - Relative production costs as trigger for investment
  - Capital stock structure → energy production mix
  - Focus on technology switch “tipping points”

Extensions in START2030

- **Economic**: all economic feedback mechanisms
  - Endogenous final demand & investment
  - Price system of all 77 commodities & Supply/Use Tables
  - Labor market feedback
  - Explicit electricity commodity (NACE 35.1)
  - Different household groups & prosumer

- **Electricity** generation: Detailed bottom-up model
  - Regional aspect (nodes) of AT
  - Detailed costs; varying demand load; electricity market; learning curves
  - Explicit depiction of AT physical electricity generation & demand
  - Technology specific investments + Infrastructure and storage
**Soft-Link** – iterative data exchange

**ATLANTIS → DYNK**
- Electricity generation by technology (GWh)

**Electricity Generation costs (per GWh)**

**Market price (Whole sale) (€/MW)**

**Employment in electricity sector**

**Investment needs**

**DYNK → ATLANTIS**
- Final electricity demand

**Data exchange until convergence is achieved**
Soft-Link – iterative data exchange

ATLANTIS → DYNK

Electricity generation by technology (GWh)
- Biomass, Coal, Gas, Hydro, Oil, Pump storage,
- Solar, Hydro storage, Wind, Battery

Electricity Generation costs (per GWh)
- Fuel; Personal; O&M; Depreciation; Interest rates; Emission certificates

Market price (Whole sale) (€/kWh)
- Short term costs

Employment in electricity sector (VZÄ/MW)
- Per capacity installed

Investment needs (€/MW)
- Plants, storage and grid

DYNK → ATLANTIS

Final electricity demand
- Per sector & private households

Database and scenario definitions
- Power plants, grid, load profile ...
- Fuel prices, ...

System adequacy
- For annual peak load (if necessary: adding power plants)

Energy balance, dispatch, electricity exchange
- For the peak- and offpeak-period of each month

Load flow and redispatch
- For the peak- and offpeak-period of each month

Financial accounting and CO₂ emissions
- Annually for each company

Analysis of results
- Graphical presentations for each company and each market

ATLANTIS

Analysis of results
- Focusing on socio economic impact on households

Change in final energy demand
- Change in final electricity demand

Macroeconomic modelling
- of economic effects
- sectoral emission effects
- distribution effects

Input information
- Change in electricity prices, investment needs, technologies

DYNK

Change in final energy demand
- Year +1

Database and scenario definitions
- IO tables, HBS, ... | Fuel prices, efficiency, ...

Year +1

Analysis of results
- Focusing on socio economic impact on households

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Year +1
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  - Fuel; Personal; O&M; Depreciation; Interest rates; Emission certificates
- Market price (Whole sale) (€/kWh)
  - Short term costs & grid costs
- Employment in electricity sector (VZÄ/MW)
  - Per capacity installed
- Investment needs (€/MW)
  - Plants, storage and grid

**DYNK → ATLANTIS**
- Final electricity demand
  - Per sector & private households

**Inputs used to change ...**

- **IO Coefficients** "techswitch"
- **Electricity Commodity price**
- **Employment intensity**
- **Investment demand**
- **Regional & temporal distributed electricity demand**

**Figure: Illustrative IO-Tables**
START2030

Data Processing

- **Soft-Link** – iterative data exchange

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- **DYNK → ATLANTIS**
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Inputs used to change ...

IO Coefficients "techswitch"

Electricity
Commodity price

Employment intensity

Investment demand

Regional & temporal distributed electricity demand
"Techswitch": Aim: Change in IO coefficients based on electricity generation mix

- Available Data:
  - Technology specific IO-coefficients, based on Exiobase MRIO
  - Calibrated to AT-IOT 2017

- Step 1: Derive change in technology costs (by ATLANTIS results)
  - i.e. change in fuel costs, O&M etc. & change in output

- Step 2: Re-weighting of technology vectors
  - Electricity distribution & trade is constant

- Step 3: Aggregation of vectors to "new" NACE 35.1 sector input coefficients

- Step 4: Adapt coefficients in IO matrix & re-run DYNK

Figure: Illustrative Sub-Sector aggregation
**Soft-Link** – iterative data exchange

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"Price for Electricity", AIM: Extract consumer price of electricity

- Available data (ATLANTIS)
  - Generation costs per technology (Mio.€) – including emission certificate costs
  - Grid costs (€/kWh)

- **Step 1**: derive long-term generation costs
  - Total costs per GWh & Technology produced
  - Includes **capital** costs (depreciation, interest rates) and **labour** costs

- **Step 2**: Add fixed profit mark-up and grid costs
  - Based on historic shares (%)
  - Grid costs (€/kWh)

- **Step 3**: Add taxes & fees Derive price index

- **Step 4**: Derive price index
  - Starting year 2017 = 1
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  - "techswitch"
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- **Investment demand**
- Regional & temporal distributed **electricity demand**
"Demand for electricity": Aim: Link Electricity demand (physical) to IOT

Available data
- Sectoral electricity consumption (monetary & physical)

Step 1: Extract nominal electricity commodity (CPA 35.1) consumption \( (D) \)
- from simulated IOT, current prices
- Industries & private households

Step 2: Deflate monetary values
- By Price index for commodity CPA35.1 \( (P) \)

Step 3: Derive physical electricity demand \( (X) \)
- By Energy intensity factor \( (Z) \)
- where: Energy intensity factor is extrapolated from historic developments

\[
X_{elec} = \frac{D_{35.1}}{P_{35.1}} Z
\]

Stylized representation of physical electricity demand derivation
Are essential feedbacks missing?

Are our assumptions to derive electricity demand plausible? Are there other drivers?

Are electricity generation technologies represented sufficiently?
  - Costs: O&M, fuel, emission certificates, capital costs

Do you have any experience with linking B-U & T-D models?
  - Obstacles, good practice, advise