Overview of Commodity Trade Modeling in VTT TIMES Models

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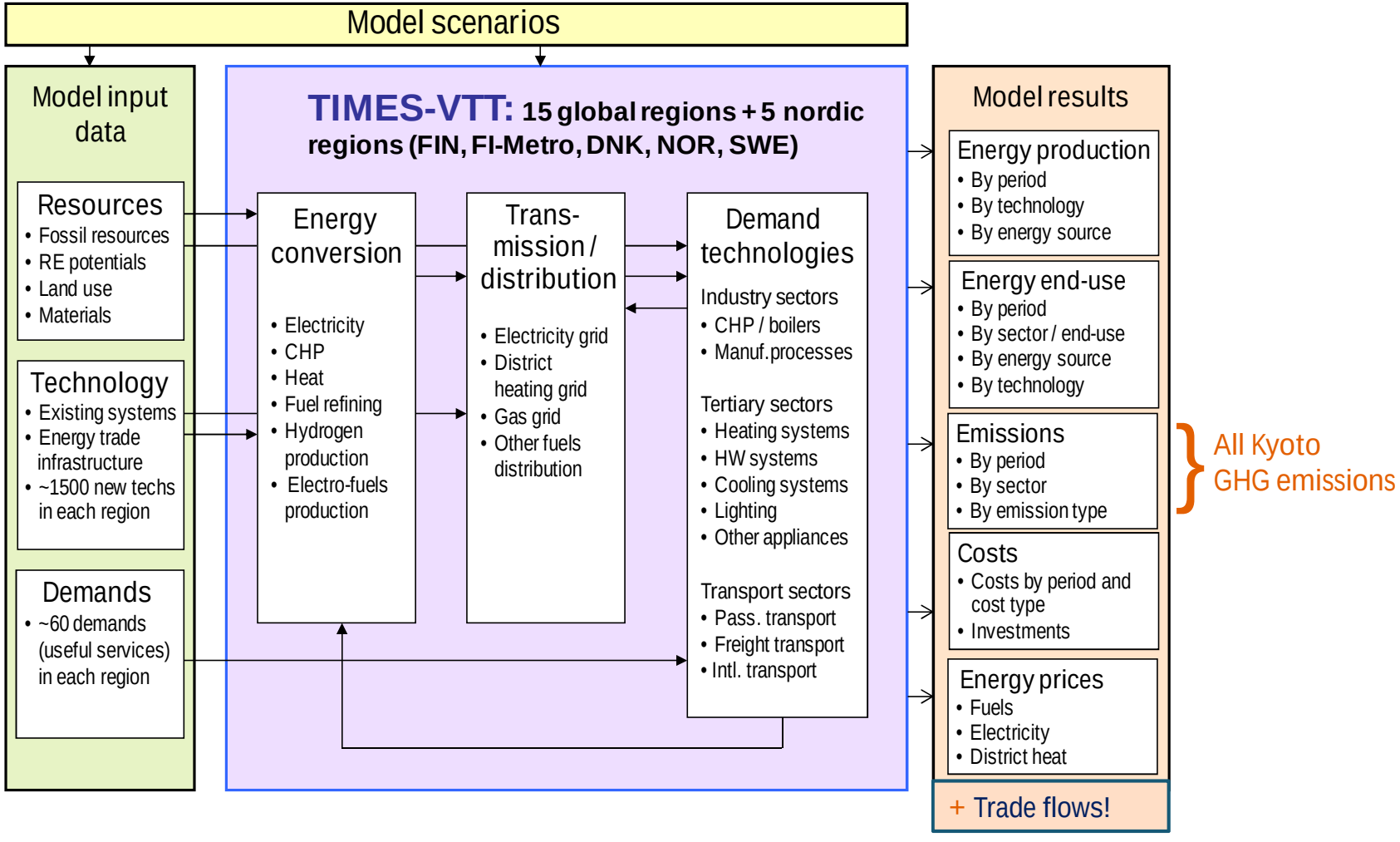
ETSAP Workshop 2022-09-16

