Modelling of energy sector in Lithuania

Overview of selected models and modelling approaches

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Circumstances determining area and character of research

Restoration of independence – necessity of planning of energy sector development, preparation and further corrections of the National energy strategy, analysis of rational development ways for various energy sectors and systems;

Pecularities of the Lithuanian energy sector –economic recession and declining demand, overcapacities, preservation problems, large units and difficulties of reservation, close interlinks with energy systems of neighbouring countries, variety of technological solutions (CHP, HPSPP, district heating, etc.);

Forced closure of the Ignalina NPP and ideas for building new large NPP – analysis of economic consequences, macroeconomic impact, reservation problems, security of energy supply, trade with neighboring countries;

Broader use of renewable energy sources, distributed generation, Lithuanian contribution to climate change mitigation – balancing of intermittent generation, interplay with large units, role of agriculture, forestry and transportation sector, energy efficiency (including end-use- sectors), modelling of smart grids, etc.

Area of research

Modelling and analysis of energy sector development and operation in the region (Estonia, Latvia, Lithuania, Poland including links with third countries);

Modelling and analysis of energy sector development and operation of a single country (Lithuania, Latvia, Poland, Serbia, Greece, Mongolia, Sudan, Nigeria, Egypt, Malawi, Ghana, etc);

Modelling and analysis of single energy system (Power system, district heating system, etc.);

Modelling and analysis of a single enterprise (Refinery, system of district heating in particular town, power plant, boiler-house**);**

Modelling and analysis of smart grid;

Coupling of energy models with agriculture and forestry;

Economy models and their linking with energy models;

Modelling of various operational and policy problems in energy systems.

Topics presented

Incorporating land use and forestry into energy sector models;

Modelling of district heating systems;

Modelling of reserve capacities;

Incorporating land use and forestry into energy sector models

Assessment of possible reaction of the Lithuanian energy sector to the changed situation and energy policy initiatives for broader utilisation of RES

Under contracts with Ministry of energy,
Scientific Council of Lithuania and
IAEA CLEW project;

Main attitudes for analysis

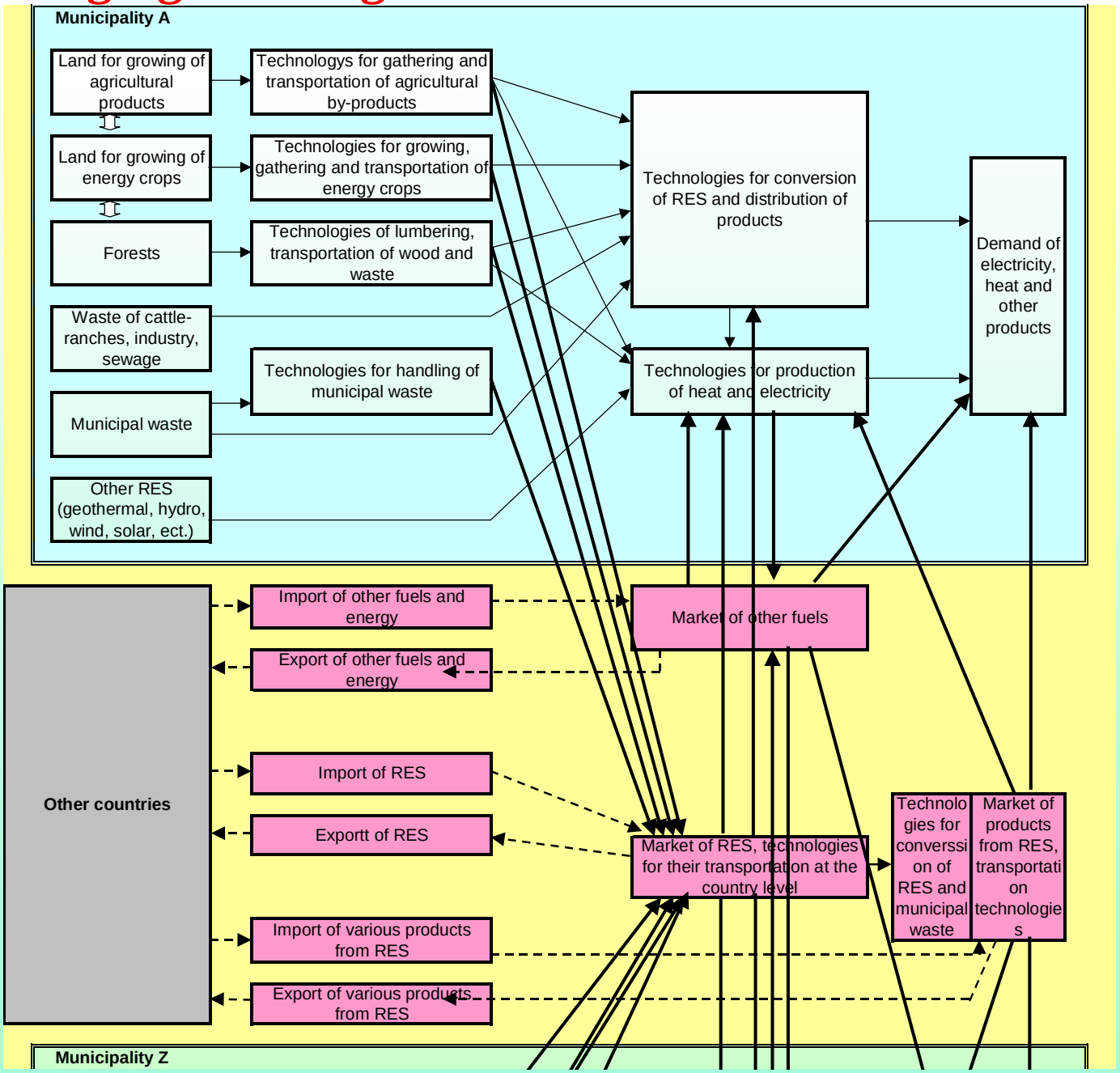
Effectiveness of utilisation of each type of RES is analysed in parallel with possible utilisation options of other energy sources,

Level of RES utilisation should meet requirements of EU Directive 2009/28/EC, should be in correspondence with the rational objective of the country for energy security and commitments of the country in the field of environment protection, etc.,

Broader utilisation of RES has to be reached on the least cost basis,

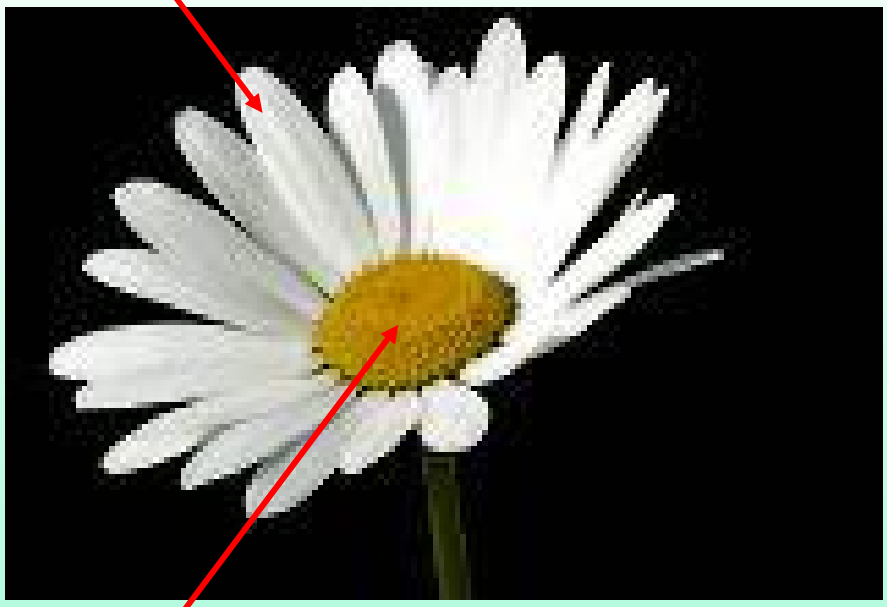
Analysis has to take into account regional (municipality or other) pecularities.

Agregated diagram of the mathematical model



Characteristic of the mathematical model

Energy systems
of 60 municipalities



State market of fuels
and energies

Time period under analysis:
until year 2045,

5 time steps within a year,

60 types of fuels and energies,

12 types of agricultural products,

~ 8 thousand technologies and processes,

~2 milions variables,

Few milions equations.

Land use

Land (fixed amount)**:**

Used for roads,

Used by urban areas,

Occupied by forest,

Used for agricultural purposes,

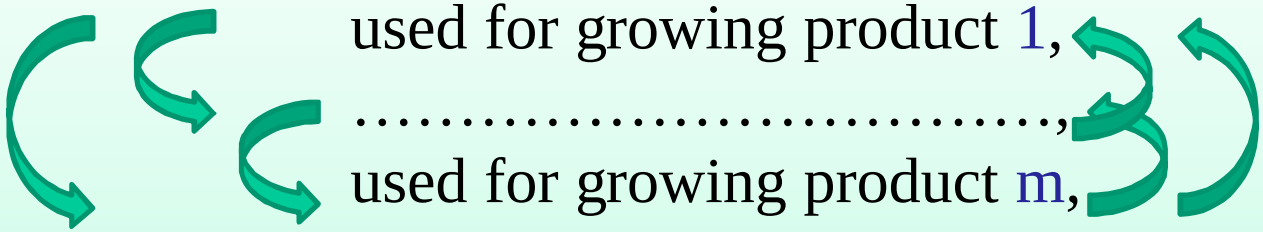
Used for other things,

Not used.

Land used for agricultural purposes

Soil type 1

gardens,
green lands,
arable land



used for growing product 1,
……,
used for growing product m,

……

Soil type n

gardens,
green lands,
arable land

used for growing product 1,
……,
used for growing product k,

Land “Not used”

Damaged,

Not used because of excess:

Soil type 1,

Soil type 2,

……..

