Modelling of the Lithuanian energy sector

A. Galinis

Lithuanian Energy Institute
Plan of presentation

Overview of research area and selected models:

- Model for analysis of energy sector development of Baltic states,
- Model for analysis of power sector development of Baltic states,
- Model for analysis of energy sector development of Lithuania,
- Model for analysis of district heating sector development of Kaunas municipality.

Overview of few studies prepared using various models:

- Impact of unit size of the new Visaginas NPP to the requirement of reserve capacity and future development of power system. Under contract with LEO LT, 2009,
- Use of renewable energy sources (bio-fuels, hydroenergy, solar energy, geothermal energy, municipal waste, etc.) for production of energy. Under contract with Ministry of energy, 2010,
Area of research

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

Modelling and analysis of energy system development and operation of a single country (Lithuania, Latvia, Poland, Serbia, Mongolia, Sudan, Nigeria, etc.);

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

Modelling and analysis of a single enterprise (Refinery, system of district heating, power plant, boiler-house).
Modelling and analysis of energy sector development in the Baltic region

Regional constrains, regional policy measures

Fuel supply

Model of Estonian energy sector

Model of Latvian energy sector

Model of Lithuanian energy sector

System of oil supply

Oil products

System of gas supply

Gas

System of other fuel supply

Other fuels

System of electricity and heat generation and distribution

Electricity import

Final energy demand

Oil products

Electricity

Heat

Other fuels

Analyses of Energy Supply Options and Security of Energy Supply in the Baltic States
Model of the Baltic power system
Baltic power system and links with third countries

- EstLink
- Nordel
- SwedLit
- LitPolLink
- Polish PS and link with UCTE
- IPS/UPS
- Russia
Representation of Polish power system
Representation of links with UCTE, Nordel, IPS/UPS

**Lines:**
- Commissioning date,
- Throughput capacity,
- Losses,
- Investment and O&M cost,

**Markets:**
- Availability of electricity (bounds on flows in lines),
- Market prices and their variation (variable cost),
- Availability of reserve capacities of different type,

**Others**
Size of nuclear unit and reserve capacity

How much of the primary reserve and secondary reserve is necessary to have a tertiary reserve?

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?

Depend on unit size
Depend on normatives of systems
Depend on throughput capacity of links, import-export flows,
<table>
<thead>
<tr>
<th>LEO9a4 Variantas5</th>
<th>Installed capacity in Lithuania, MW</th>
<th>Generation, MW</th>
<th>Accessible primary reserve, MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elektrinės vardas</td>
<td>2020</td>
<td>Summer working day</td>
<td>Winter working day</td>
</tr>
<tr>
<td>150 MW units at Lithuanian PP</td>
<td>300</td>
<td>8</td>
<td>8</td>
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<tr>
<td>300 MW units at Lithuanian PP</td>
<td>1200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>New CCGT unit at Lithuanian PP</td>
<td>400</td>
<td>160</td>
<td>360</td>
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<tr>
<td>Vilnius CHP-3</td>
<td>400</td>
<td>69</td>
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<tr>
<td>Vilnius CHP-2</td>
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<tr>
<td>Kaunas CHP</td>
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<tr>
<td>New Kaunas CCGT CHP</td>
<td>163</td>
<td>88</td>
<td>146</td>
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<tr>
<td>Petrasų CHP</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Mazeikiai CHP</td>
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<td>22</td>
<td>22</td>
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<tr>
<td>Klaipėda CHP</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>New Ignalina NPP unit 2</td>
<td>1600</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>New Ignalina NPP unit 1</td>
<td>1600</td>
<td>1253</td>
<td>1253</td>
</tr>
<tr>
<td>New Ignalina NPP unit 3</td>
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<td>0</td>
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<td>New Ignalina CCGT</td>
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<td>0</td>
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<tr>
<td>Kruonis HPSPP</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Kaunas hydro PP</td>
<td>101</td>
<td>20</td>
<td>73</td>
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<td>Small hydro PP</td>
<td>31</td>
<td>12</td>
<td>12</td>
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<tr>
<td>Industrial CHP</td>
<td>33</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Wind PP</td>
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<td>New GT CHP</td>
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<td>2161</td>
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<tr>
<td>Total supplied</td>
<td>787*</td>
<td>1323*</td>
<td>1159*</td>
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### Generation, primary, secondary, tertiary reserves. Lithuania (2)

