Investment decisions testing in multi-agent systems

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Structure

1. Research background and objectives
2. Theoretical foundation
3. Methodology
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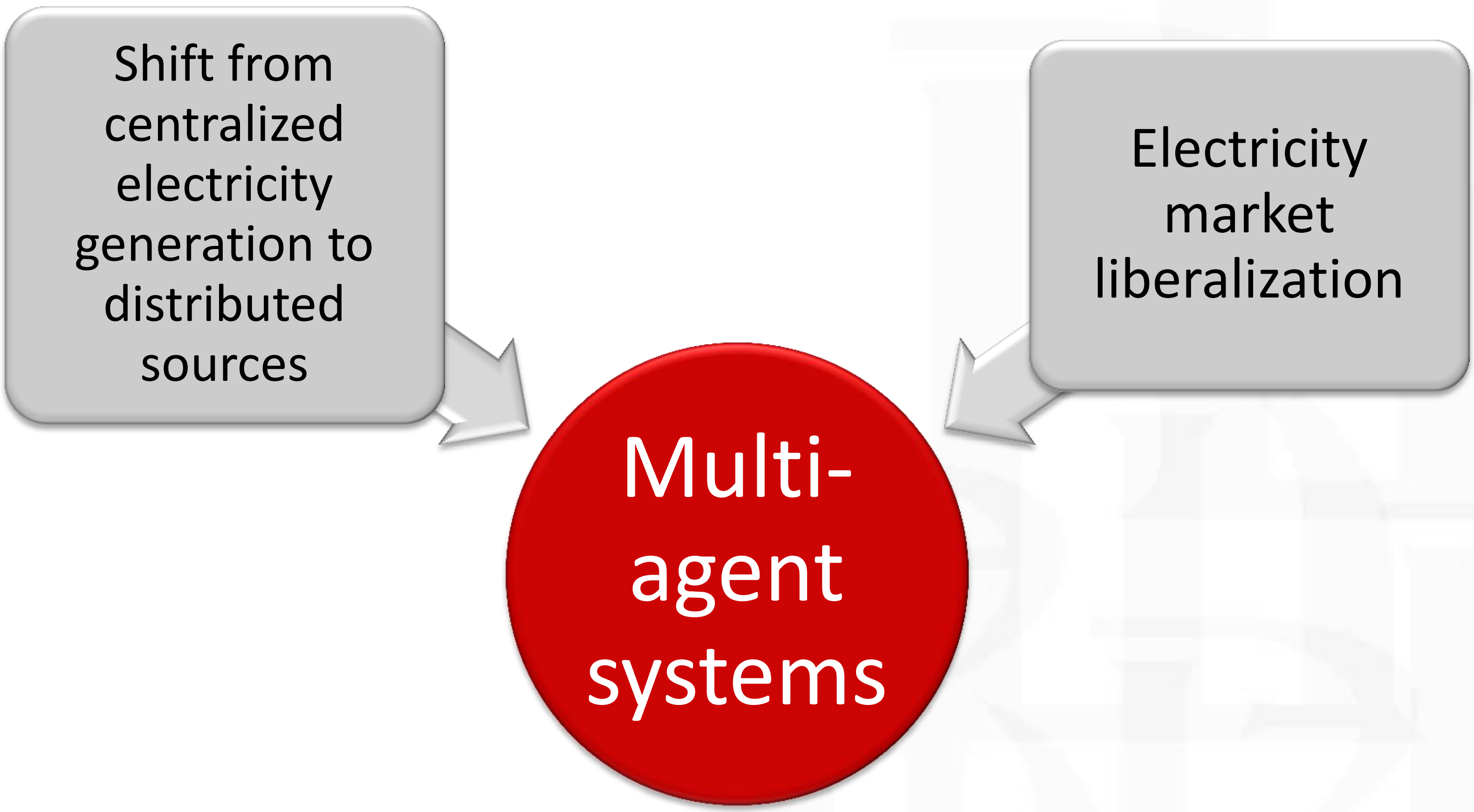
5. Conclusion