Soil type n

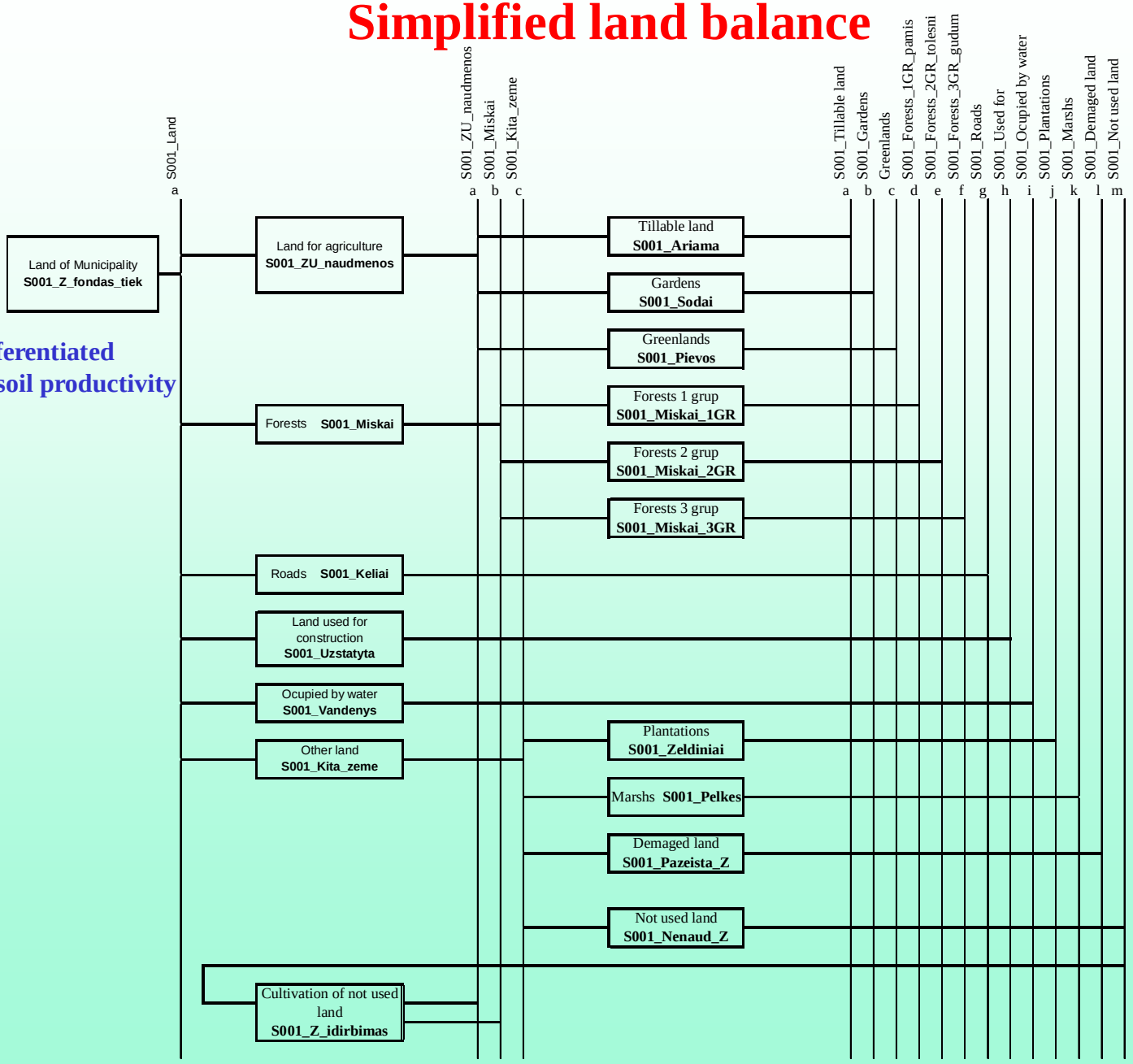
gardens,
green lands,
arable land

used for growing product 1,

…….,

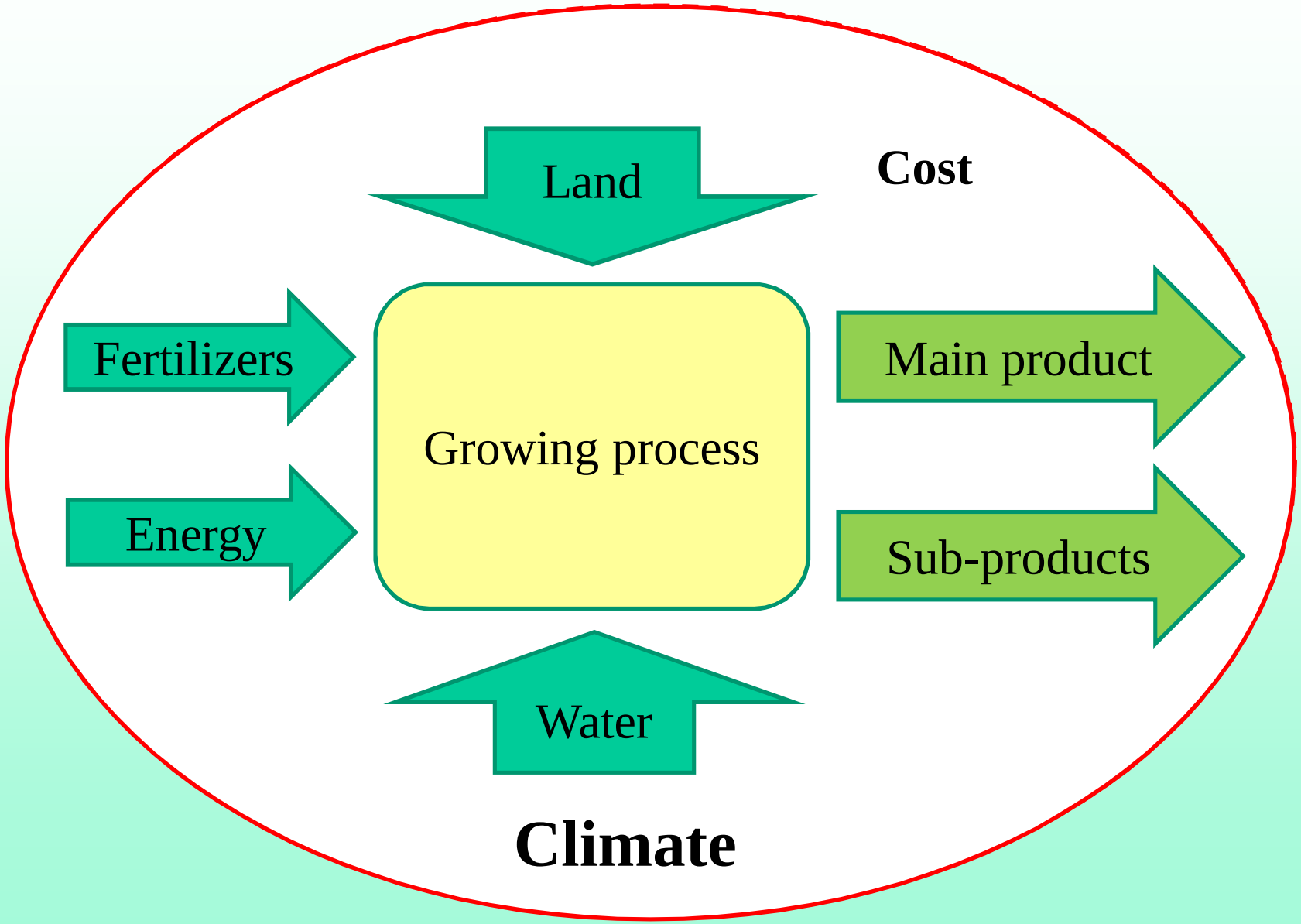
used for growing product m,

Fragment of the mathematical model diagram. Simplified land balance

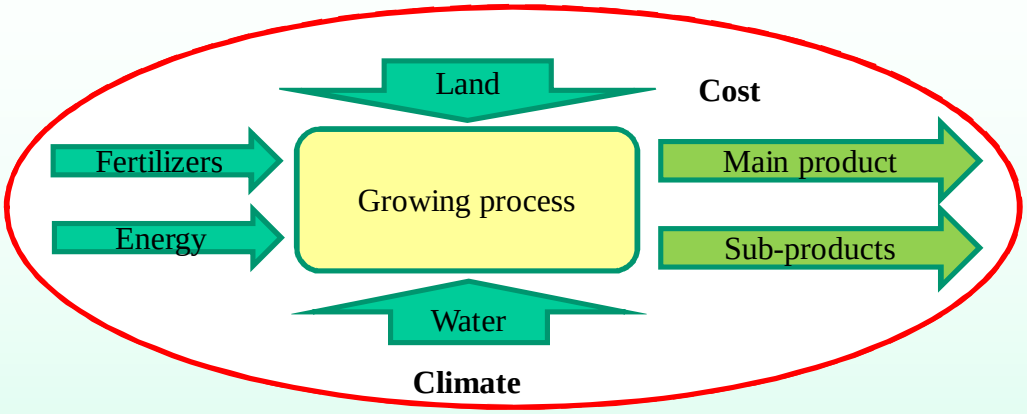


Can be differentiated according soil productivity

Growing of agricultural product



Modeling of growing agricultural product



Representation as technology in the mathematical model

Comp-osite input: Land, Water, Fertilizers, Energy

Technology with multiple inputs and outputs

Efficiency

Cost

Product

Sub-product

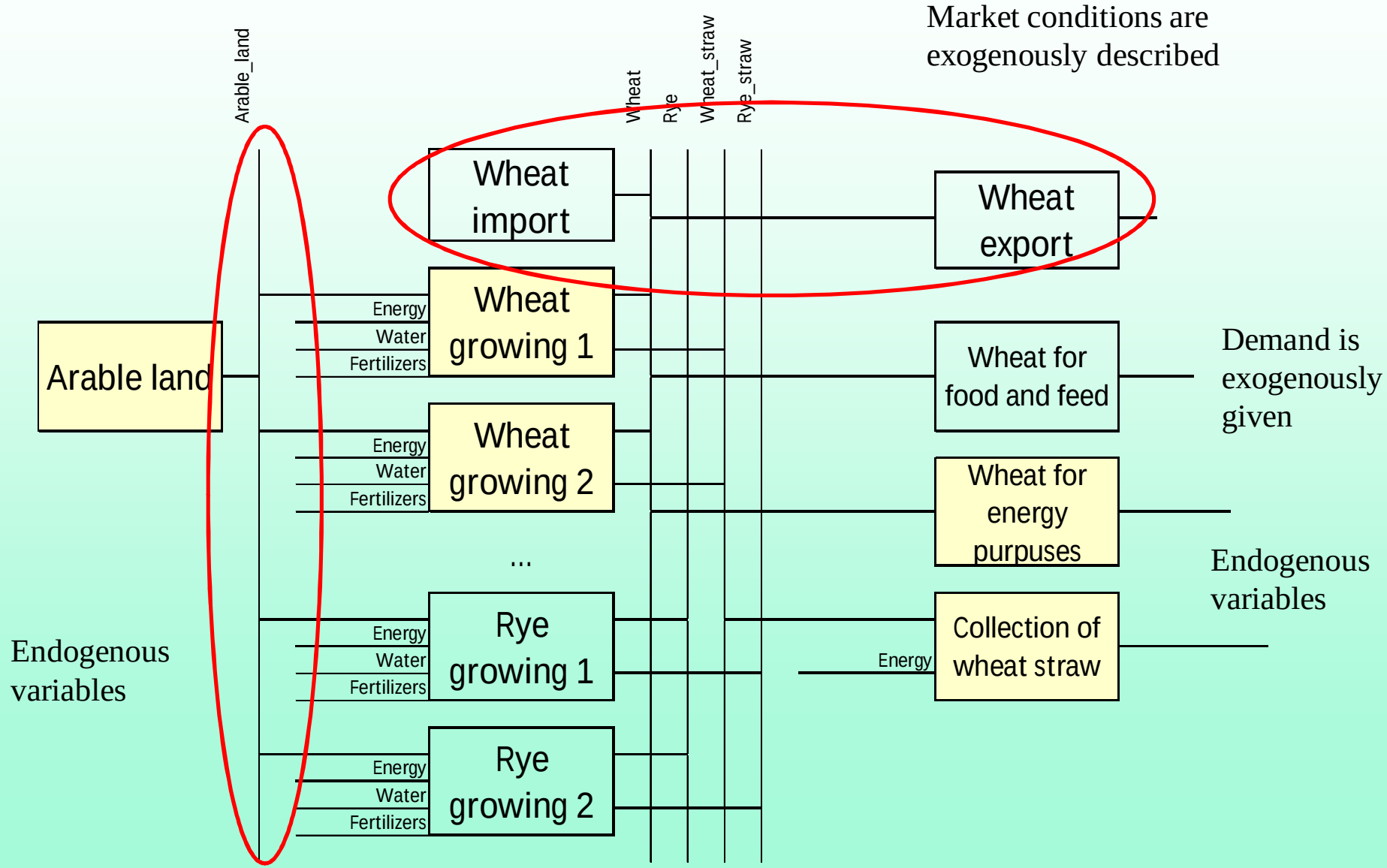
Comp-osite output

$$\text{Efficiency} = \frac{\text{Main product}}{\text{Land}}$$

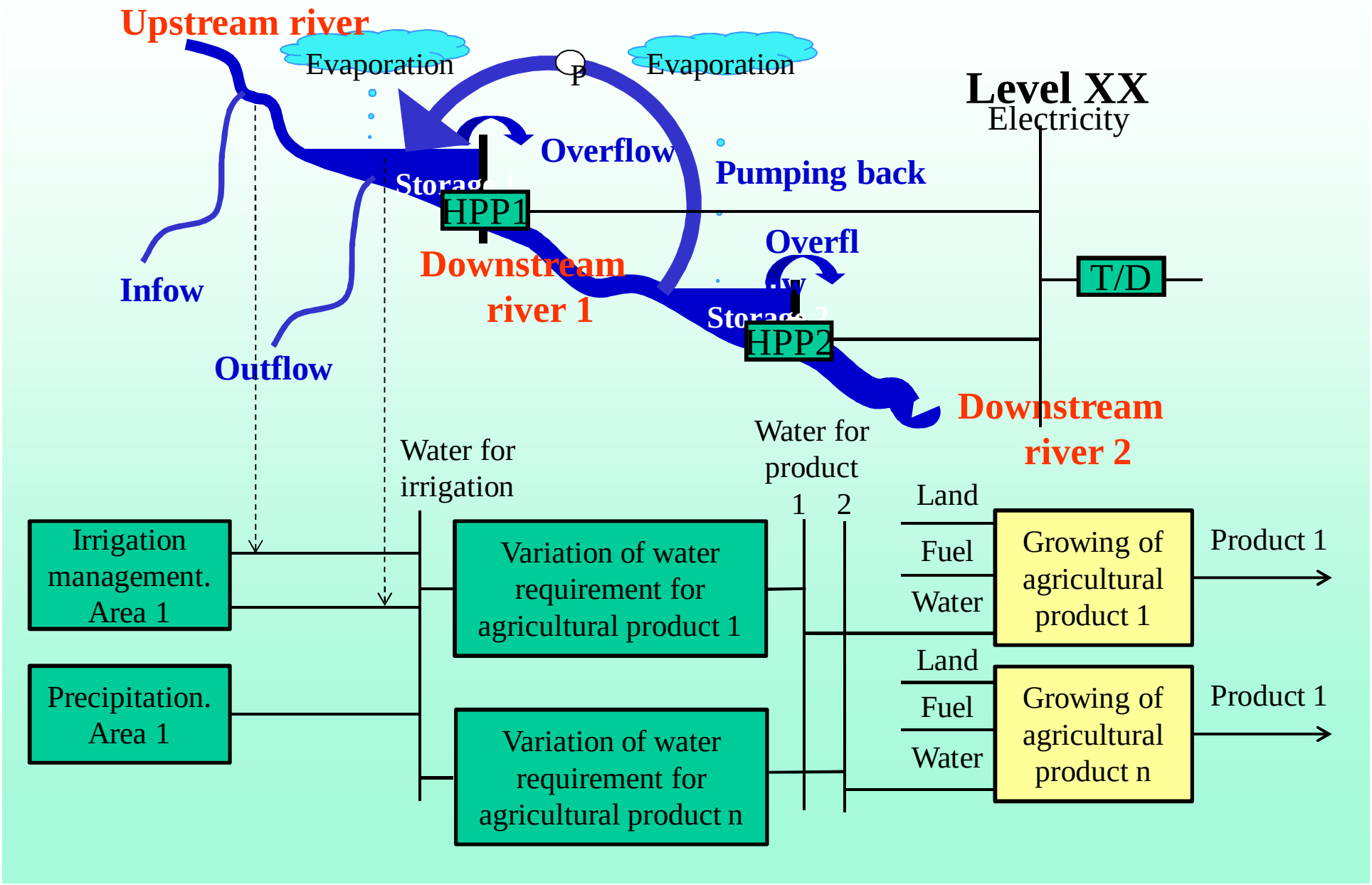
Depend on climate

$$\text{Cost} = \frac{\text{Growing cost}}{\text{Main product}}$$

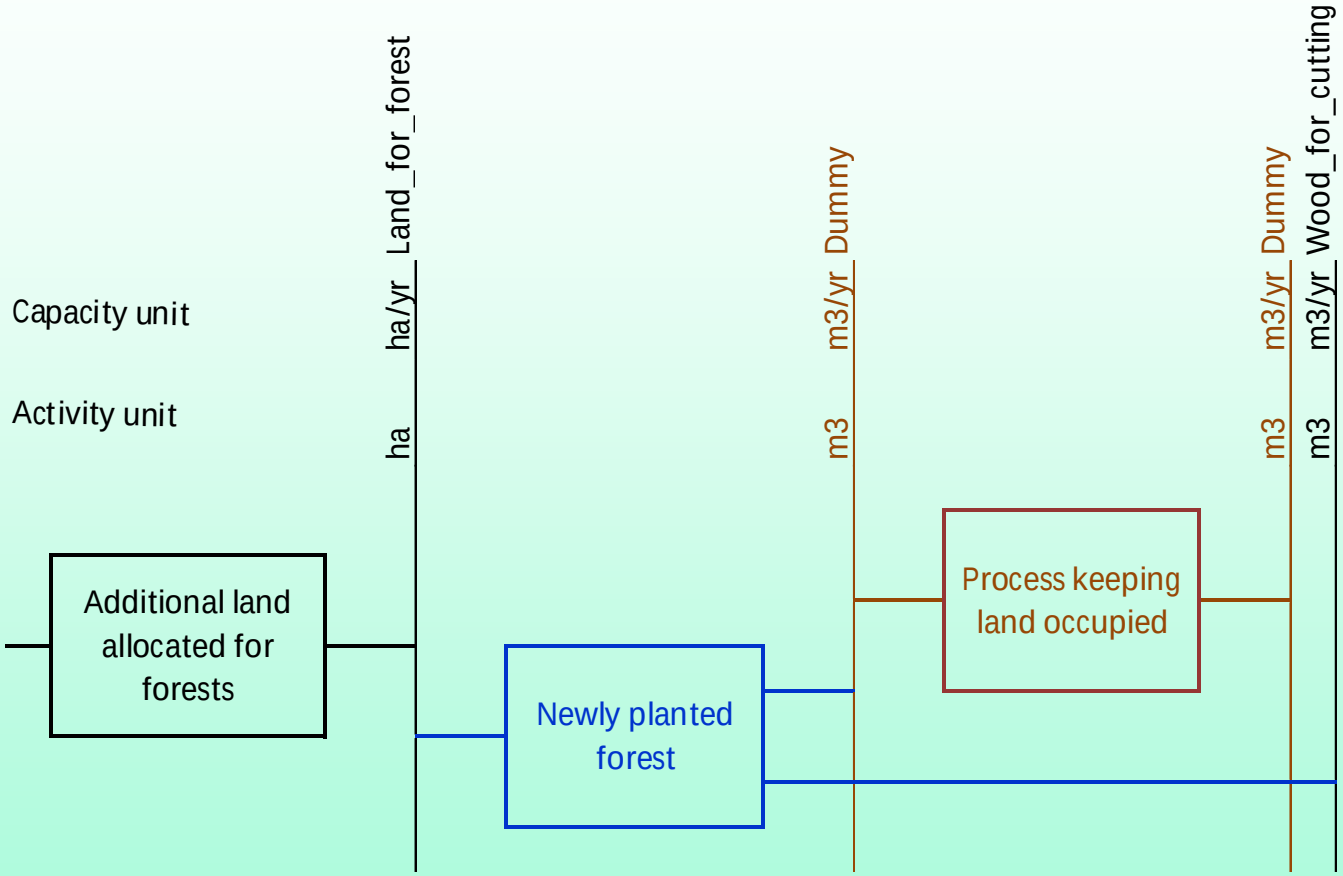
Fragment of the mathematical model. Growing of agricultural products