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<thead>
<tr>
<th>Elektrinės vardas</th>
<th>Accesible secondary reserve, MW</th>
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<tr>
<td></td>
<td>Summer working day</td>
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</tr>
<tr>
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<td>0</td>
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<tr>
<td>New CCGT unit at Lithuanian PP</td>
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<td>40</td>
</tr>
<tr>
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<td>Vilnius CHP-2</td>
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<td>Petrasiuai CHP</td>
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<td>0</td>
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<td>0</td>
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<tr>
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<td>0</td>
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<tr>
<td>Wind PP</td>
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<td>0</td>
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<td>45</td>
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<td>New coal PP</td>
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<tr>
<td>New GT CHP</td>
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<tr>
<td>Modular CHP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Renewable CHP</td>
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<tr>
<td>Total available</td>
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<td>980</td>
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<tr>
<td>Total supplied</td>
<td>637</td>
<td>721</td>
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### Operation regime of the Baltic power system during maximal and minimal load in 2020

#### LEO9a4 Case5

<table>
<thead>
<tr>
<th>Source of reserve capacity</th>
<th>Installed capacity, Flows via lines, MW</th>
<th>Generation, MW</th>
<th>Accessible primary reserve, MW</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Summer working day</td>
<td>Winter working day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Summer Min</td>
<td>Summ er Max</td>
</tr>
<tr>
<td>Baltic region</td>
<td>2020</td>
<td>Generation by PP in EE, LV and LT</td>
<td>11344</td>
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<tr>
<td></td>
<td></td>
<td>Flow from Finland</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow from Sweden</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow from UCTE</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow from IPS/UPS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total available</td>
<td>2048</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total required</td>
<td>1633*</td>
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</table>

*Galutiniai poreikiai

#### Source of reserve capacity

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<thead>
<tr>
<th>Installed capacity, Flows via lines, MW</th>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>Flow from UCTE</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Flow from IPS/UPS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total available</td>
<td>1385</td>
</tr>
<tr>
<td></td>
<td>Total required</td>
<td>1385</td>
</tr>
</tbody>
</table>
Conclusions

Due to lack of primary reserve unit size of even 500 MW of the new NPP is too big for Baltic states if their power system would operate isolated and no reserve capacity would be obtained from UCTE, Nordel or IPS/UPS.

Unit size of 1600 MW is too big when power system of Baltic states operates synchronously with UCTE but capacity of the link is only 1000 MW. 1300 MW is acceptable. In the case larger unit is installed it’s operating capacity is reduced in order not to have possible disturbance in the system larger than available reserve capacity.

Unit size of 1600 MW is acceptable when power system of Baltic states operates synchronously with IPS/UPS.
Characteristics of the energy sector model of Lithuania

Municipality A
- Land for growing of agricultural products
- Land for growing of energy crops
- Forests
- Waste of cattle-ranches, industry, sewage
- Municipal waste
- Other RES (geothermal, hydro, wind, solar, etc.)

Other countries
- Import of other fuels and energy
- Export of other fuels and energy
- Import of RES
- Export of RES
- Import of various products from RES
- Export of various products from RES

Energy systems of all 60 municipalities
Energy market and large energy objects

Time period analysed 2006-2035,
5 time periods in a year,
60 types of fuels and energy,
About 8 thousands technologies and processes, ~2 millions variables,

From the set of existing and possible new technologies according least cost criterion select technologies, fuel and energy forms which satisfy final demand of consumers during time period analysed,
Linear programming.
Alternatives under consideration

Electricity sector:
   a) Future operation of existing power plants and their refurbishment,
   b) Construction of new power plants (Wind, solar, hydro, gas PP, RES PP, nuclear PP, etc.);

Sector of district heating:
   a) Future operation of existing boiler houses and CHP, their modernisation, change of fuel types,
   b) Construction of new boiler houses and CHP on fossil fuel, bio fuel and municipal waste, use of heat pumps;

Sector of decentralized heat supply:
   a) Future operation of existing equipments for space heating and hot water preparation,
   b) Construction of new equipments for space heating and hot water preparation (bio fuel, fossil fuel, solar, geothermal, etc.);

Sector for production of bio fuel:
   a) Production of bio components from agricultural products for blending with gasoline and diesel,
   b) Production of hard bio fuels from wood, wood waste, forestry waste, agricultural products, etc.,
   c) Production of biogas from stock-rising waste, industrial and sewerage waste, agricultural products, residues from production of liquid bio fuels, etc.;
RES in gross final demand