1. Introduction



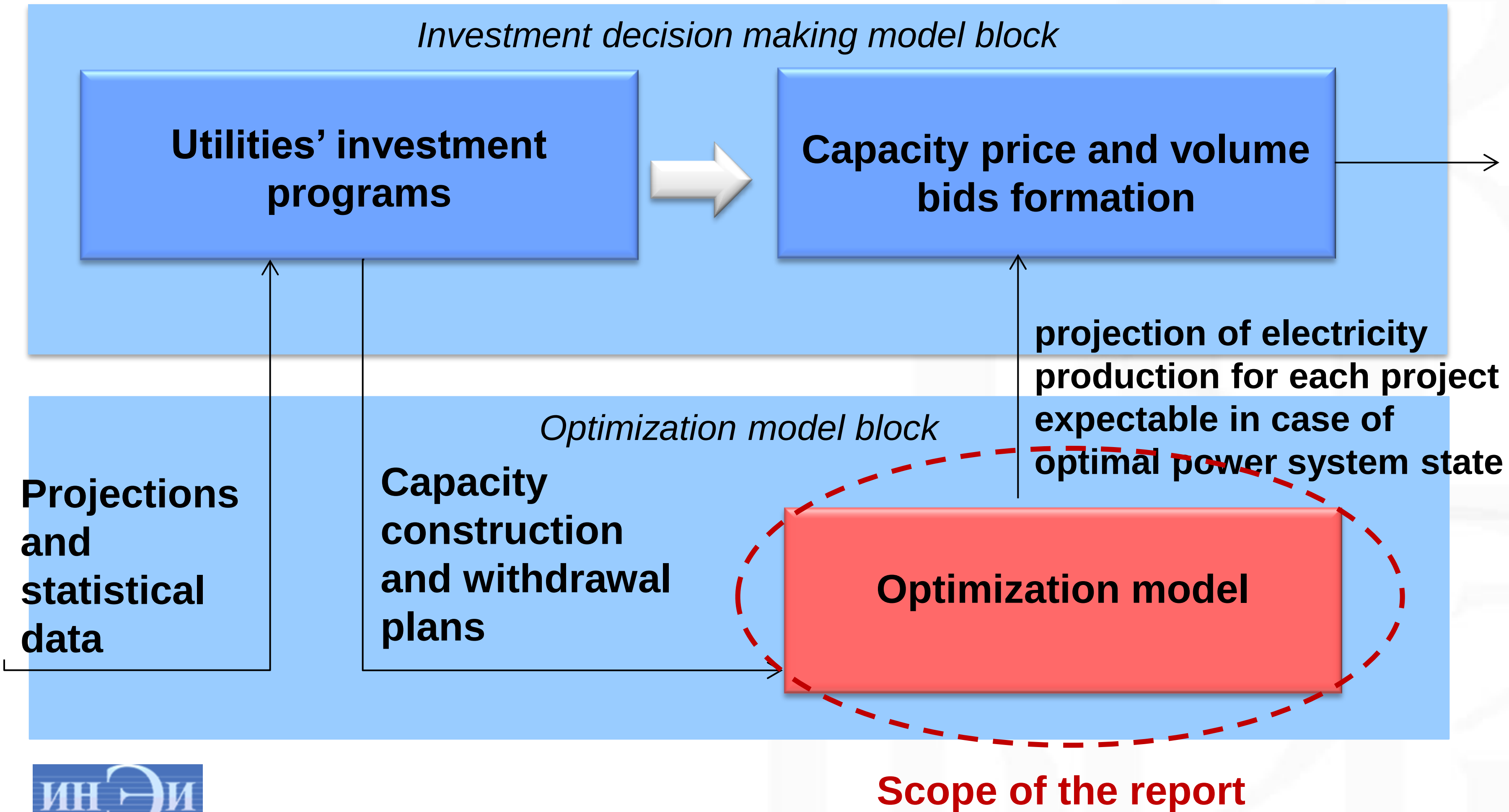
Current research background and purpose

The project is a part of the Russian Academy of Sciences research program "**Investigation of the role of centralized management in the development of large-scale power systems**".

ИНЭИ РАН *http://www.eriras.ru/eng*

The **research purpose** is to develop an electric power system model for testing agents' investment decisions from the point of view of supply and demand balance.

The scheme of the research



2. Theoretical foundation

Limitations of traditional energy modeling approaches for the liberalized electricity market

- Dyner and Larsen (2001)
- Bunn and Dyner (1996)