TIMES-VTT Energy System Model

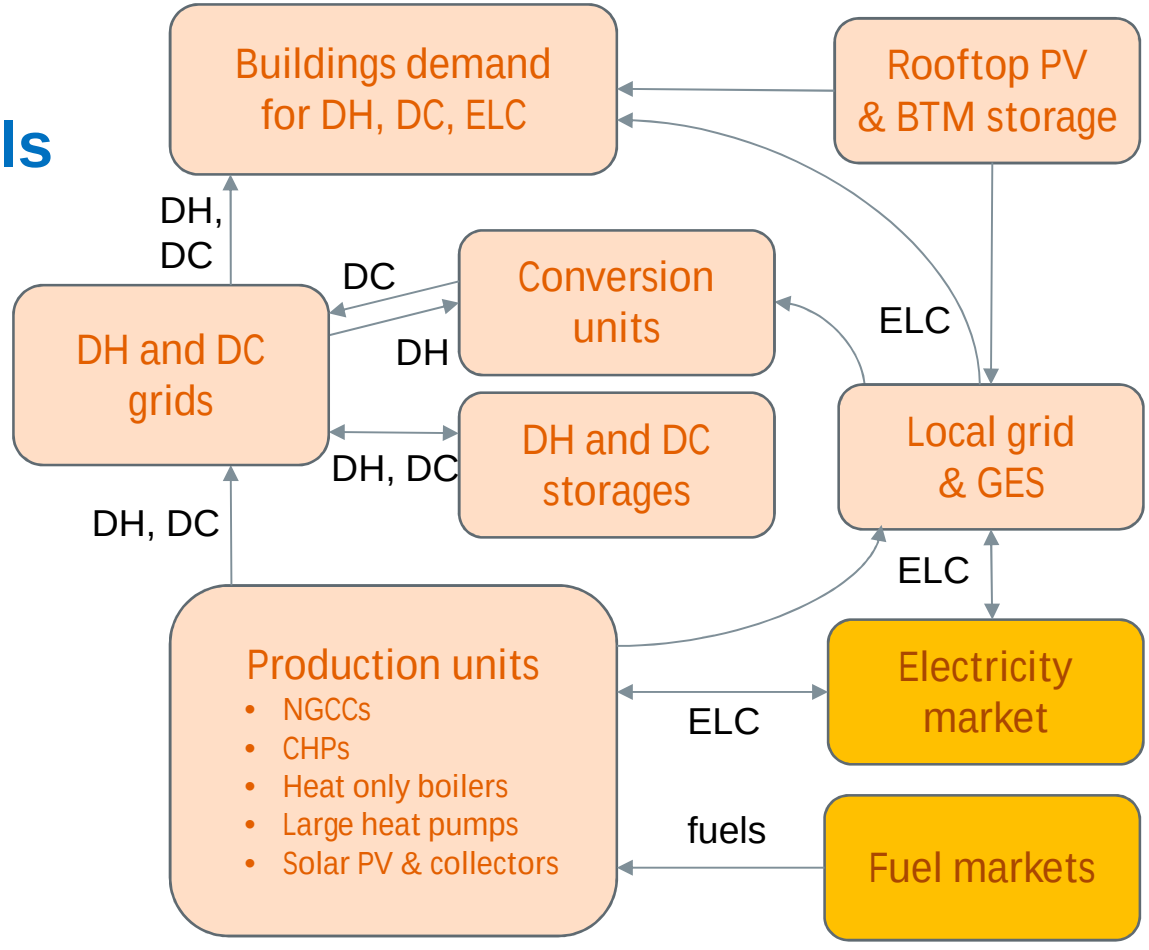


Local energy system optimization modeling

Characteristics of VTT city level models

Detailed modelling of
- District heating, district cooling and electricity generation
- Production unit commitment
- Storages
- Hourly demands for electricity and district heat

Simplified links to fuel and electricity markets.
Perspective of utility operator, maximizing operator profits.
H2 options have also been included in wider scale cross-sectoral models



How do our models consider energy trade:
1. What is the spatial resolution of our model?