Year

Base HP
External cost HP
Expected HP
Base LP
External cost LP
Expected LP

%
RES in various sectors

**District heating**

**Electricity**

**Share of decentralised heat generated from RES**
Structure of fuel and energy used in the country

- Wood
- Gas
- LPG
- Heavy oil products
- Coal
- Light oil products
- Heat from chemical reactions and nuclear fuel
- Imported electricity
- Municipal waste
- Biogas
- Straw, grass
- Bio gas
- Municipal waste
- Heat from chemical reactions and nuclear fuel
- Imported electricity

Share of RES
Structure of RES

- Wind
- Hydro
- Solar
- Geothermal
- Biogas
- Straw, grass and their products
- Wood and its products

Year:
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020

%:
- 0.00
- 0.05
- 0.10
- 0.15
- 0.20
- 0.25
- 0.30
- 0.35
- 0.40
- 0.45
- 0.50
- 0.55
- 0.60
- 0.65
- 0.70
- 0.75
- 0.80
- 0.85
- 0.90
- 0.95
- 1.00
- 1.05
- 1.10
- 1.15
- 1.20
- 1.25
- 1.30
- 1.35
- 1.40
- 1.45
- 1.50
- 1.55
- 1.60
- 1.65
- 1.70
- 1.75
- 1.80
- 1.85
- 1.90
- 1.95
- 2.00
- 2.05
- 2.10
- 2.15
- 2.20
- 2.25
- 2.30
- 2.35
- 2.40
- 2.45
- 2.50

Metai
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
Production of district heat

- **Boiler houses**
- **Power plants**

<table>
<thead>
<tr>
<th>Year</th>
<th>MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>6869.2</td>
</tr>
<tr>
<td>2007</td>
<td>6534.2</td>
</tr>
<tr>
<td>2008</td>
<td>6311.0</td>
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<tr>
<td>2009</td>
<td>7157.2</td>
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<td>2010</td>
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<td>2011</td>
<td>5306.3</td>
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<td>2012</td>
<td>5475.9</td>
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<td>2013</td>
<td>4717.9</td>
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<td>2014</td>
<td>2867.8</td>
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<td>2015</td>
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<td>2016</td>
<td>2820.1</td>
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<tr>
<td>2017</td>
<td>2885.9</td>
</tr>
<tr>
<td>2018</td>
<td>2951.7</td>
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<tr>
<td>2019</td>
<td>3017.6</td>
</tr>
<tr>
<td>2020</td>
<td>3042.0</td>
</tr>
</tbody>
</table>

**Production Breakdown**

- **Boiler houses**
  - Gas boilers
  - Gas & liquid f. boilers
  - Hard f. boilers
  - Gas & biogas CHP
  - CCGT CHP
  - Bio fuel CHP
  - Waste incinerators

- **Power plants**

**RES**

**Fossil fuel**
Installed capacity of boilers in municipalities

**Total**

![Graph showing installed capacity of boilers in municipalities Total.]

**New bio-fuel boilers**

![Graph showing new bio-fuel boilers.]

Legend:
- 2010
- 2020
Investments into electricity and district heat production units, Mln Lt

Actual investments in 2005-2008 made 45-62% from calculated values in 2010-2020 m.
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,

Special approach for counting heat losses in the network.
Model of district heating system (2)
(Boiler-house)
Dynamics of installed capacities in Kaunas district heating system

- Kiti šaltiniai
- UAB "Fortum"
- UAB "Valnetas" biokuro VŠK
- UAB "MD Kaunas" biokuro VŠK
- UAB "GECO (SSPC)" biokuro VŠK
- UAB "SSPC-Taikos" biokuro TE
- UAB "Optina" biokuro VŠK
- UAB "Omiteksas" biokuro VŠK
- UAB "Pram. energija" biokuro VŠK
- UAB "Alma" biokuro VŠK
- UAB "ES&CO" biokuro VŠK
- UAB "Lorizon energy"
- Kauno elektrinė
- Petrašiūnų elektrinė
- Inkaro katilinė
- Šilko katilinė
- Pergalės katilinė

- Galutiniai poreikiai be taupymo
- Poreikiai įskaitant nuostolius
- Poreikiai įskaitant taupymą
Dynamics of district heat production in Kaunas

- Kiti šaltiniai
- UAB "Fortum"
- UAB "Valnetas" biokuro VŠK
- UAB "MD Kaunas" biokuro VŠK
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Seasonal variation of district heat production in Kaunas

Year 2019
Evolution of heat production cost

- Actual inflation
- 2% inflation

[Graph showing heat production cost over time, with Lt 2006 and Einamųjų metųLt indicated.]
Thank you for your attention