

The TIMES model

*Potential use in "Pathways to Sustainable Energy"
from an IVL perspective*

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IVL Swedish Environmental Research Institute

- An independent, non-profit research organisation owned by a foundation established by the Swedish government and industry.
- Established in 1966 and has since then been involved in the development of solutions to environmental problems at national and international level.
- The institute comprises Sweden's largest groups of environmental experts and employs around 250 people, which makes IVL a leading institute for applied environmental research and consultancy services in Sweden.
- Undertakes research projects and contract assignments in the following areas:
 - Natural resources
 - Climate and environment
 - Resource-efficient recycling and consumption
 - Sustainable production and environmental technology
 - Sustainable urban development and transport

Energy systems modeling at IVL

- Main tool for energy systems modeling at IVL is ***TIMES***
- TIMES modeling at IVL has (so far) mostly focused on Sweden/the Nordic region
 - Nordic model (Sweden, Norway, Denmark, Finland) under development
 - City scale modeling
- Upcoming EU project Surecity
 - TIMES modeling on city level for several European cities

What is TIMES?

- A model generator, not a ready to run model for a specific region
 - Applications of TIMES must be developed to make a model analysis
 - Numerous applications of TIMES exists, for nations, regions, on global level etc.
- An acronym for **The Integrated MARKAL-EFOM System**
- Developed and maintained within ETSAP (Energy Technology System Analysis Program), an implementing agreement of the International Energy Agency (IEA)
- Commercially available
- Written in GAMS modeling language, has two different user interfaces (VEDA and Answer)

Features of TIMES

- TIMES is used for "the exploration of possible energy futures based on contrasted scenarios"
- Technology rich, bottom-up
- Optimization based on linear-programming
- Partial equilibrium
- Produce a least-cost energy system scenarios, optimized according to a number of user constraints
- Medium to long-term time horizons