Modeling of irrigation



Growing of forest in MESSAGE terms

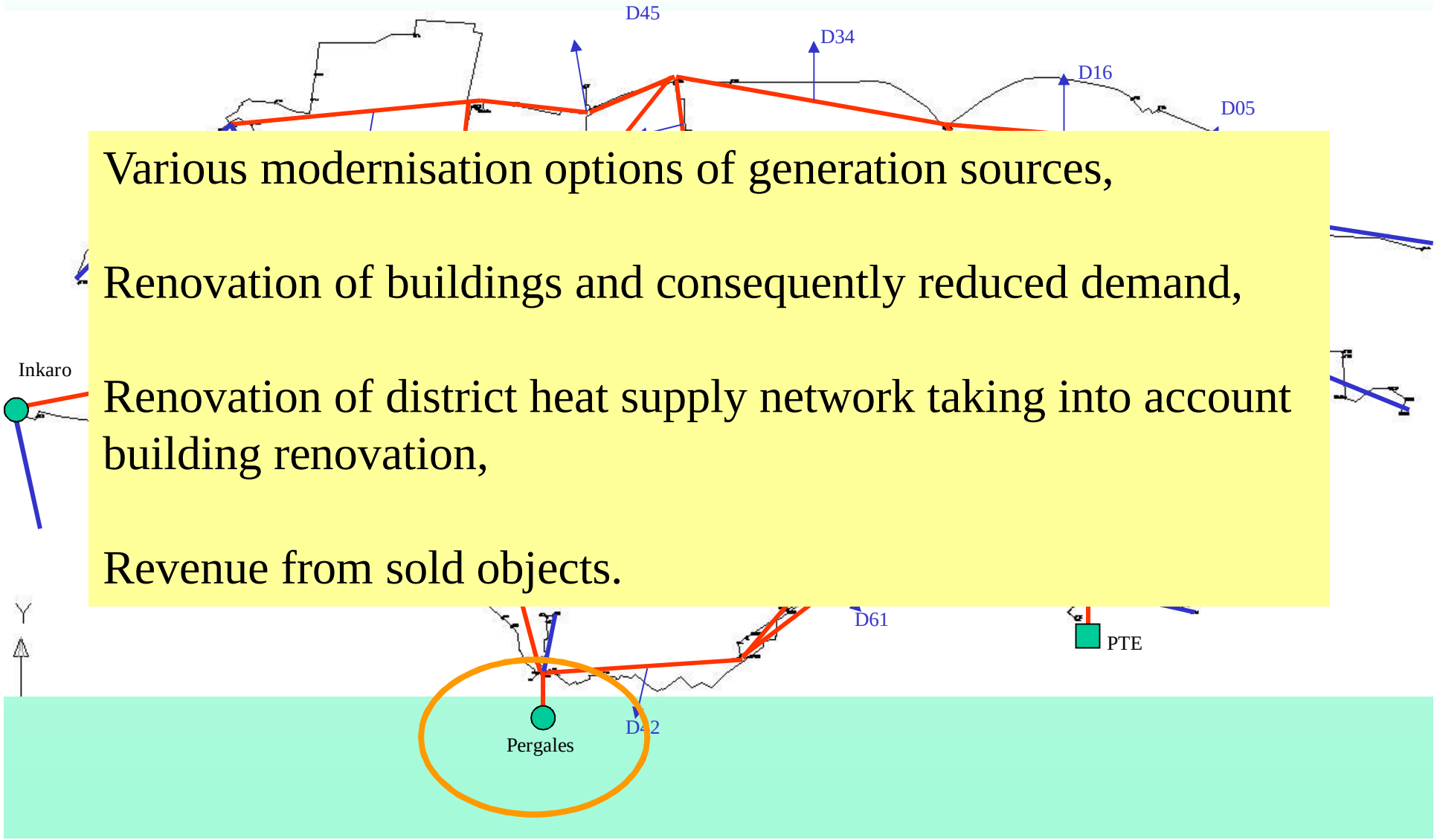


Modelling of district heating systems

Strategy for development of Kaunas district heating

Under contract with JSC “Kauno energija”

Model of district heating system (1)



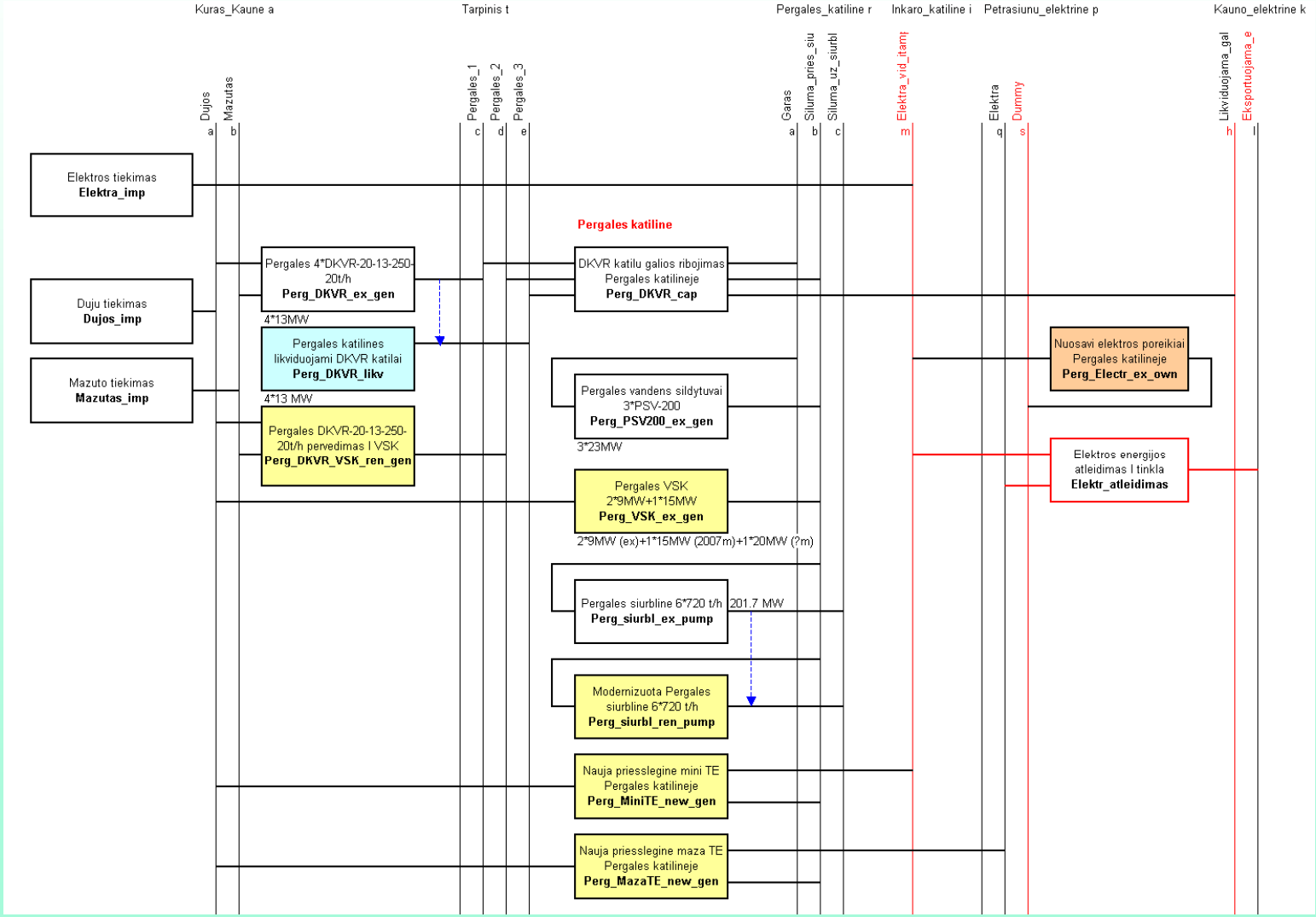
Various modernisation options of generation sources,

Renovation of buildings and consequently reduced demand,

Renovation of district heat supply network taking into account building renovation,

Revenue from sold objects.

Model of district heating system (2) (Boiler-house)



Operational problems and their modelling

Variety of suppliers (Heat suppliers, independent producers, regulated, not regulated, etc.);

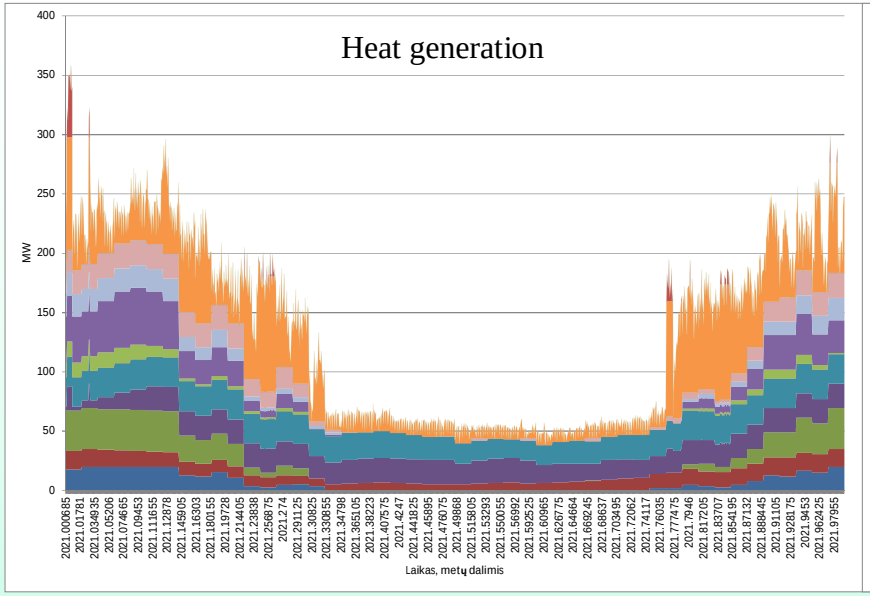
Regulation is imperfect (Relations between different actors is not properly adjusted; This requires changes in legal documents);

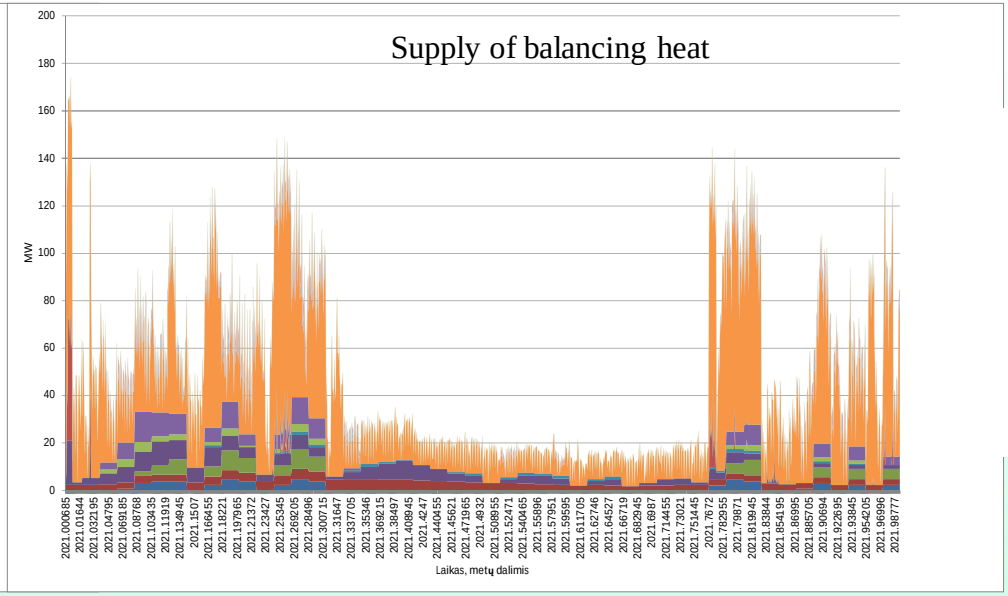
Monthly auctions for district heat production (Does not take into account fluctuation of heat demand, every supplier expect to produce heat during the entire month, but this does not happen; Various disputes, courts, etc. as a consequence);

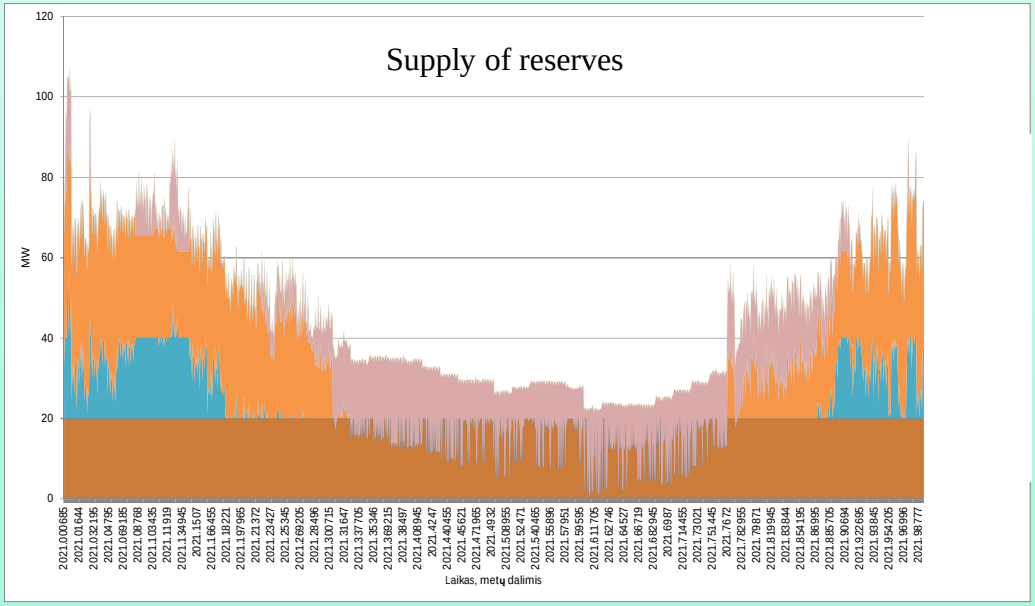
Free market relations for heat production, supply of balancing heat, providing reservation services.

Explicit modelling of heat production, supply of balancing heat, providing reservation services**.**

Operation of the district heating system







Modelling of reserve capacities

Development of the Lithuanian energy sector and investigation of economical efficiency of the new Visaginas NPP

Preparation of updated National Energy Strategy.