- Our most used model is our global TIMES-VTT model:
  - Originally based on the EFDA global TIMES (a variant of TIAM)
  - Each Nordic country as a separate region plus FI-Metro region
  - Two other European regions WEU + EEU; optionally Baltic States separated
  - ROW consists of 12 regions
- In some projects we may use European-wide models:
  - 9 European regions version model, based on the global model, including the Nordic countries, the Baltic States, WEU, and EEU
  - Another option is using the JRC-EU-TIMES with 31/37 country regions
- Less often, we have been using a Nordic level model:
  - All Nordic countries with a few sub-regions in each, 11 regions in total
- Shorter term local level optimization models (not TIMES)

How do our models consider energy trade:

2. What commodities are traded between internal and external regions?

- Commodities trades between internal regions:
  - Electricity, when possible with links corresponding to real cross-border lines
  - Fossil fuels: crude oil, major oil products, natural gas, LNG, hard coal
  - Nuclear fuel: Uranium-based fission fuel, lithium for fusion
  - Bio- and e-fuels: diesel, gasoline, ethanol, hydrogen, ammonia, bio-pellets, wood chips
  - Geological storage services for CO_2; green certificates, CO_2 allowances
- Trades between internal and external regions: Global model
  - Only some minor traded fuel commodities, and mainly for calibration with statistical balances (e.g. coke, lignite, peat, charcoal, NGL)
  - For projection periods, exogenous trade is thereby mostly disabled
  - CO_2 captured from air partly external, but is assumed freely available
- Trades between internal and external regions: European levels
  - External trade only in electricity (from AFR, CIS, MEA), fossil fuels (oil, gas, coal), liquid biofuels, bio-pellets, nuclear fuel

How do our models consider energy trade:

3. How do we model the trade of various commodities?

- Electricity commodities (endogenous & exogenous trade)
  - Existing cross-border interconnections with capacities in both directions according to statistics (ENTSO-E data for Europe)
  - Investments into new lines, usually bi-directional, with cost estimates based on literature (ENTSO-E estimates for Europe), new capacities with assumed CAP bounds
  - Transmission losses are own crude estimates (usually a few per cent)
  - Availability factors have thus far not been considered (but flow bounds used)
  - Links with external regions have timeslice-differentiated import/export prices
- Other energy commodities (endogenous & exogenous trade)
  - Natural gas pipelines modeled much in the same way as electricity interconnections: existing lines plus new investment options (ENTSO-G), new with CAP bounds
  - LNG trade assumed with activity constraints only; LNG terminals + capacities included
  - Variable transportation costs defined for all fuel trades, and most with activity bounds
  - Links with external regions have only ANNUAL level import/export prices
- Environmental commodities (geological CO_2 storage service)
  - Between internal regions; additional transportation costs for CO_2 (based on shipping)

How do our models consider energy trade:

4. How do we adjust energy trade parameters?

- Adjusting prices in internal regions:
  - Baseline fossil fuels prices are usually calibrated according to IEA price projections in order to simulate the real-world oligopoly markets
- Adjusting prices in external regions:
  - Electricity import/export price scenarios may be adjusted based on type of scenario, using data obtained from other studies
  - Electricity prices may also be differentiated according to linked external regions (e.g. AFR, CIS, MEA for European model)
  - Fossil fuels price scenarios only adjusted by type of scenario (policies effects)
- Adjusting bounds on trade from external regions:
  - Bounds on external trade may be adjusted according type of policy scenarios, optionally using results from consistent scenarios with our global model

Elastic prices for exogenous trade?

- Can we reasonably model prices elastic to traded volumes?
  - In principle, yes, but with some practical caveats
  - Convexity requirement imposes some limitations:
    1. Import price to have non-negative elasticity to import volume
    2. Export price to have non-positive elasticity to export volume
- Traditional cost-step approach is nonetheless feasible
  - For example, N steps for imports, M steps for exports (cf. VITO presentation)
  - Import price increases with volume, export price decreases with volume
  - All import price steps should have higher price than any export price step?
- Automation possible for supply elasticities like for demands
  - Simple experimental proto-facility available under the DAMAGE option
  - Supports defining an elastic add-on cost curve (on ANNUAL level)
  - If deemed useful, could be generalized for curves by timeslice

Proto support for elastic supply curves

- May be shifted down for defining an add-on price curve
- Can also be based on timeslice-specific base prices