Schematic view of a TIMES model with some inputs and outputs

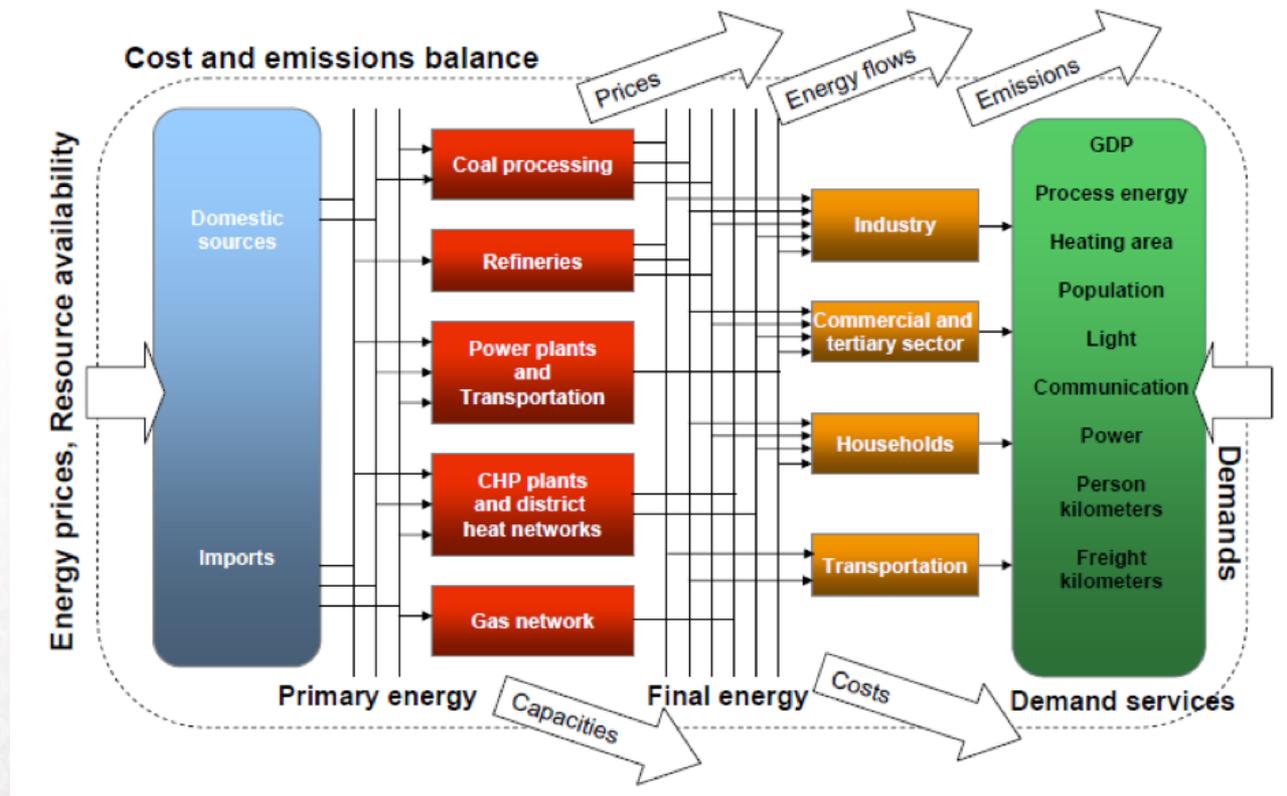


Figure from (Remme et al., 2001)

Model principle

Main inputs (exogenous)

- Energy service demands
- Fuel supply
 - Costs and availability
- Technology options
 - Base year capacities
 - Investment options
 - Tech/econ. properties
- Energy policies

Optimisation



Outputs

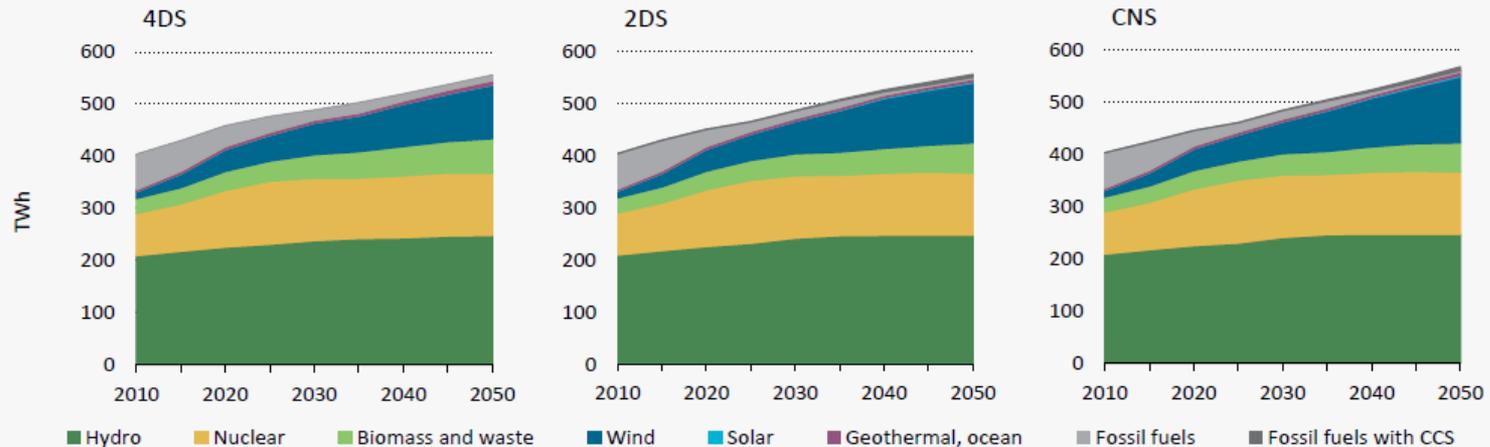
Cost-optimal mix of fuels and technologies over studied time horizon

- system cost
- emission levels
- resource allocation
- etc.