(Detailed modelling of reserve capacities and power plants with intermittent generation)

Stages in preparation of the National energy strategy

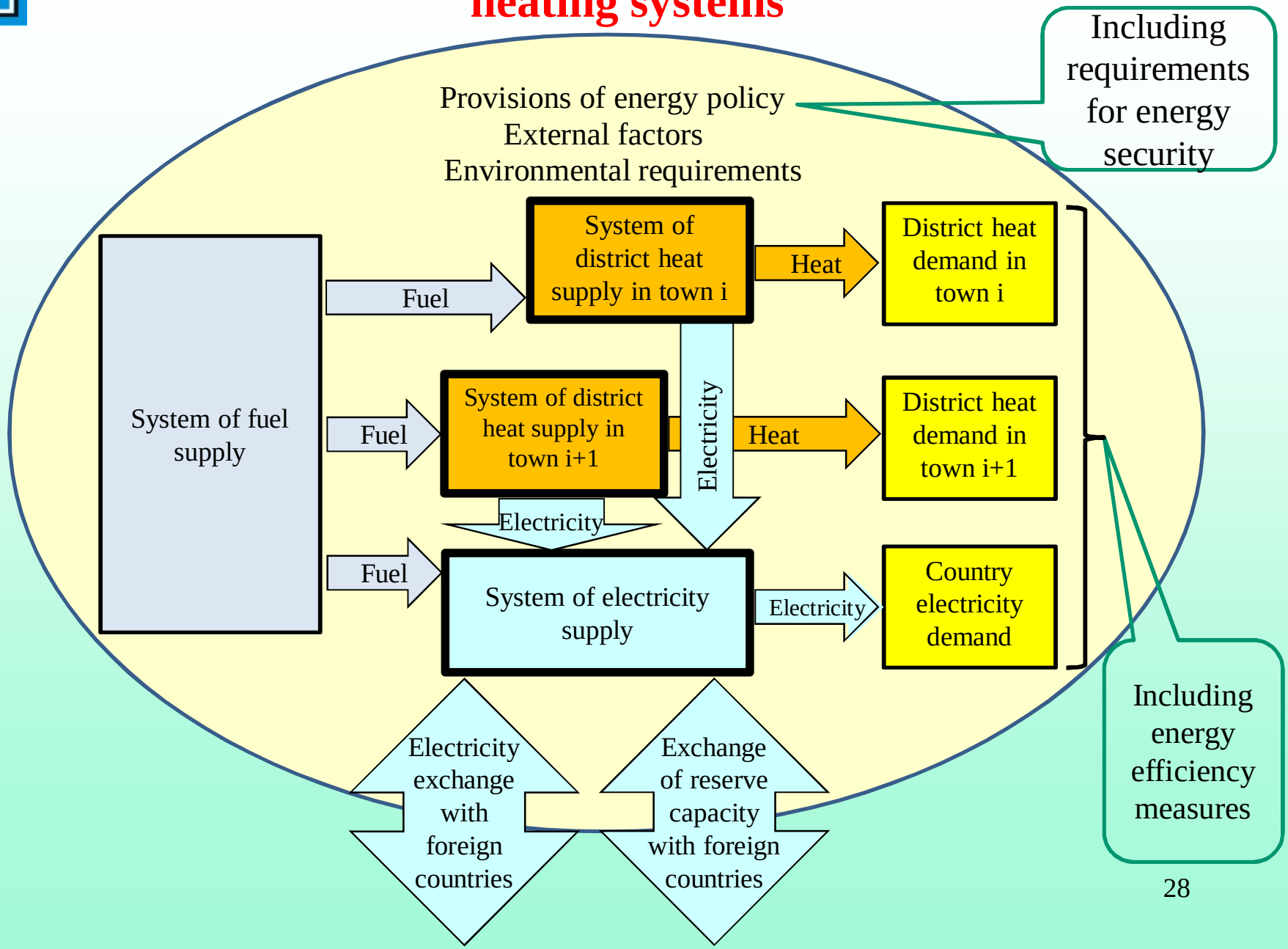
Scenario analysis of energy sector development and operation

Evaluation of energy security for energy sector development scenarios

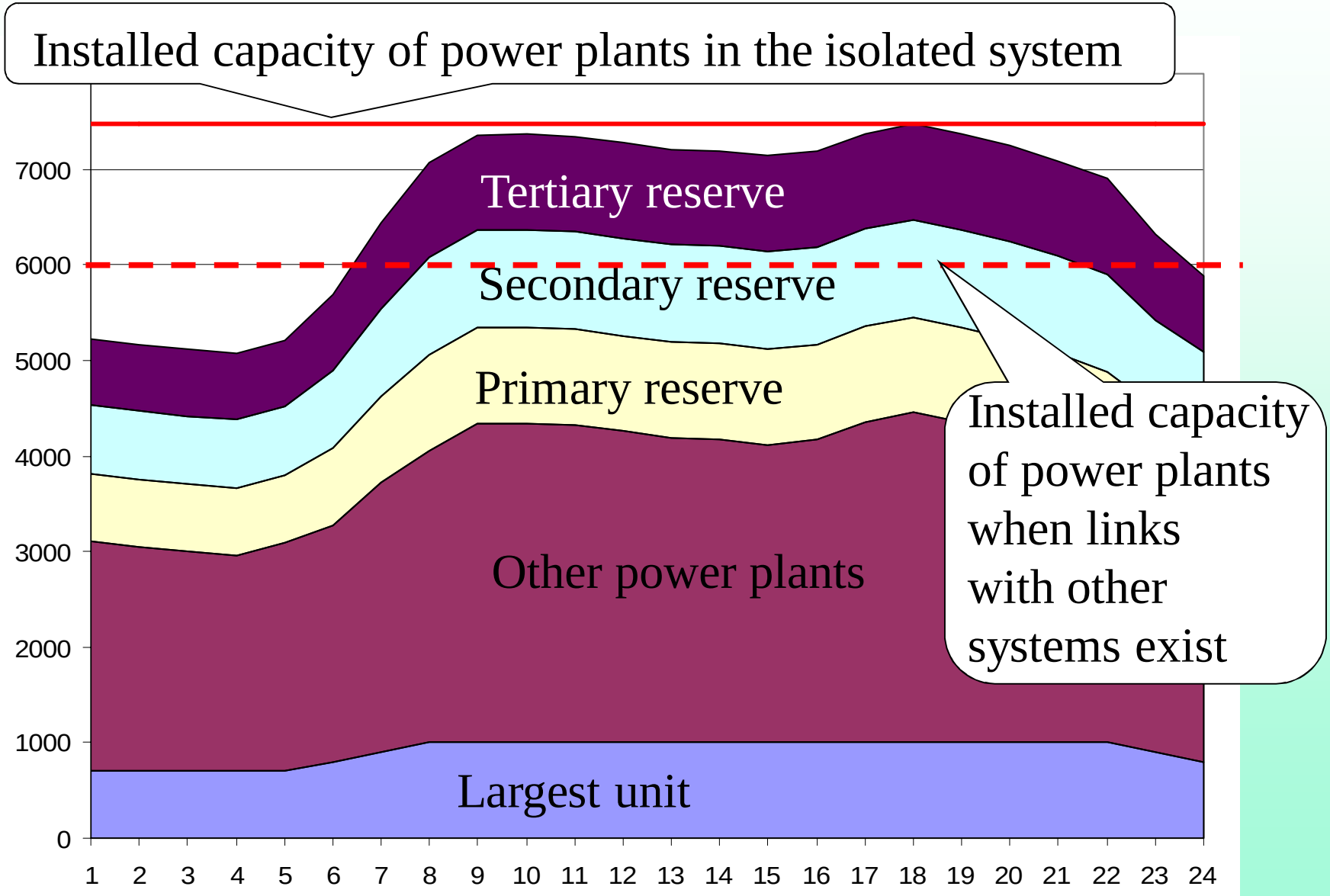
Analysis of macroeconomic impact of energy sector development scenarios

Preparation of the National energy strategy project

Structure of mathematical model of electricity and district heating systems



Nuclear unit and reserve capacity



Size of nuclear unit and reserve capacity

How much it is necessary to hav… { primary reserve? / secondary reserve? } Depend on unit

How m… is nec… have l…

How m… is poss… get fr…

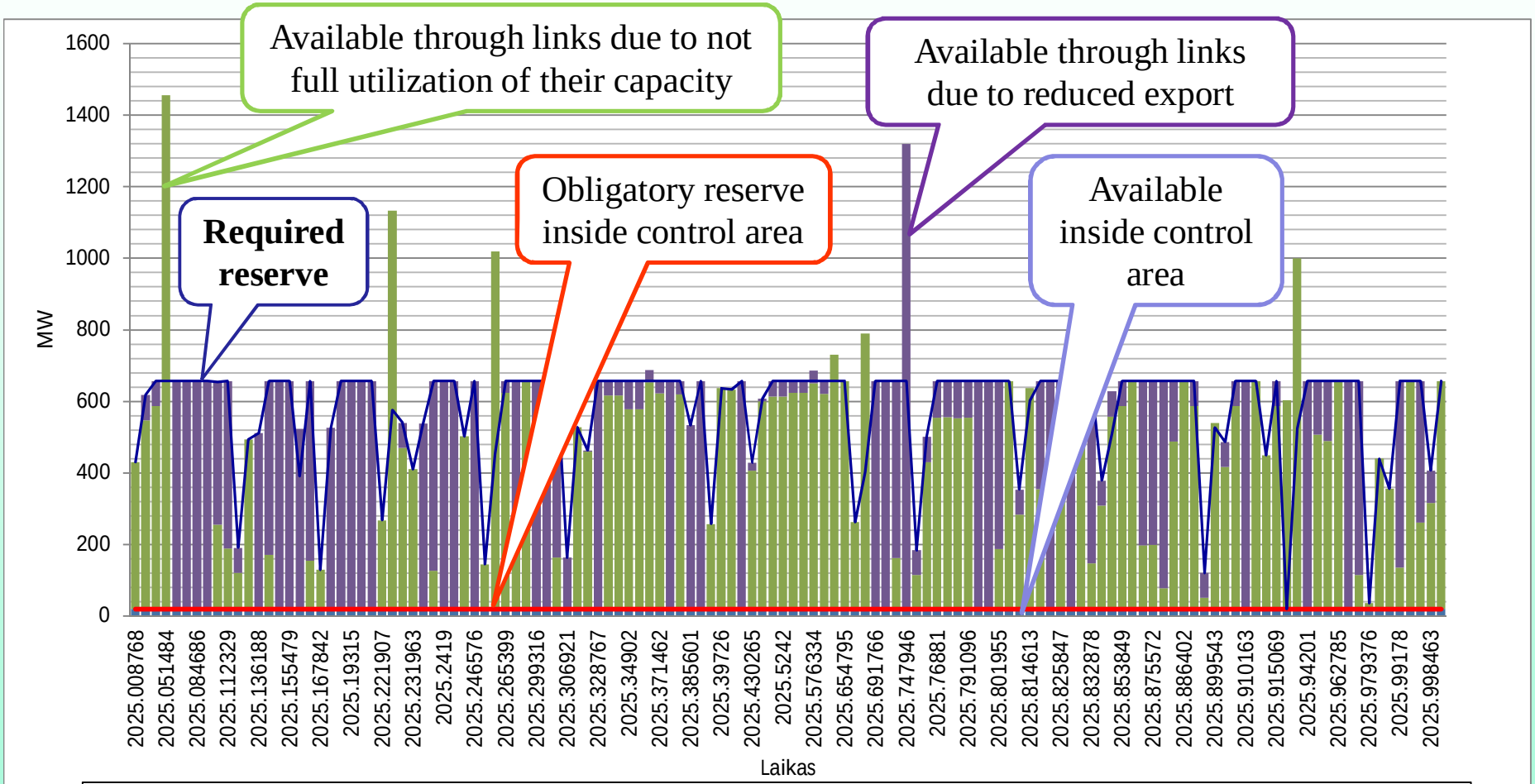
…rougput …nks, …t flows,

Will power system remain stable after failure of nuclear unit?

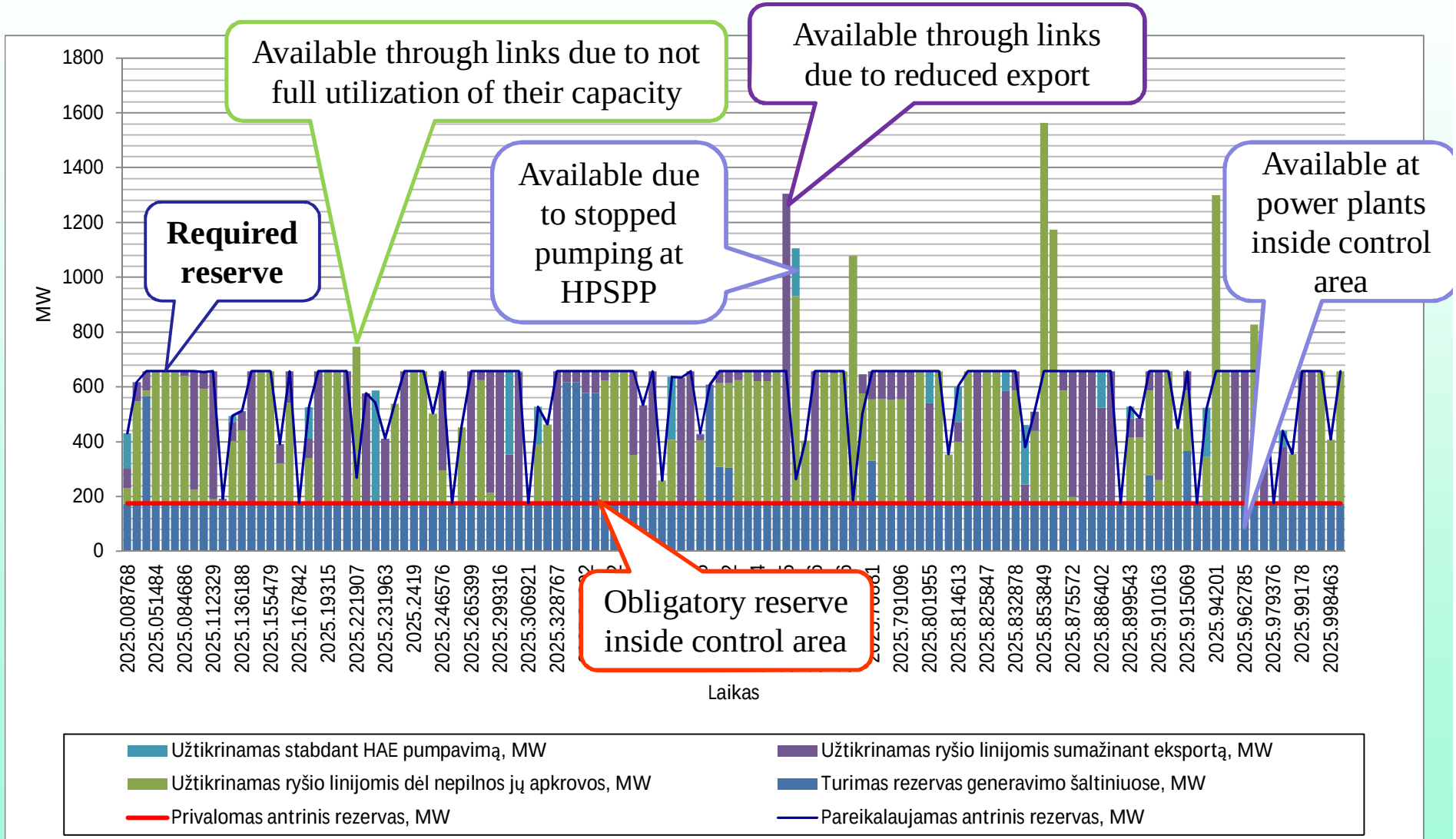
Where, when, how big and what kind reserve capacity should be located?

What should be structure of power plants, their load, import-export of electricity in order to fulfill all this?