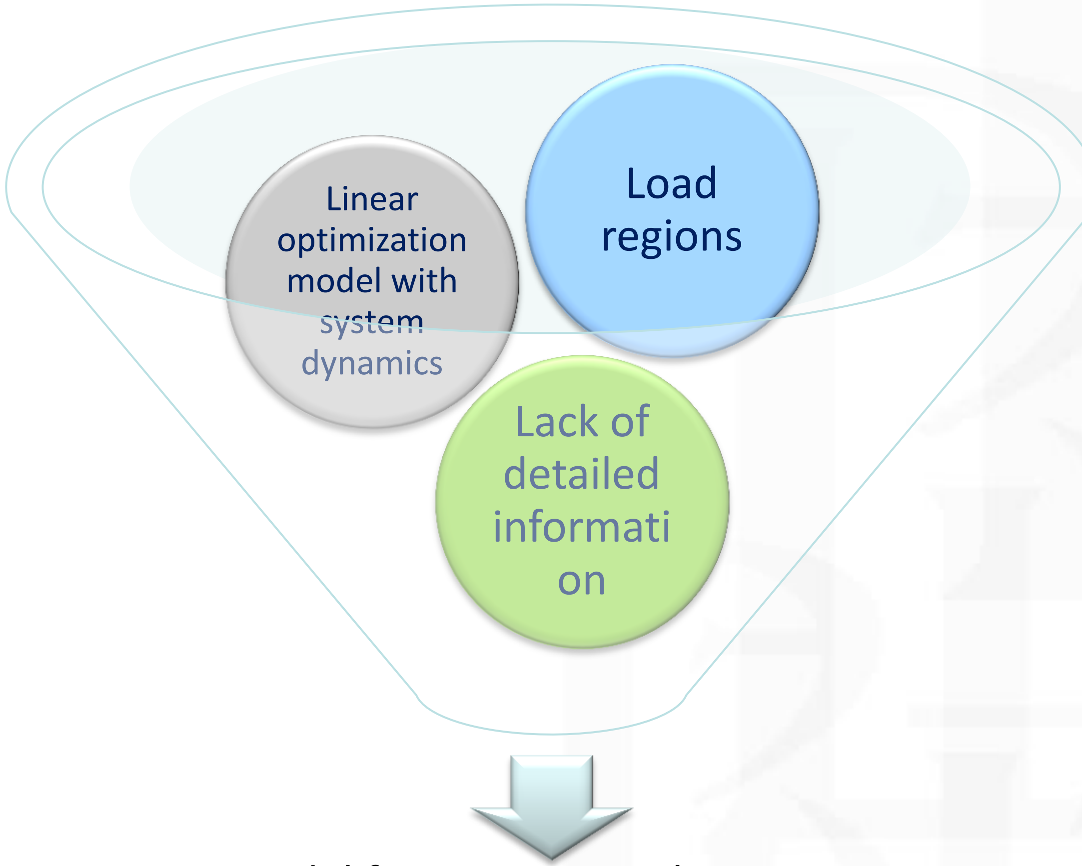
Application of several model blocks to deal with various problems

- Biegler and Grossmann (2004)
- Ford and Mann (1983)

Investment behavior modeling

- Bunn and Larsen (1992)

3. Methodological requirements



Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (**MESSAGE**)

IAEA
International Atomic Energy Agency
Atoms For Peace

Data for testing

- Two interconnected regional energy systems: Central and North-West
- 9 power generation organizations, 4 main were considered
- 150+ generation sources
- Time horizon is from 2014 (base year) to 2020
- Seasonal variations of electricity and heat demands:
  - Winter (1st October – 30th April)/ Summer (1st May – 30th September)
  - Working days/ weekends and holidays
  - Morning/ Afternoon/ Evening

Scenarios

The main difference is in the volume of new capacity addition.

lower scenario

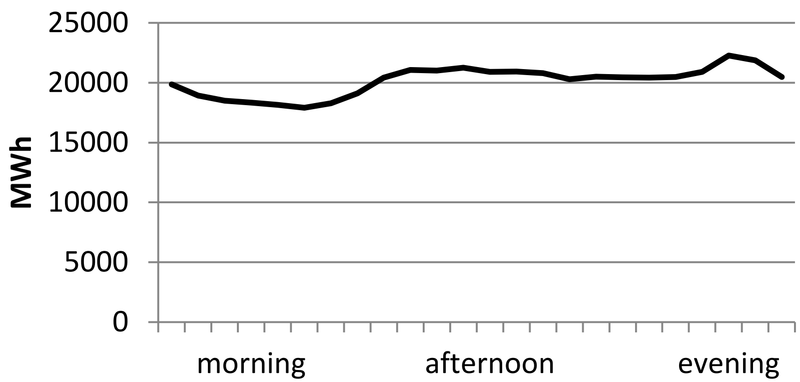
Central regional energy system + 8.2 GW until 2020
North-West regional energy system + 3.74 GW until 2020

upper scenario

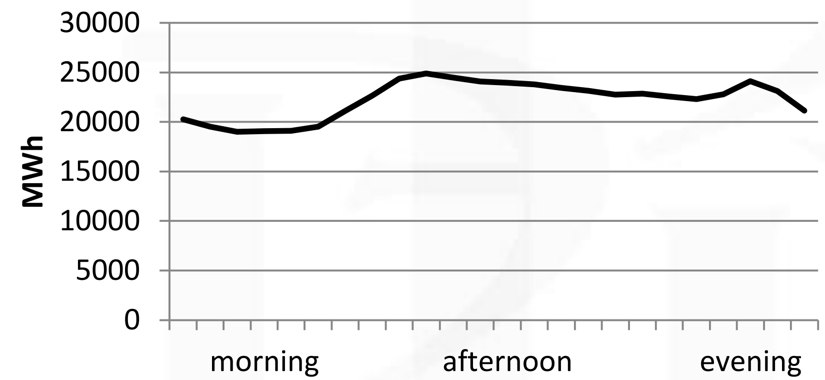
Central regional energy system + 12.5 GW until 2020
North-West regional energy system + 8.11 GW until 2020