Example of result from TIMES model runs

Figure 3.9

Nordic net electricity generation by scenario



Key point

Growth in electricity generation in all scenarios is covered by low-carbon electricity sources, mainly renewables.

From: Nordic ETP study (IEA, IVL et al , 2013)

- ➔ Potential results include: energy use in different sectors of the energy system, cost-efficient technology choices, emission levels, required capacities to meet demands, system costs of emission reductions, etc.

TIMES in “Pathways to Sustainable Energy” project?

- New model applications could be developed, as well as modifications of existing ones
- IVL recent modeling activities:
 - City scale modeling
 - Nordic model under development (Sweden, Norway, Denmark, Finland)
- IVL can access the **ETSAP-TIAM** model, a global application of TIMES

Regional division of ETSAP-TIAM model

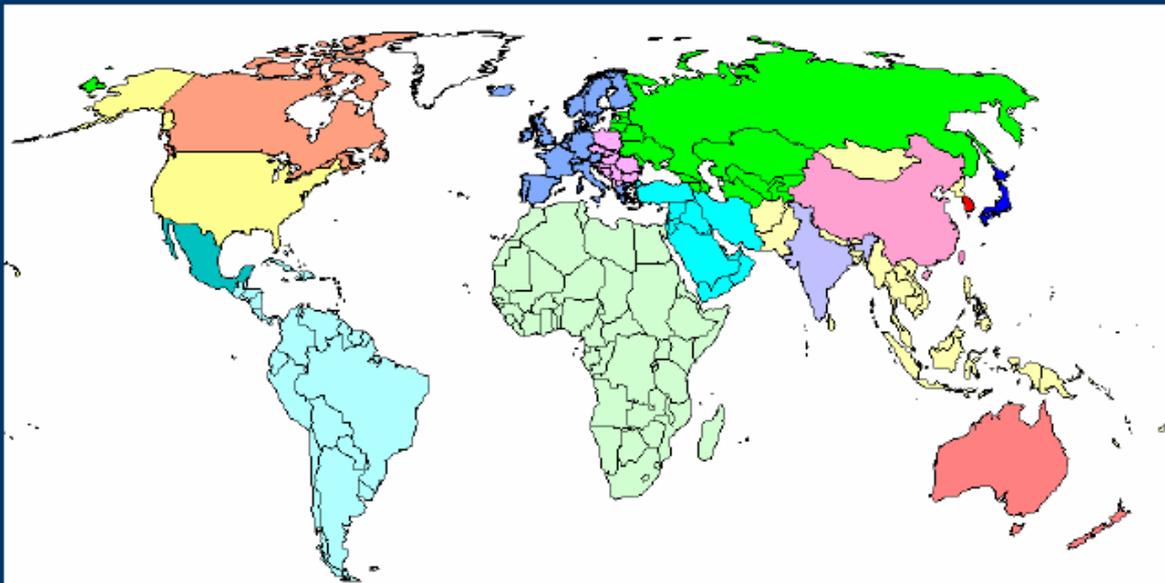
15 regions + OPEC/Non-OPEC

Africa*
Australia-New Zealand
Canada
Central and South America*