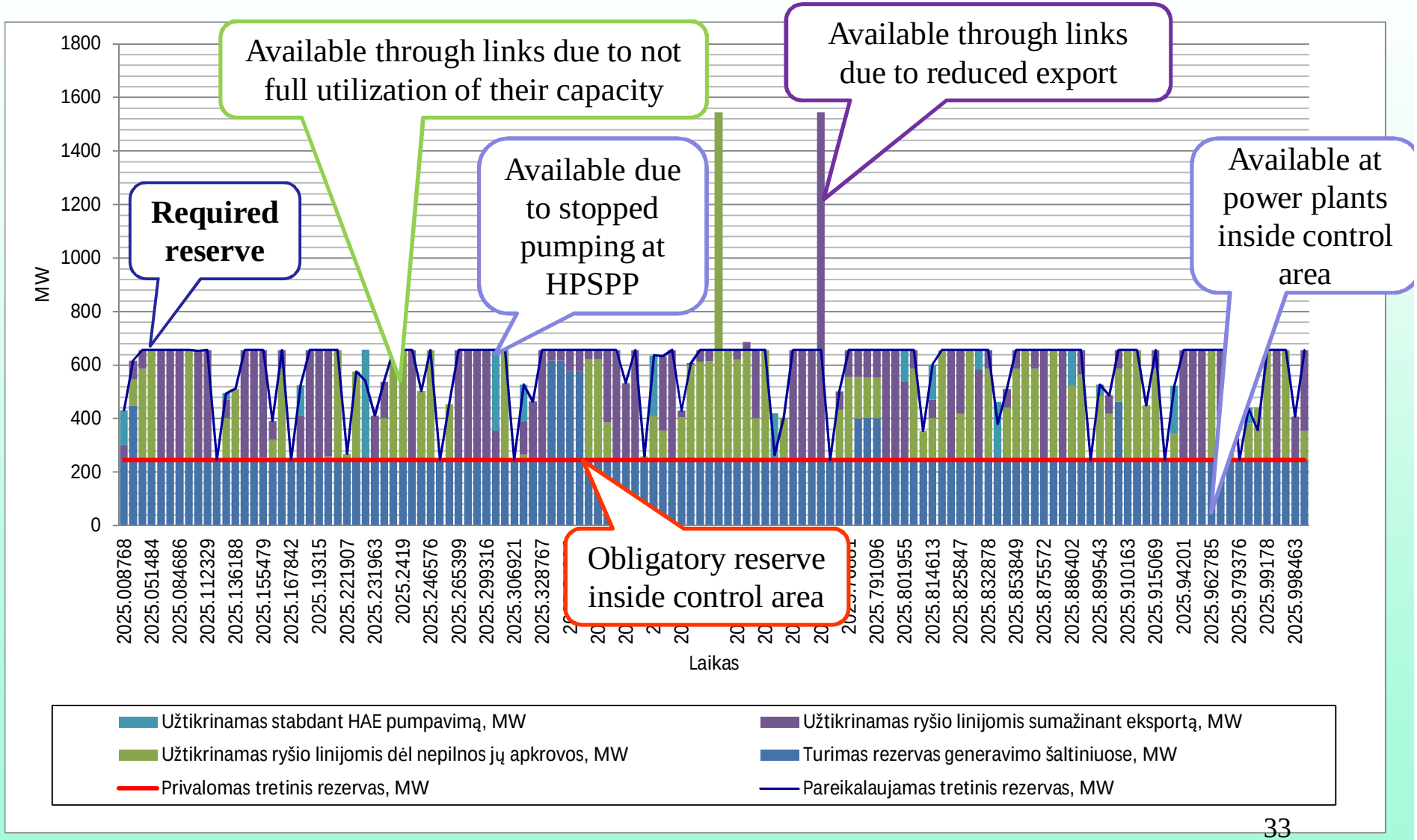
Providing of primary reserve (Example)



Providing of secondary reserve (Example)

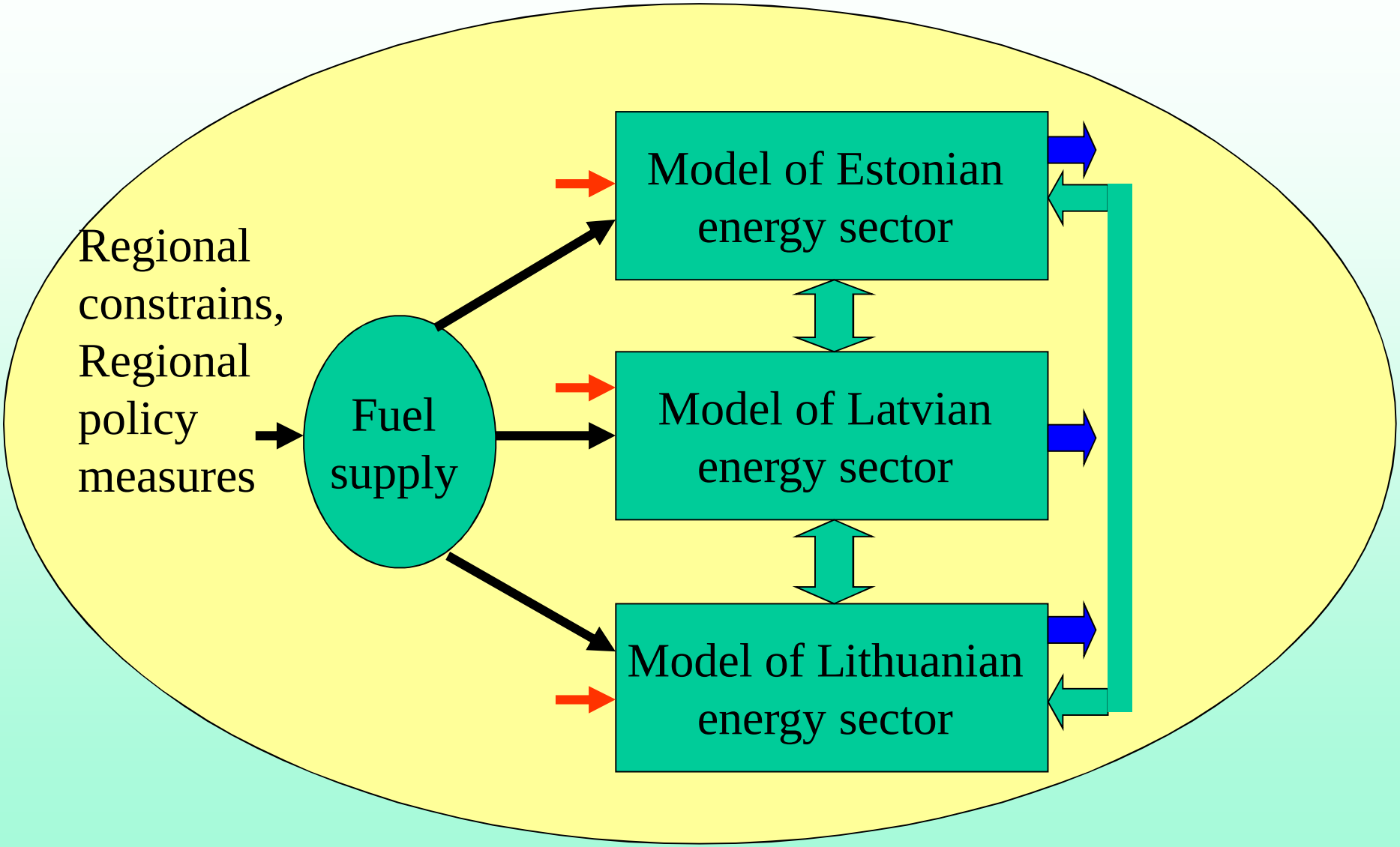


Providing of tertiary reserve (Example)

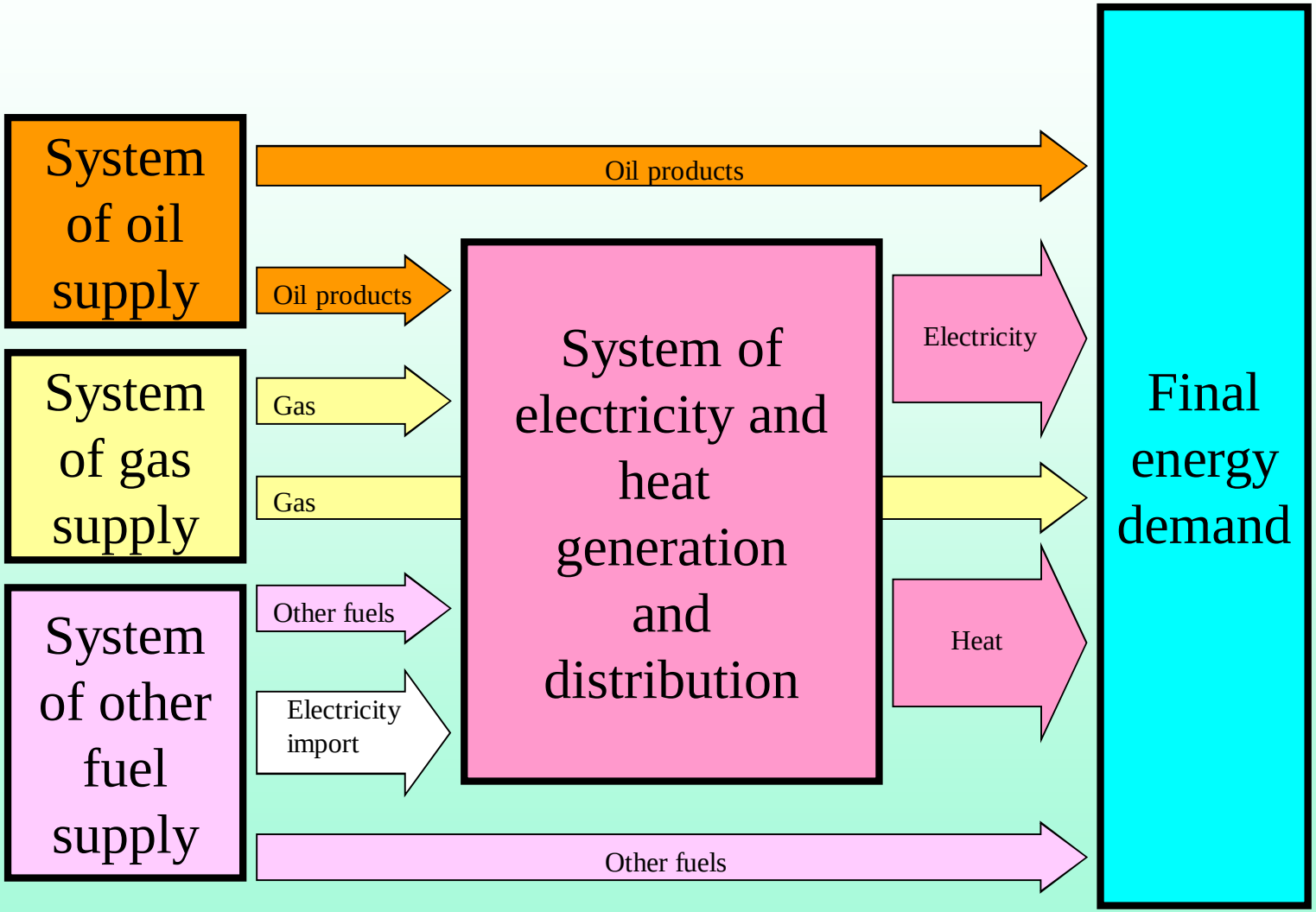


Model for analysis of energy system development and in the Baltic region

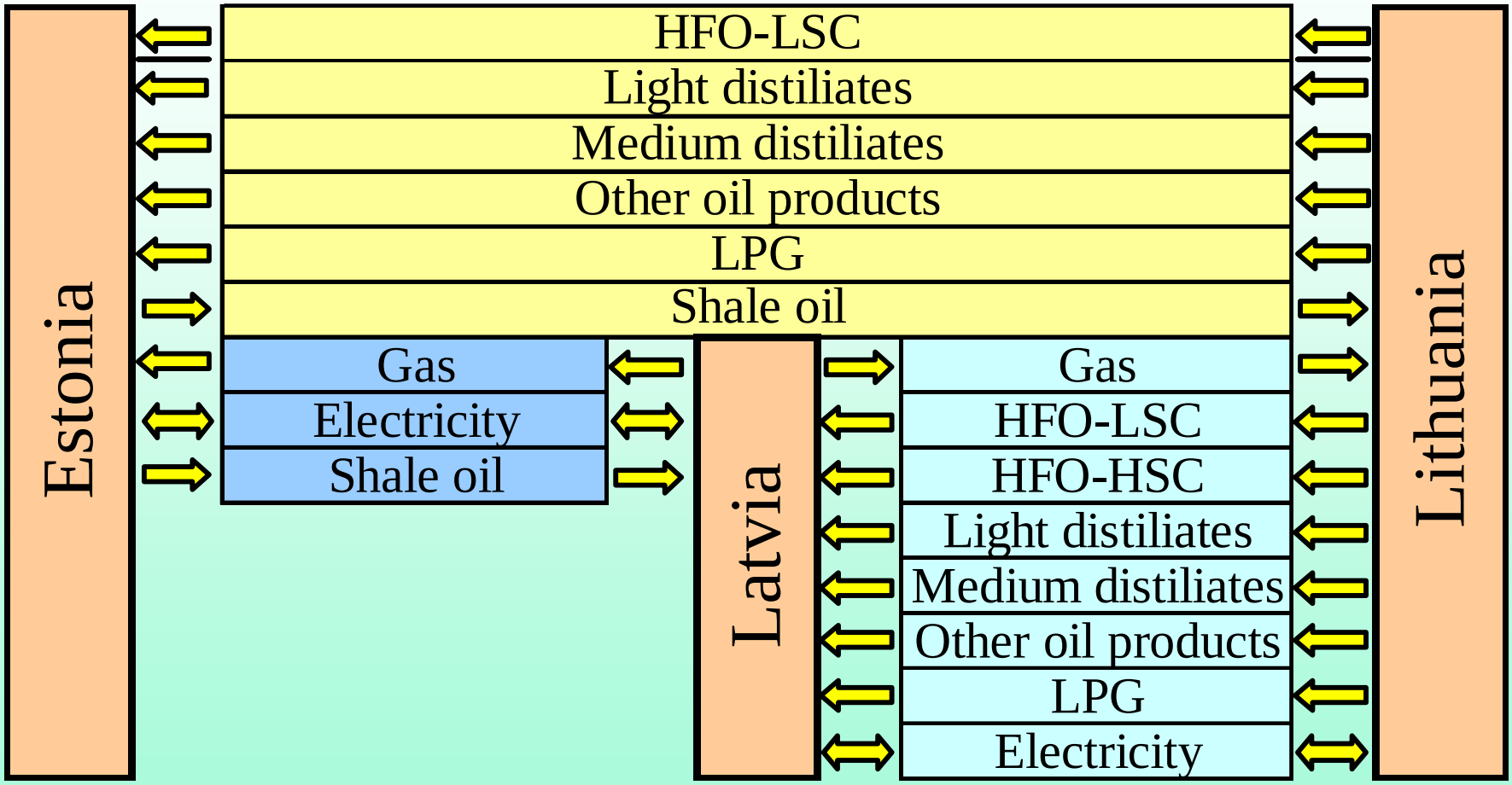
Structure of the multi-regional model



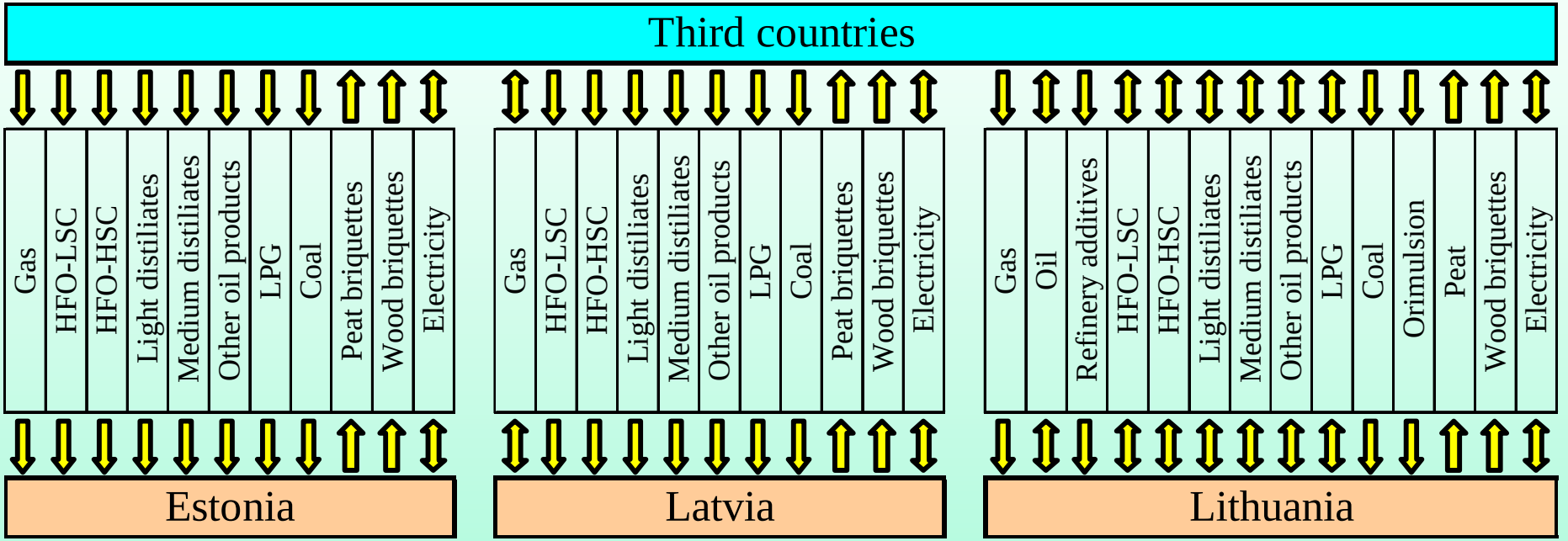
Structure of the energy sector model of Lithuania