Load regions in Central regional energy system

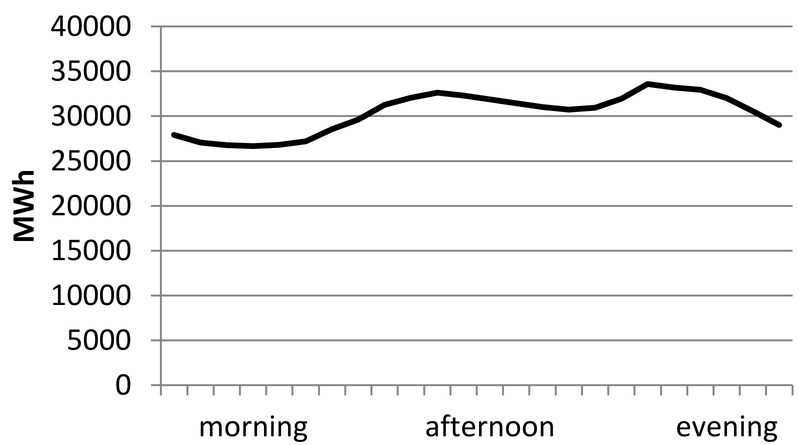
Summer, weekend



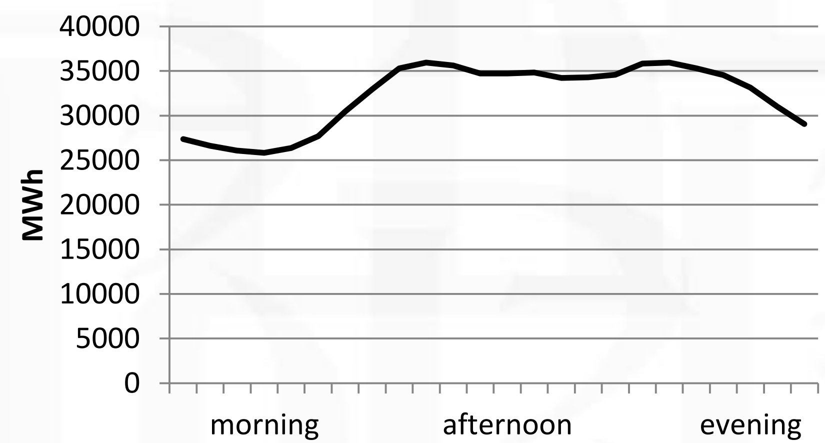
Summer, workday



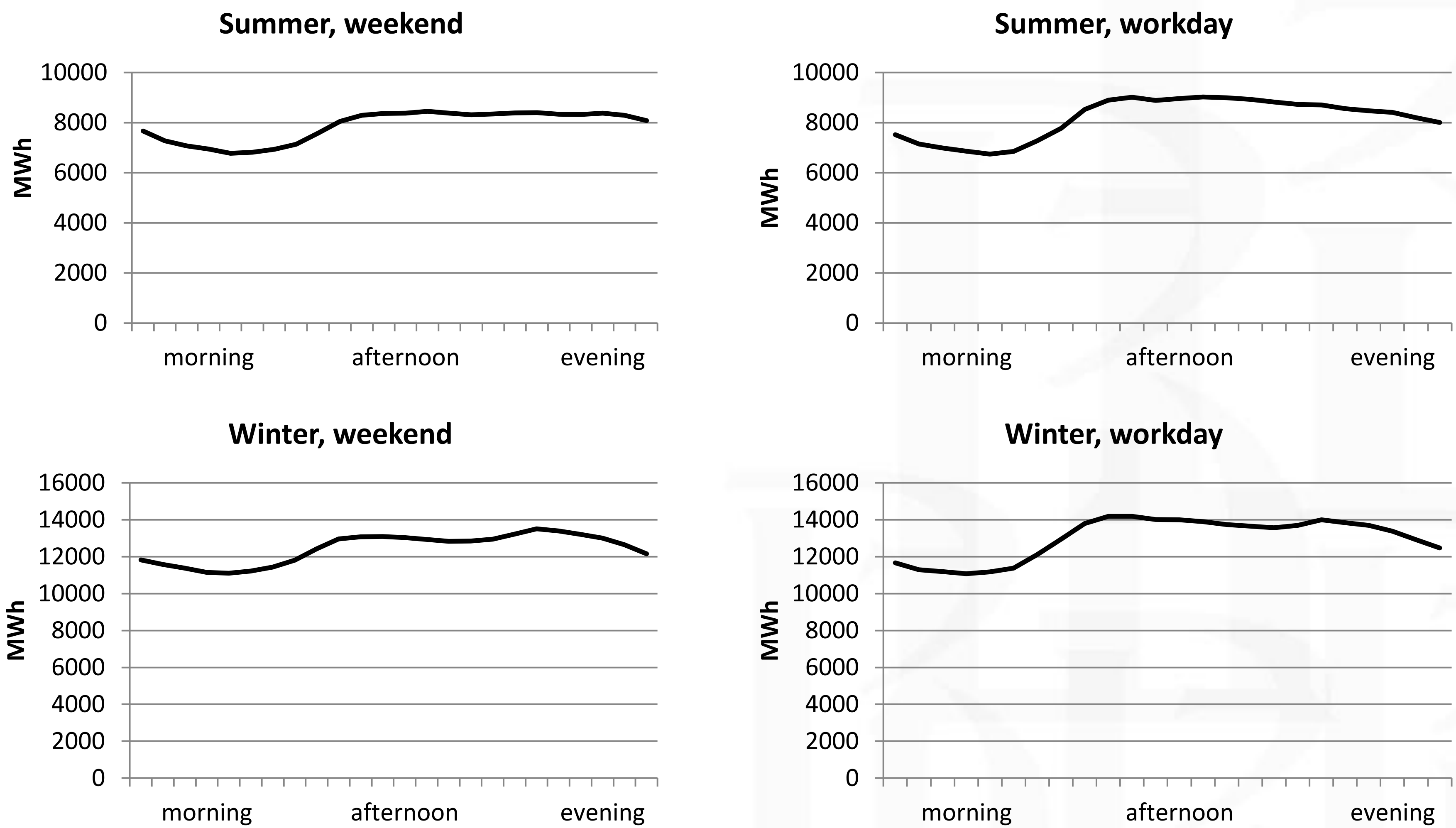
Winter, weekend



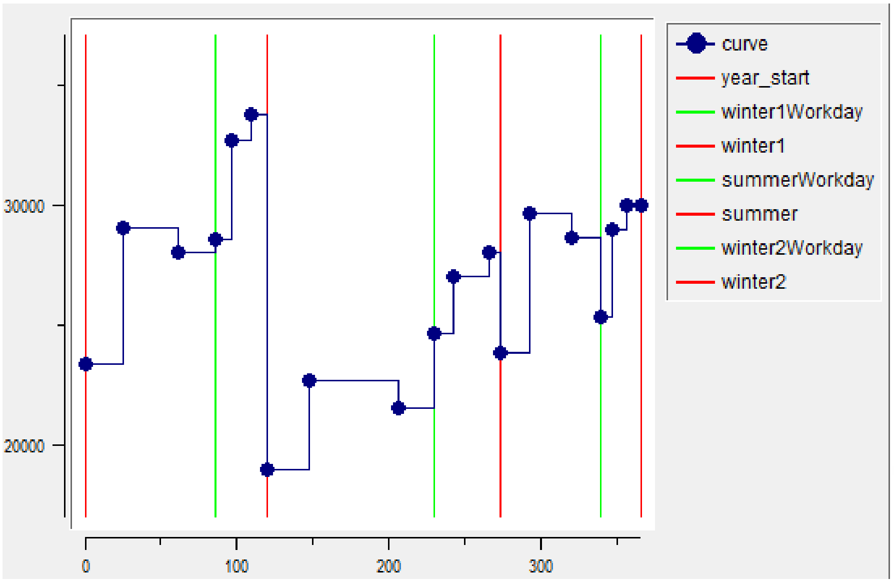
Winter, workday



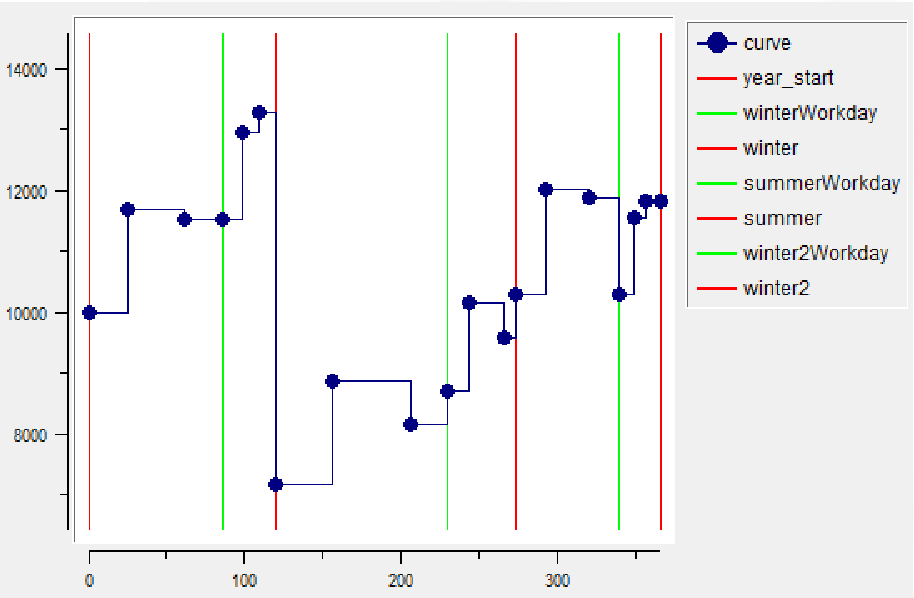
Load regions in North-West regional energy system