China

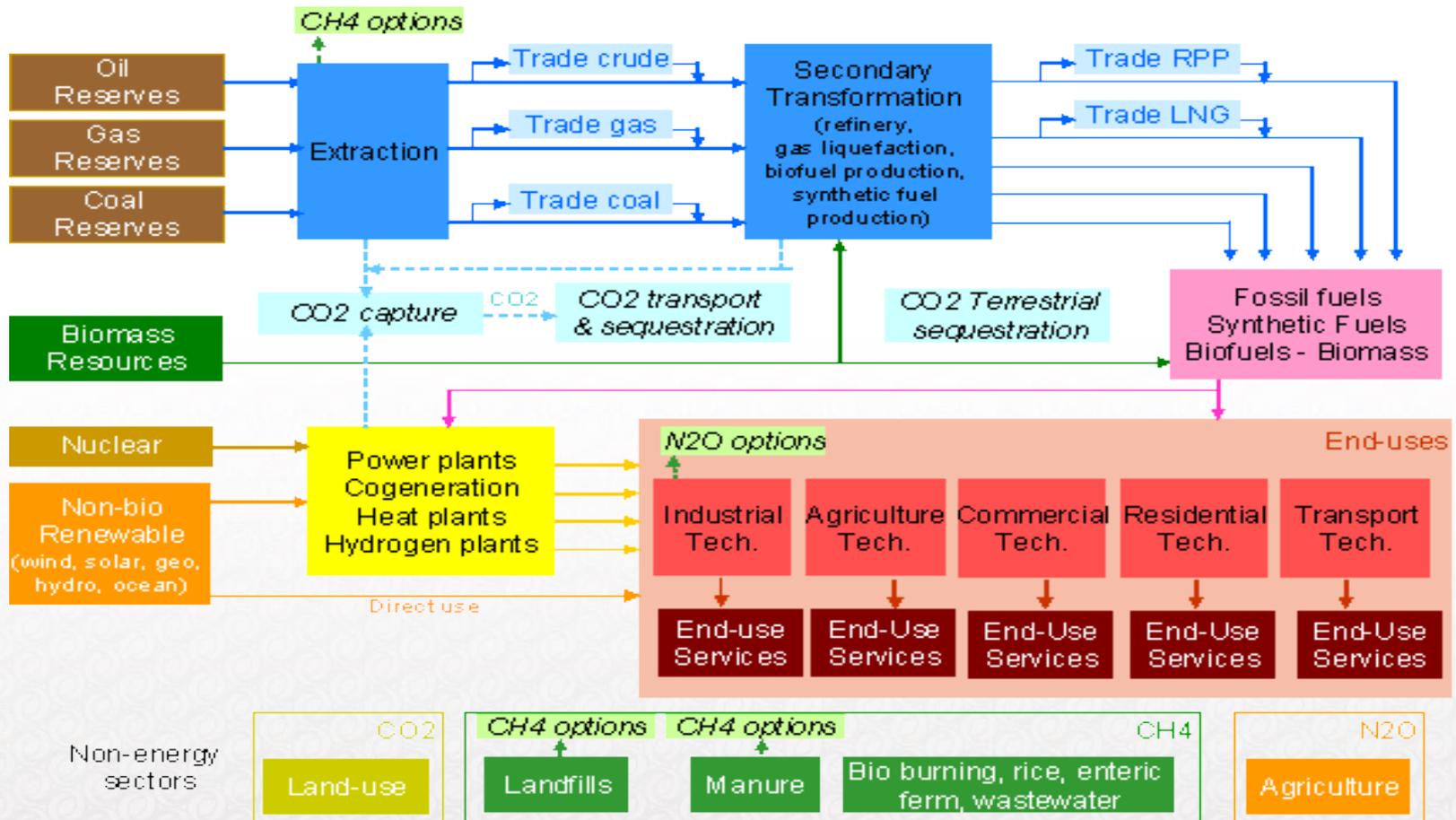
Eastern Europe
Former Soviet Union
India
Japan
Mexico

Middle-East*
Other Developing Asia*
South Korea
United States
Western Europe

* OPEC and Non-OPEC countries are separated in primary and secondary sectors \Rightarrow oil production strategies and oil price control by OPEC countries



TIAM model reference energy system



Modelling inputs from the scenarios

- ➔ Differences in **technology innovation** could be reflected by diverging scenario input data regarding:
 - Costs of technologies
 - Technical properties of technologies (efficiencies, etc.)
 - Availability of technologies
 - Allowed market shares for technologies
 - etc.

- ➔ Differences in **level of cooperation** in meeting goals could be reflected in by diverging scenario input data regarding:
 - Allowed level of cross border (/cross regional) trade of energy and/or “emission permits“
 - Level of differences in technology properties/availability between regions
 - etc.

Thank you!