Energy exchange between Baltic countries

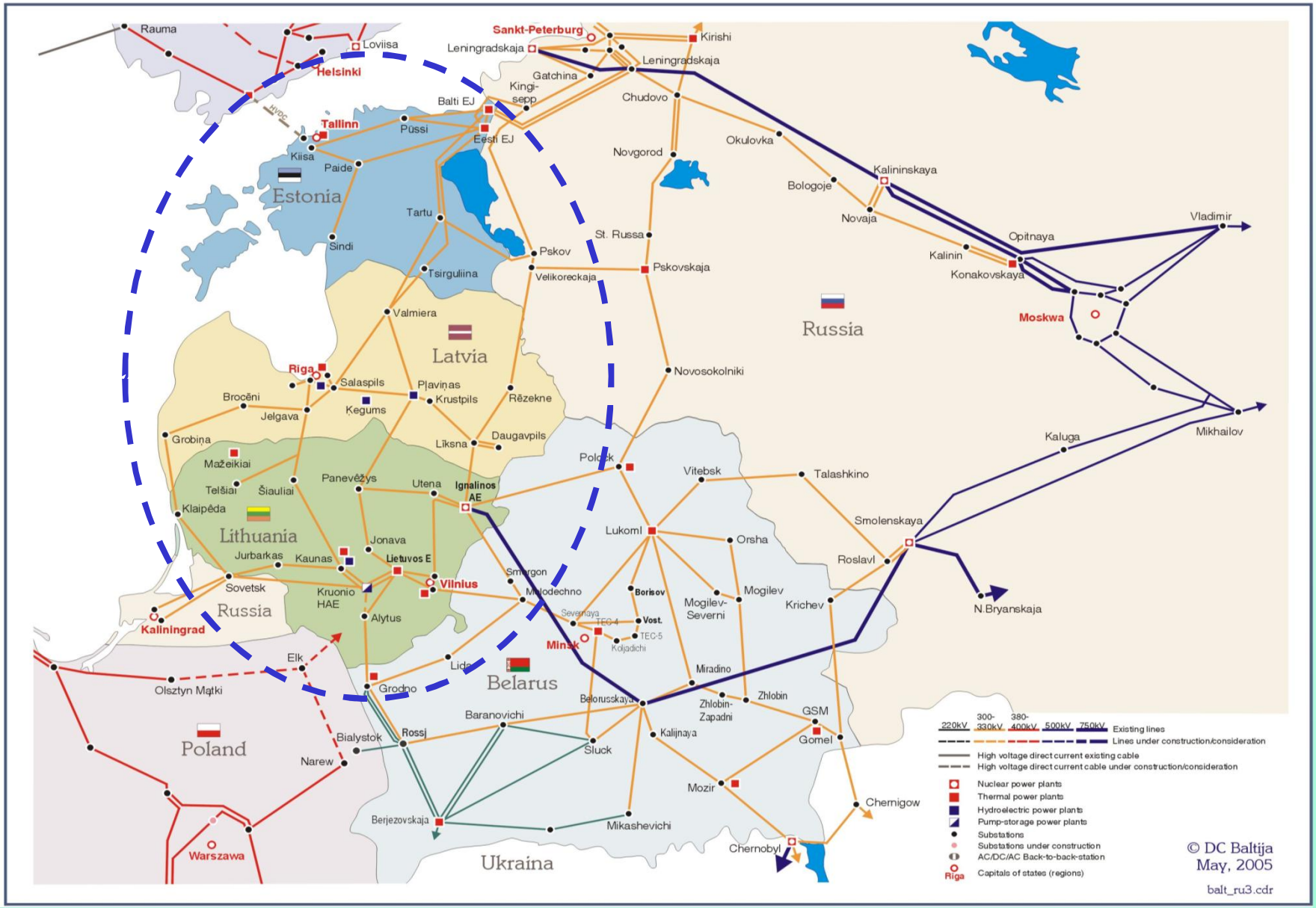


Energy exchange between Baltic countries and third countries

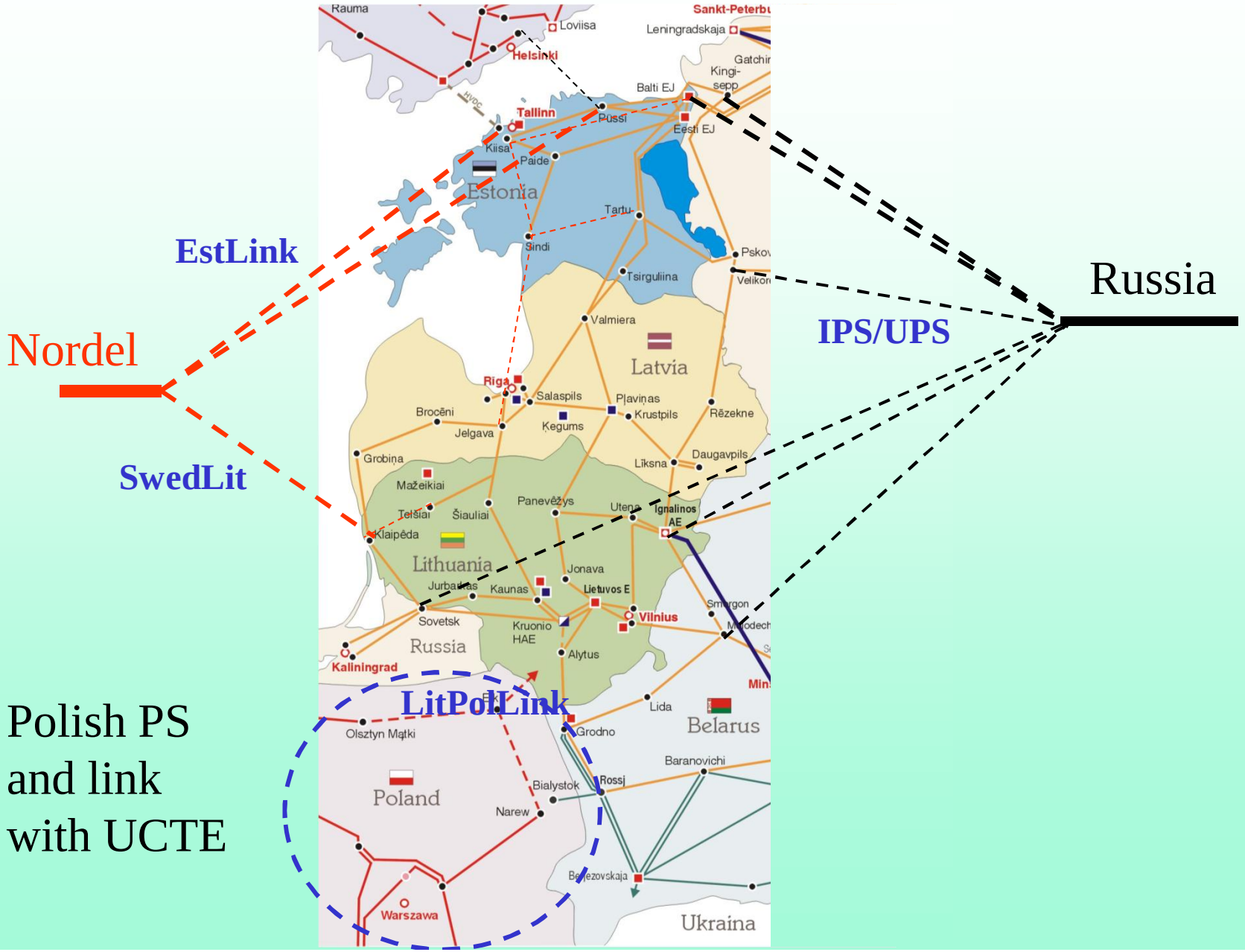


Model for analysis of power system development in the Baltic region

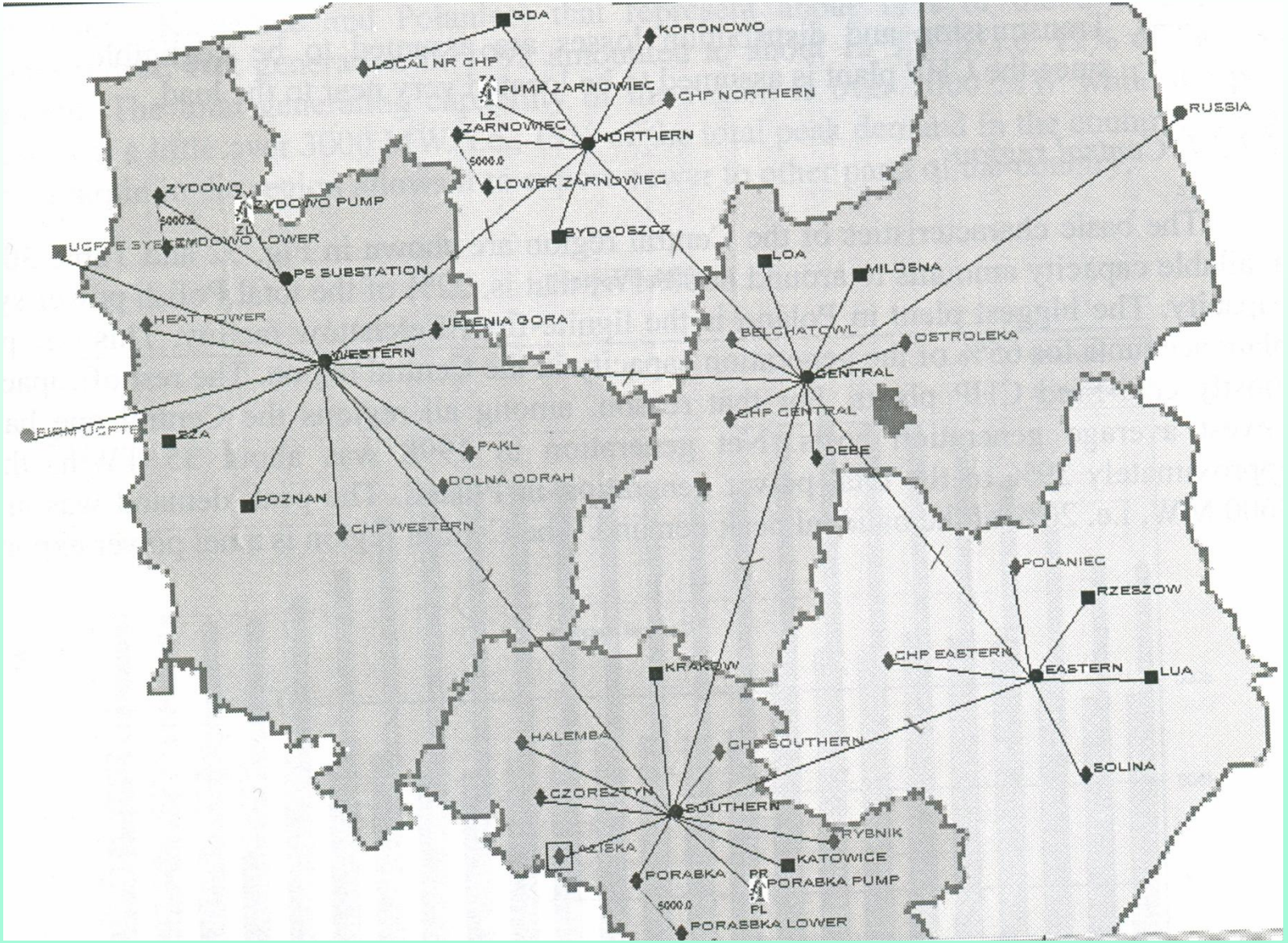
Baltic power system



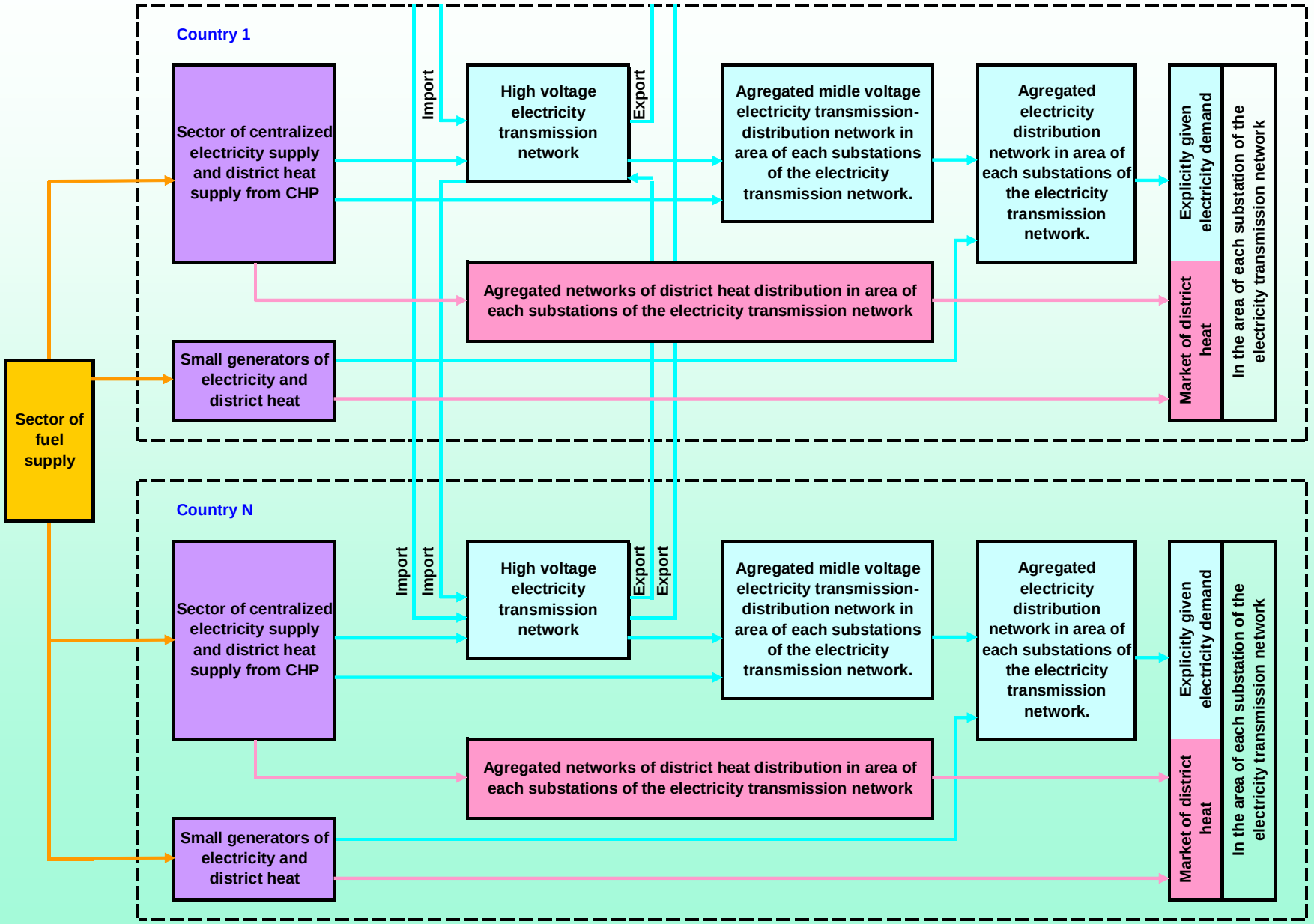
Baltic power system and links with third countries