Annual load graphs approximations



Central regional energy system



North-West regional energy system

Optimization

1. Background | 2. Theoretical foundation | 3. Methodology | 4. Testing results | 5. Conclusion

Optimization criterion - minimum of total energy system costs.

Energy balances:

- ✓ **Balance of installed capacity;**
- ✓ **Balance of electricity production;**
- ✓ **Balance of heat production;**
- ✓ **Fuel balances.**

Boundaries

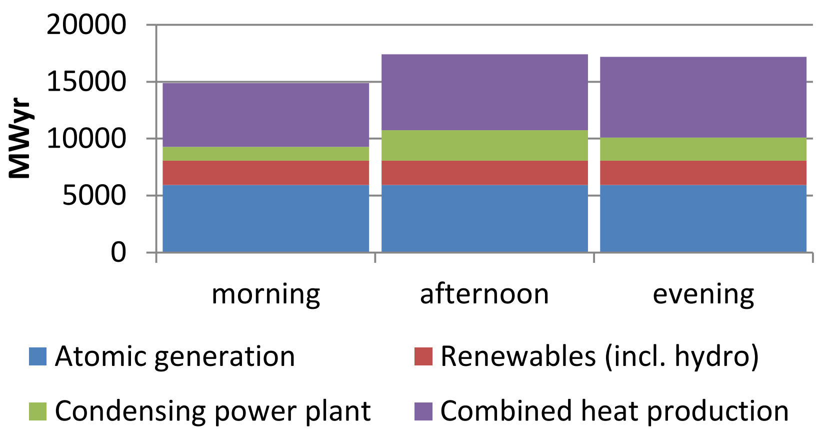
Upper: Operational power capacity excluding outage time coefficient and capacity margins;

Lower: Minimum utilization rate of generating capacities

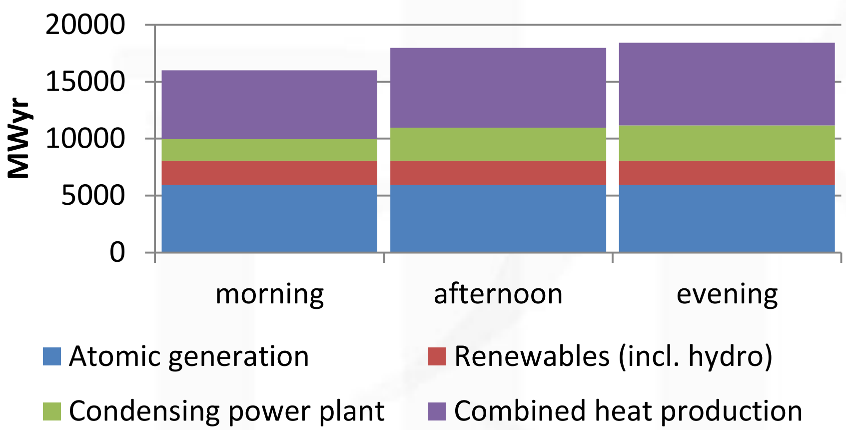
CHP power plants were modeled in two work regimes: 1) combined heat and electricity generation; 2) only electricity generation.

