

TIMES Pan European Model (TIMES-PEM of NEEDS)

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The modelling platform for the development of the country models and the Pan-European model is The Integrated MARKAL-EFOM System (TIMES), developed by the Energy Technology Systems Analysis Programme (ETSAP) of the International Energy Agency (IEA). TIMES-PEM is a technically oriented model which illustrates in detail the whole energy system of the in detail implemented member states of the EU-27 for the period from 2000 to 2050. Additionally the countries Iceland, Norway and Switzerland are modelled.

In the sectors TIMES-PEM can be described as follow:

- *Transportation* includes road and rail for passengers and freight, navigation and aviation. In road transport, there are five demand categories for passenger travel (cars – short distance, cars – long distance, buses – urban, buses - intercity, two and three-wheelers/off road), and trucking. In rail transport, there are three demand categories (passengers – light trains (metros), passengers – heavy trains and rail freight). The aviation and navigation sectors are modelled using a single generic technology each and a single generic demand each that reproduces the energy consumption.
- In *Residential* there are 11 end-uses (Space heating, Space Cooling, Water heating Cooking, Lighting, Refrigeration, Cloth washing, Cloth drying, Dish Washing, Other electric, Other energy), and the first three are differentiated by building categories (Single house – rural, Single house – urban, Multi Apartment).
- Similarly, the RES structure of the *Commercial* sector has nine end-uses (Space heating, Space Cooling, Water heating, Cooking, Refrigeration, Lighting, Public Lighting, Other electric, Other Energy Uses), with the first three being differentiated by building categories (Small / Large). *Agriculture* is modelled as a single generic technology with a mix of fuels as input and an aggregated useful energy demand as output.
- *Industry* is divided in two different sets: energy intensive industries and other industries. For the energy intensive industries, a process-oriented RES was adopted, whereas for other industries a standard structure consisting in a mix of five main energy uses (Steam, Process heat, Machine drive, Electrochemical, Others processes) was adopted. In order to start moving in the direction of Life Cycle Inventories and Assessment and External Effects, different material demands of the industrial sector (as for example steel or limestone) were modelled separately.
- The sector *Electricity and Heat production* regroups public power plants, auto production of electricity and CHP. In the RES, three types of electricity (High voltage, Medium voltage, and Low voltage) and two separated (not connected) heat grids for long distance (high temperature) and short distance (low temperature) are distinguished.
- *Supply*: Each primary resource (Crude Oil, Natural Gas, Hard coal, Lignite) is modelled by a supply curve with several cost steps. There are three categories of sources: located reserves (or producing pools), reserves growth (or enhanced recovery), and new discovery. In addition, five types of biomass are modelled: wood products, biogas, municipal waste, industrial waste-sludge, and bio fuels.

As concerns materials, in the model those whose production requires more energy or which are important for the production processes are modelled (e.g. scrap steel). Other materials are implicitly modelled as part of the variable costs and their related emissions are accounted for in the process emissions. The air emissions modelled are Carbon Dioxide (CO₂), Carbon Monoxide (CO), Methane (CH₄), Sulphur dioxide (SO₂), Nitrogen Oxides (NO_x), Nitrous Oxide (NO), Particulate (PM 2.5 and PM 10), Volatile Organic Compounds (VOC), Sulphur hexafluorides (SF₆) and Fluor Carbons (C_xF_y).