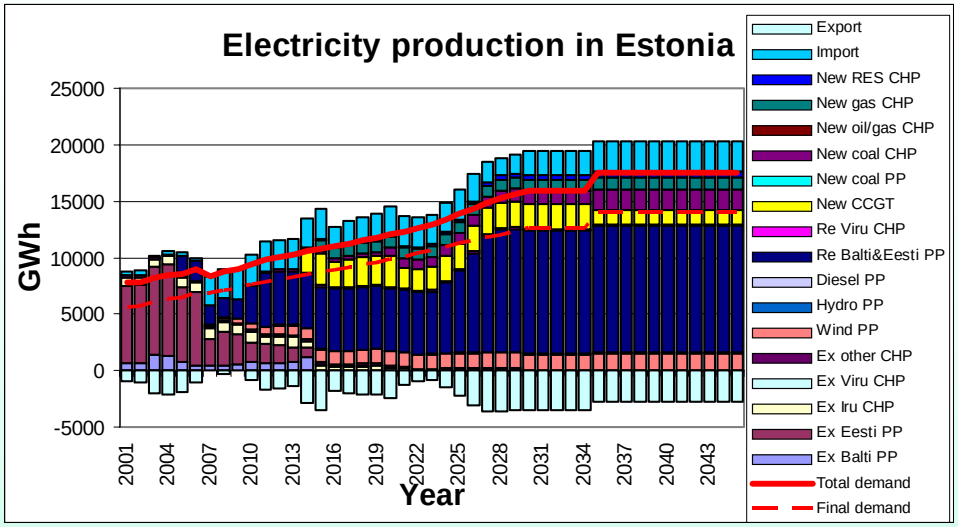
Representation of the Polish power system