4. Testing results. North-West, lower scenario

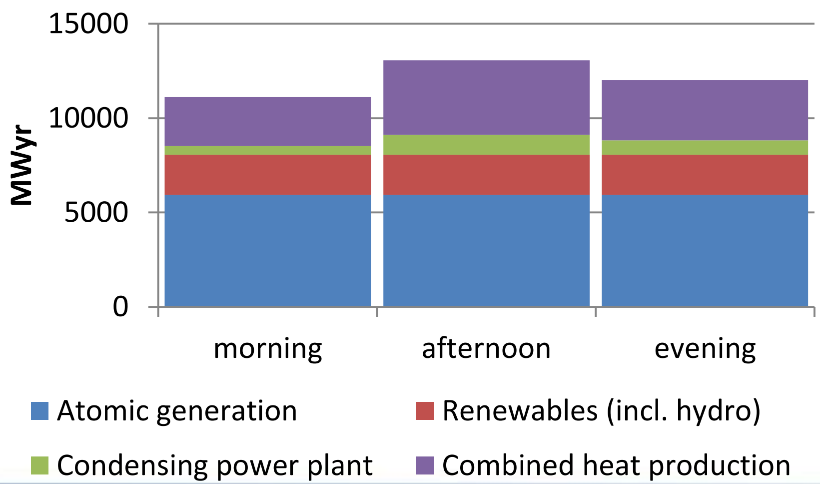
Winter, weekend



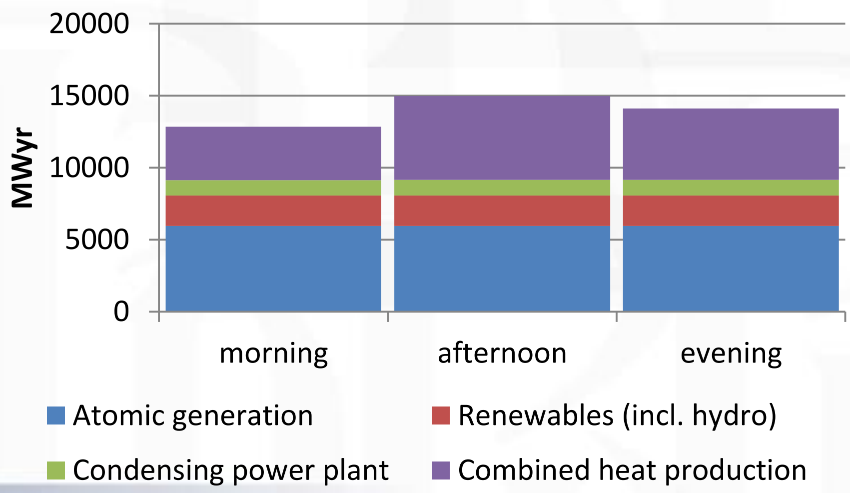
Winter, workday



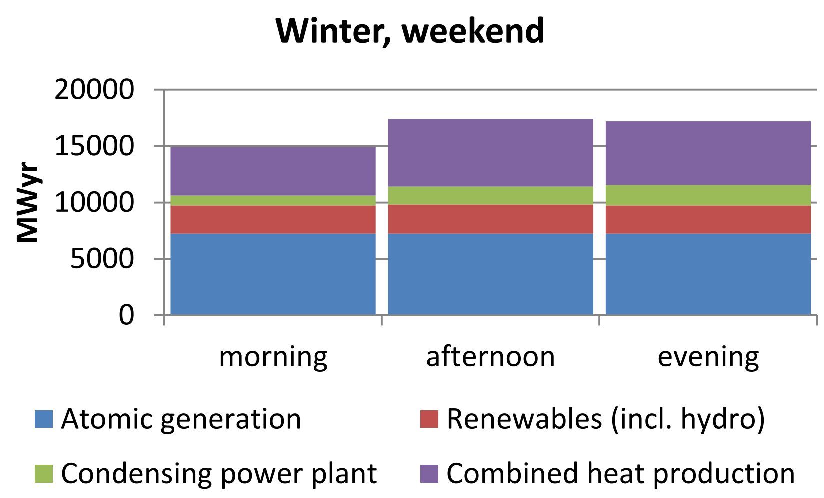
Summer, weekend