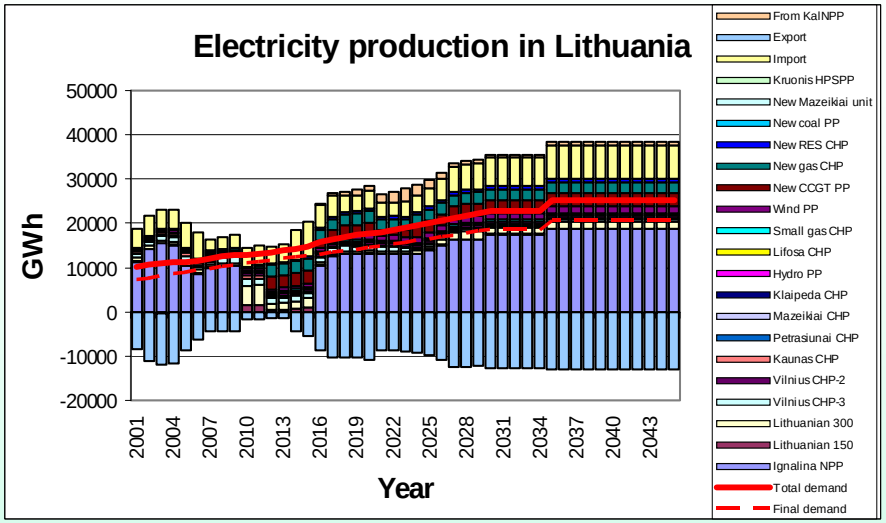


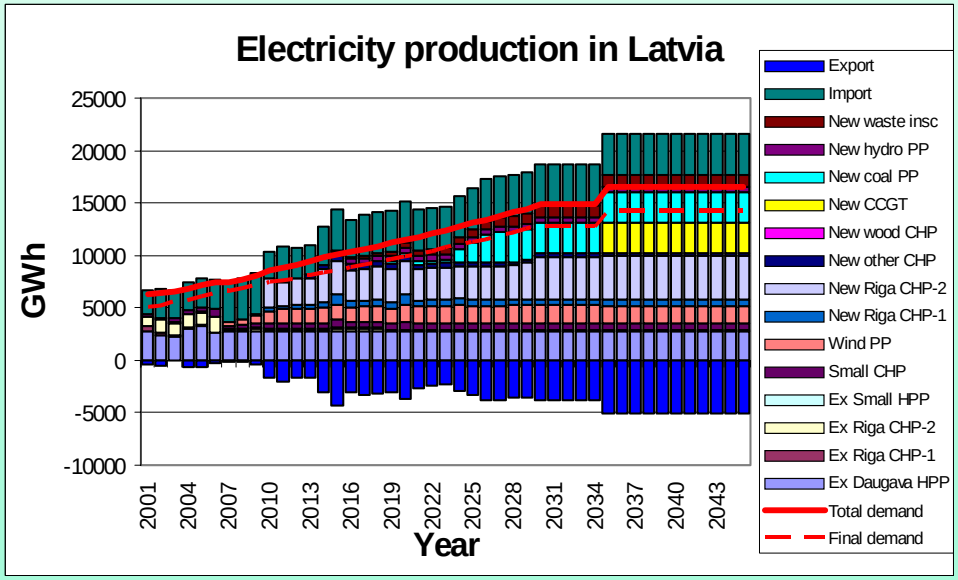
Structure of the model

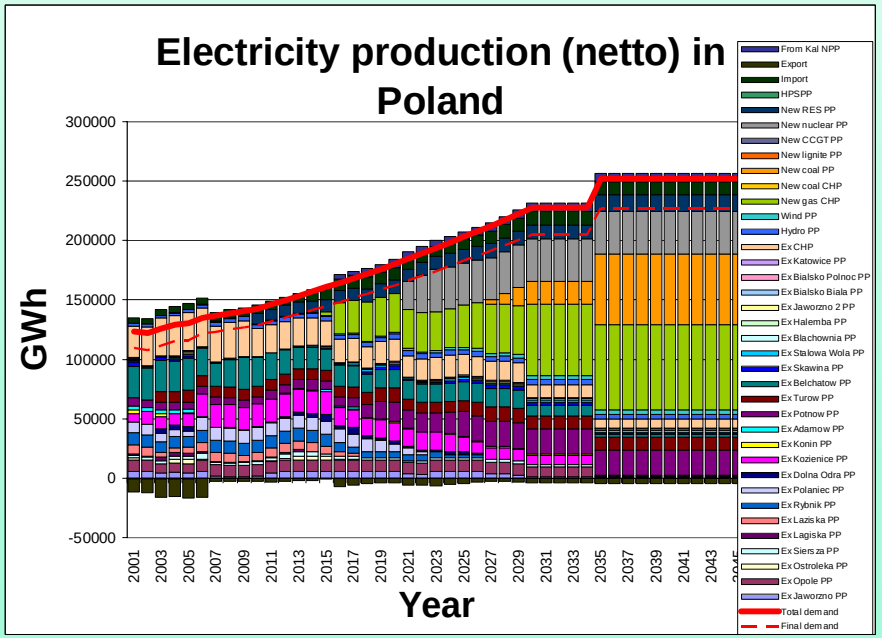


Electricity production in scenario 1



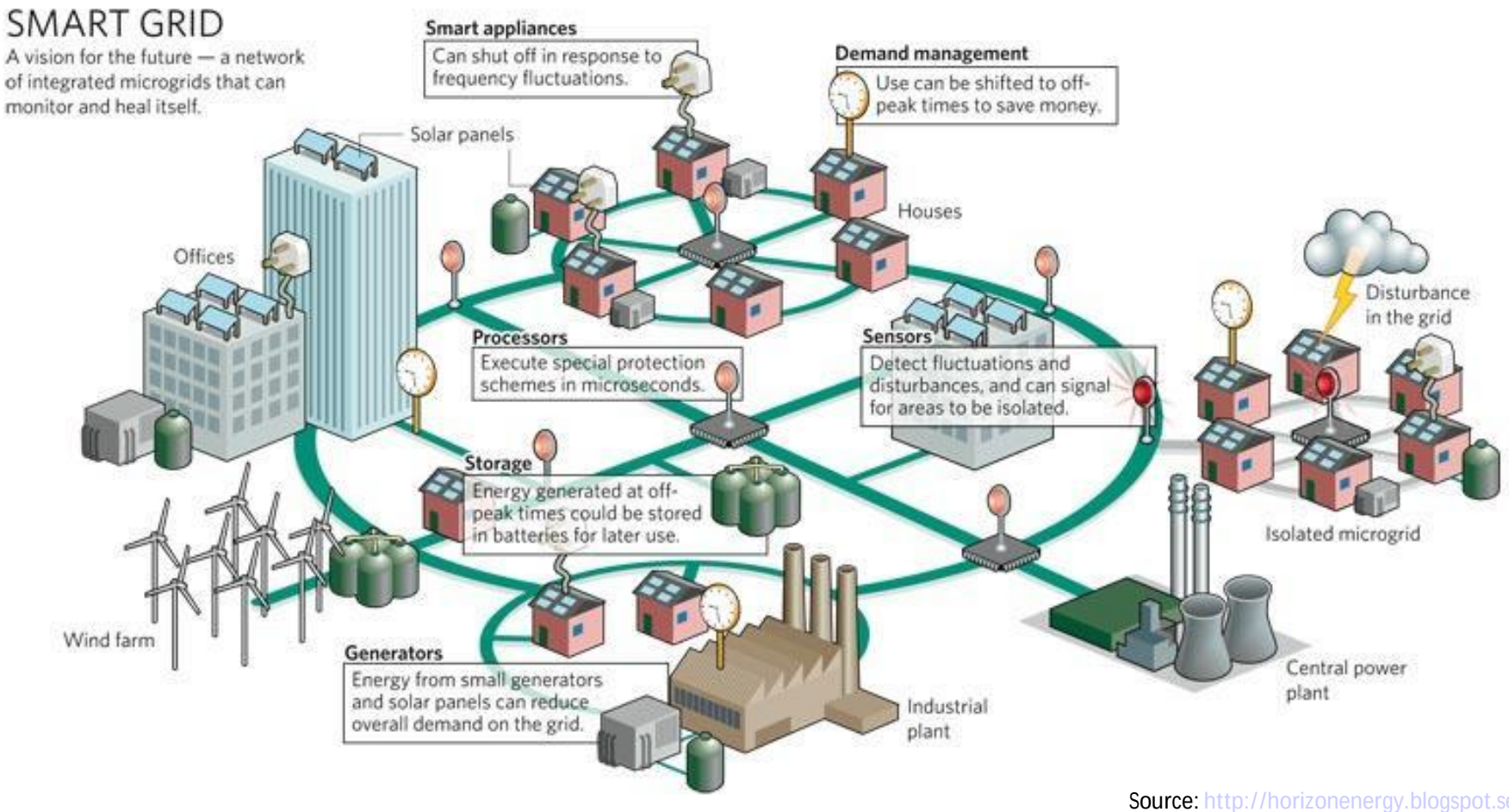






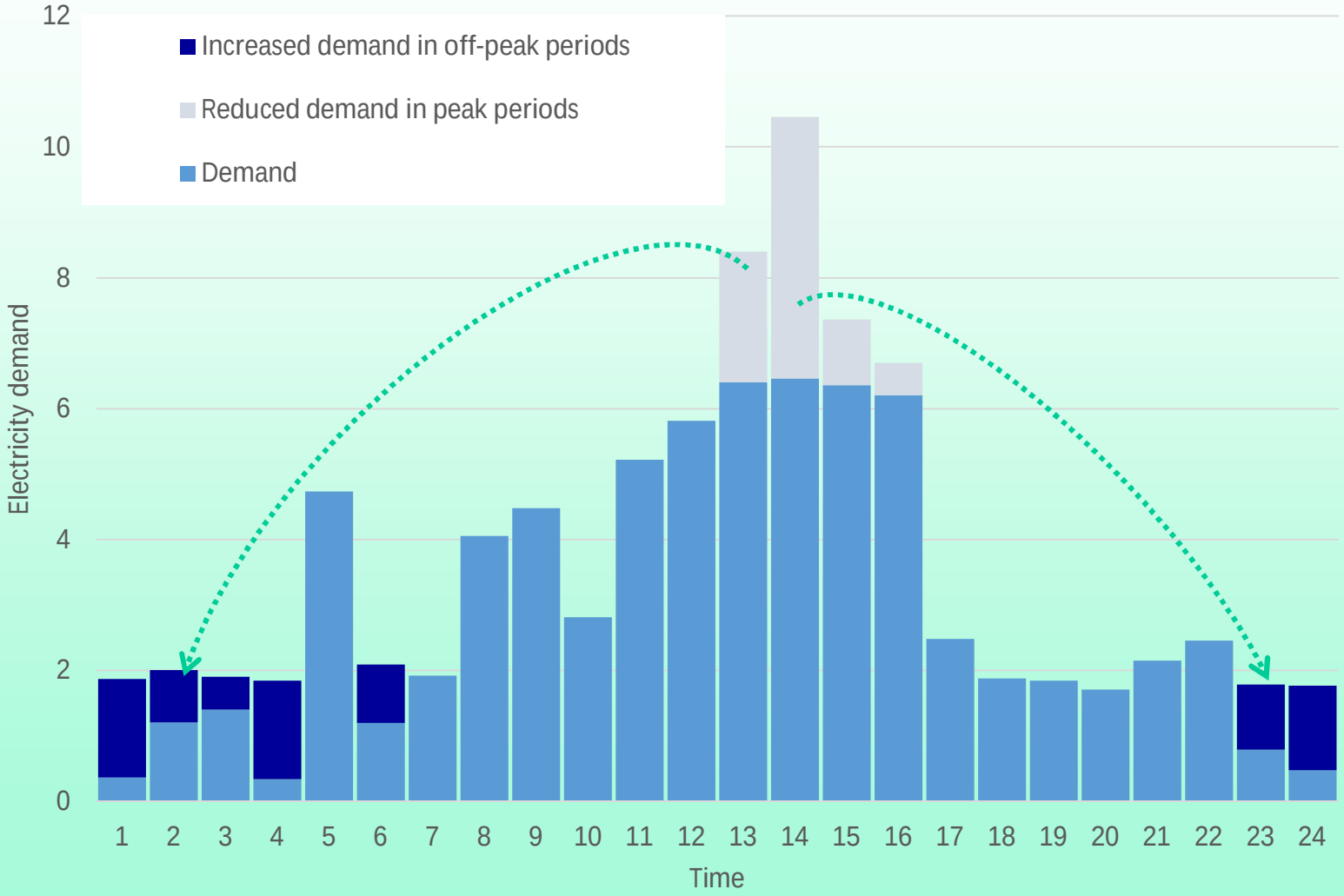
Modelling of smart grid

Smart grid

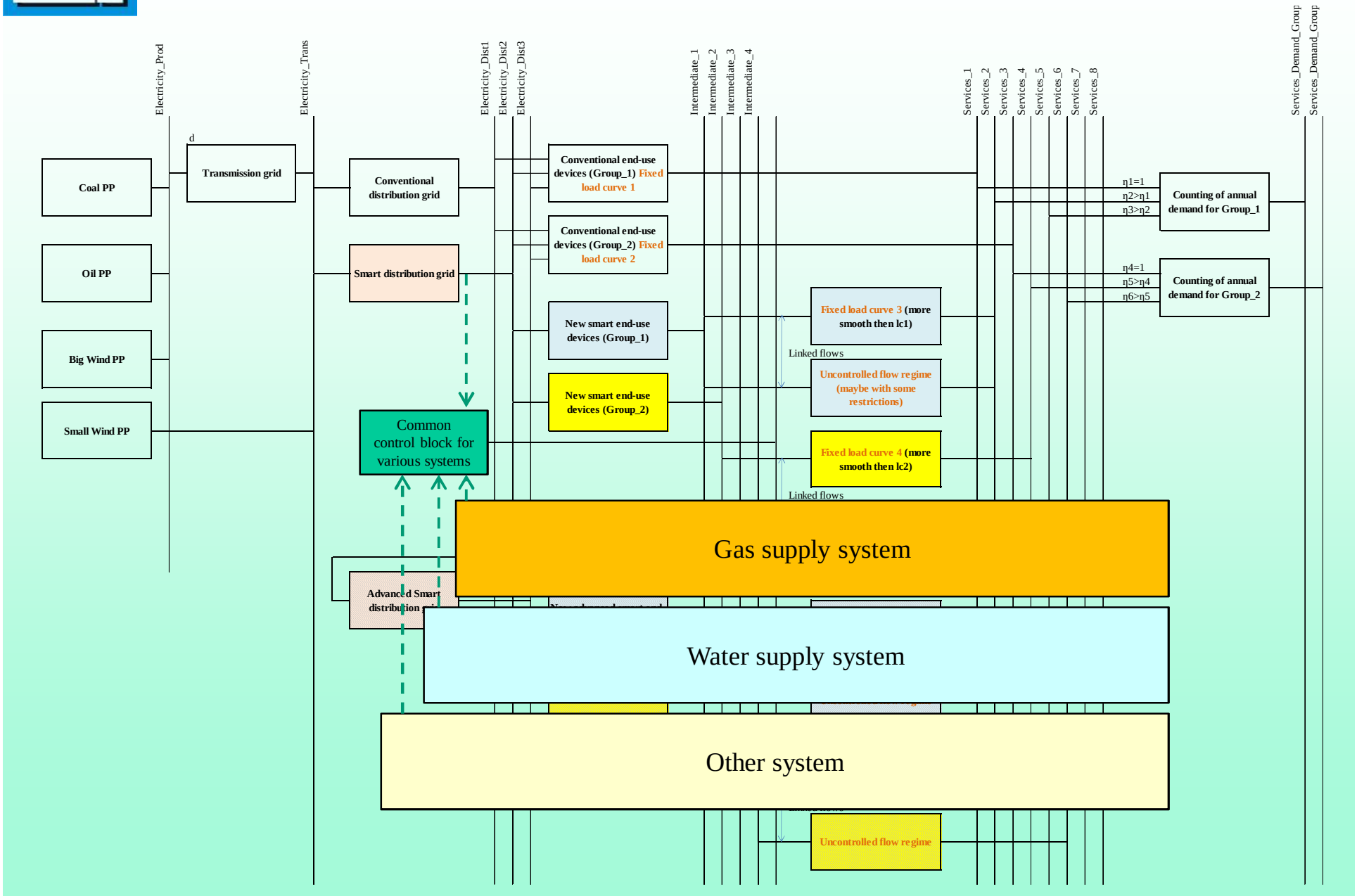


Source: http://horizonenergy.blogspot.se/

Load changes

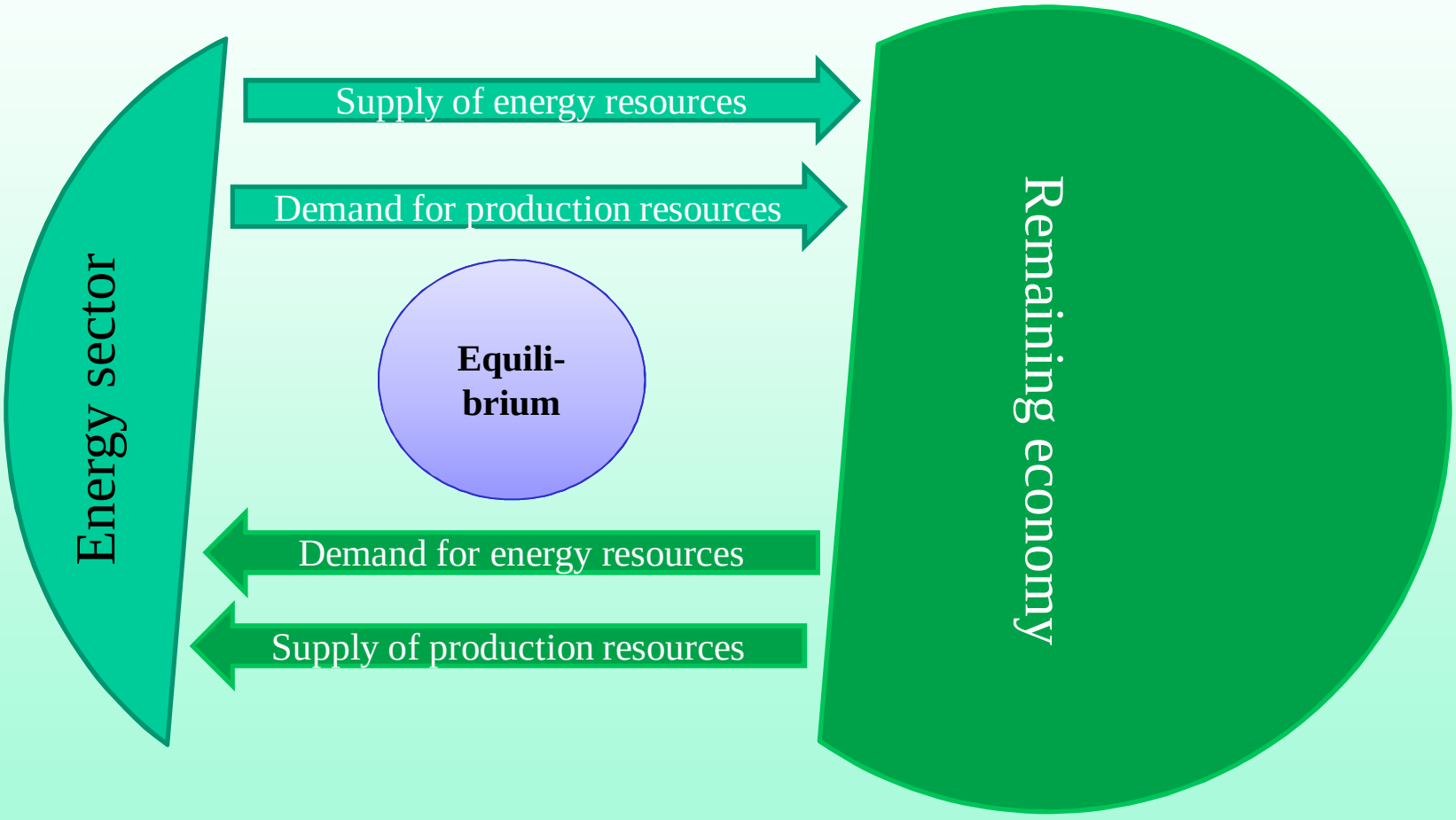


Modelling of smart grid



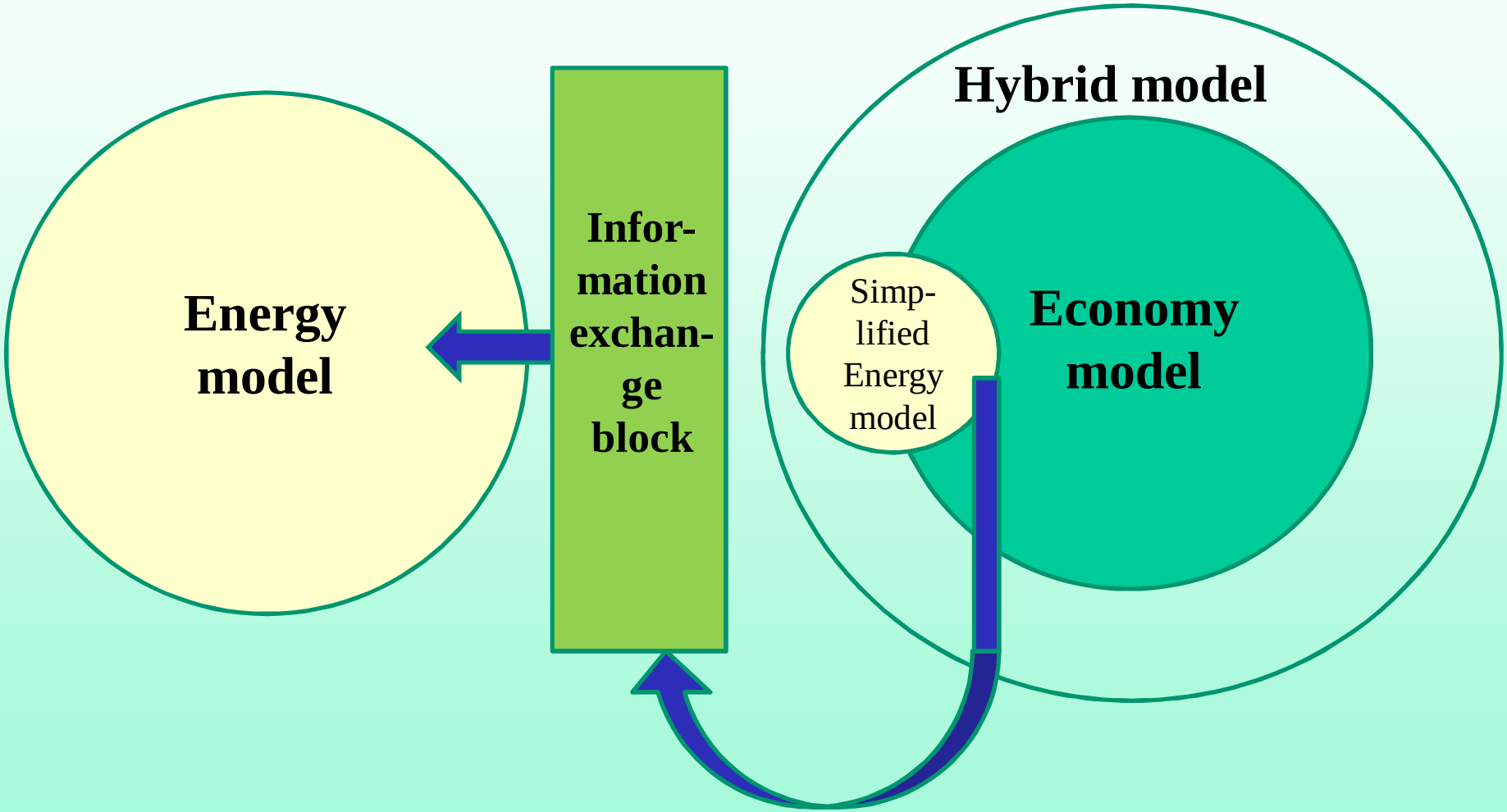
Linking energy and remaining economy models

Structure of the energy-economy model*



*Based on principles developed by Vidas Lekavicius in his PhD thesis , http://www.lei.lt/_img/_up/File/atvir/2013/Disertacijos/Lekavicius_Santrauka.pdf

Linking of energy and economy models*



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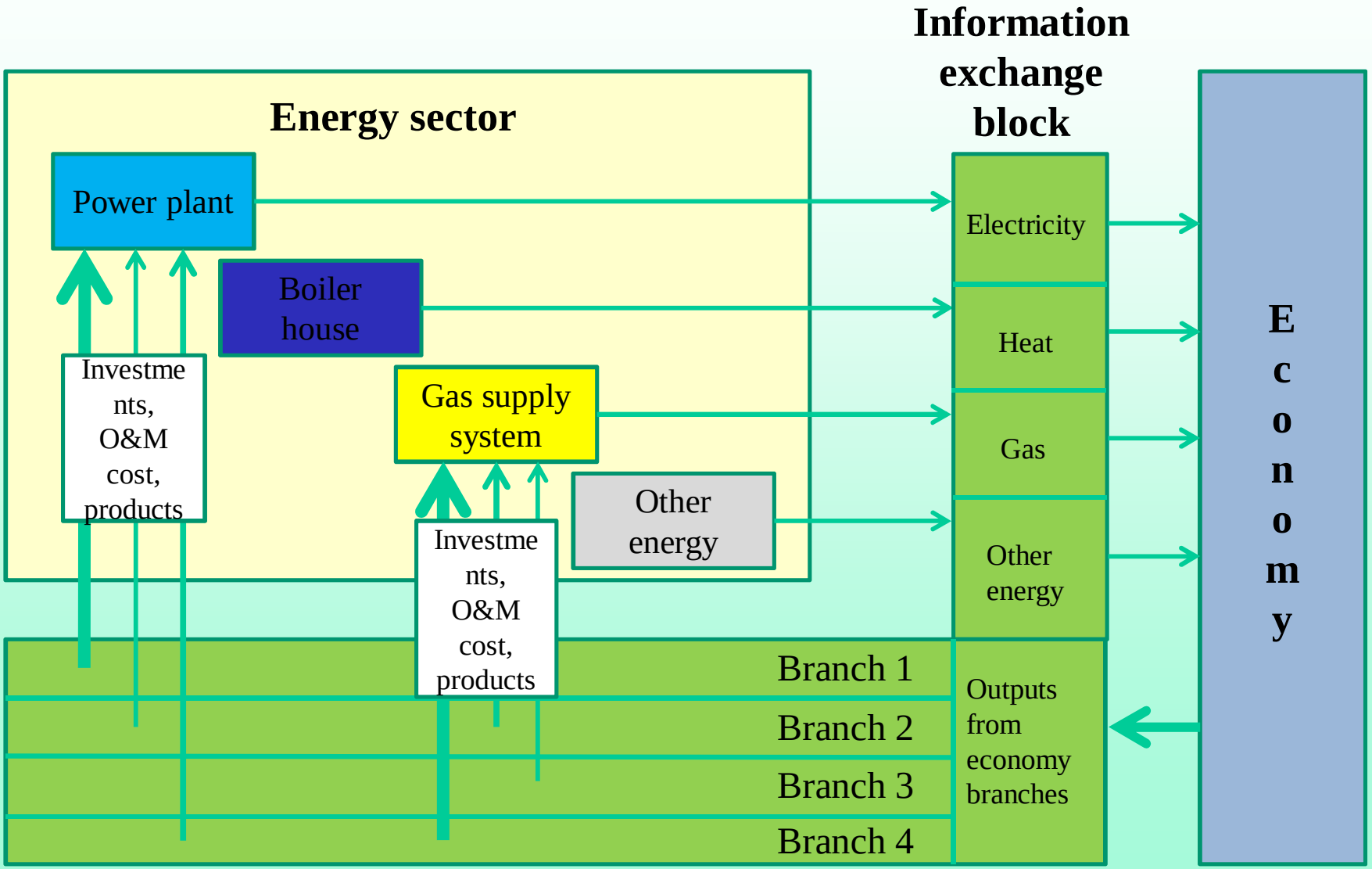
Information exchange between energy model and information block*



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