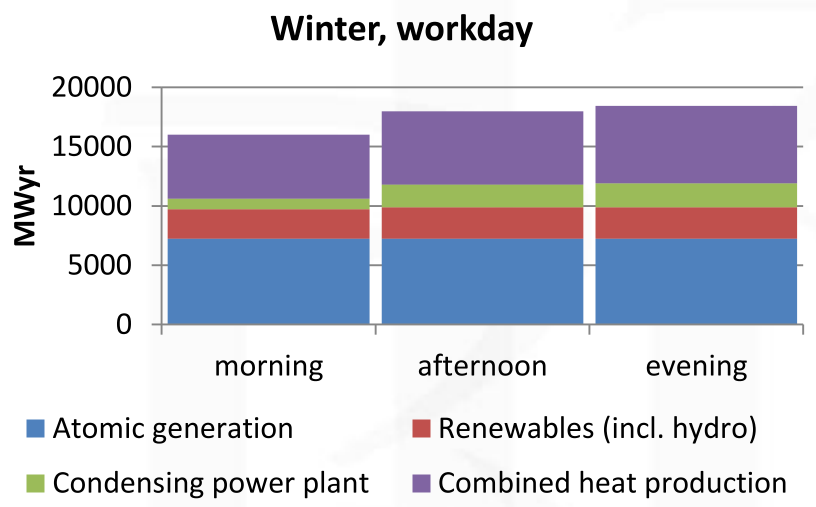


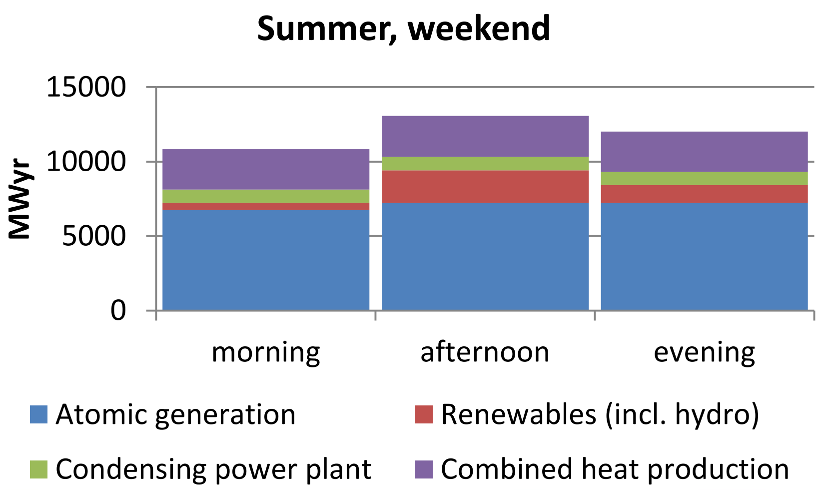
Summer, workday

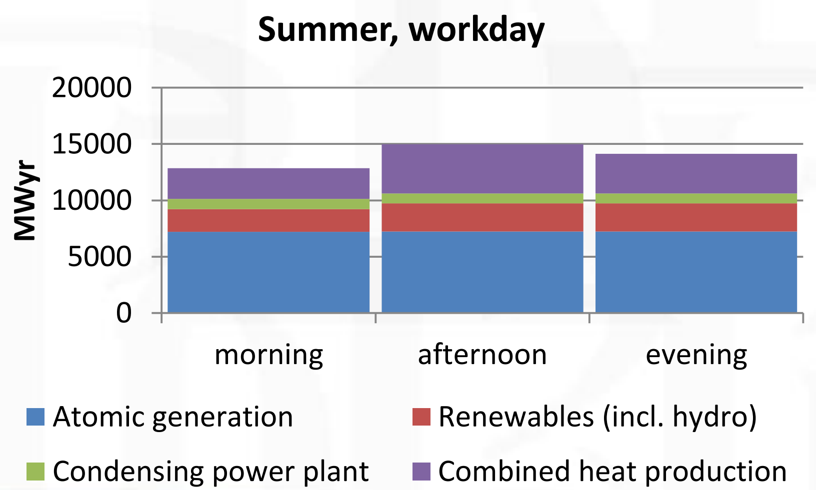


Testing results. North-West, upper scenario

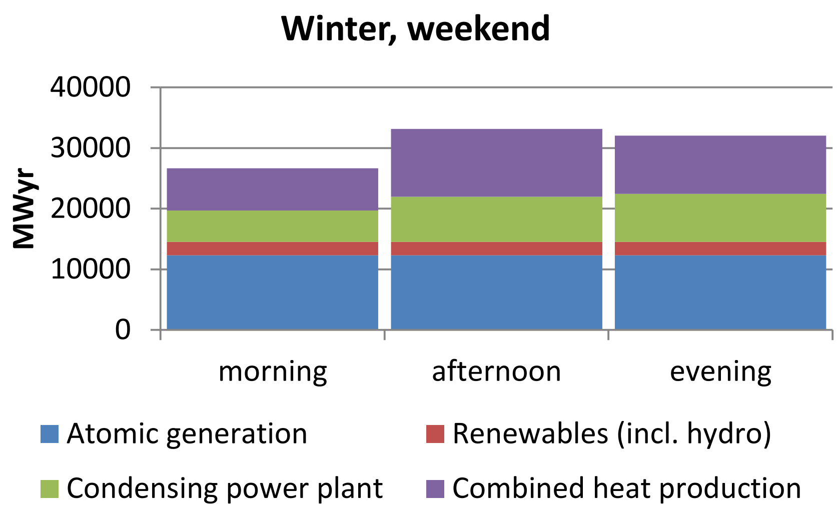


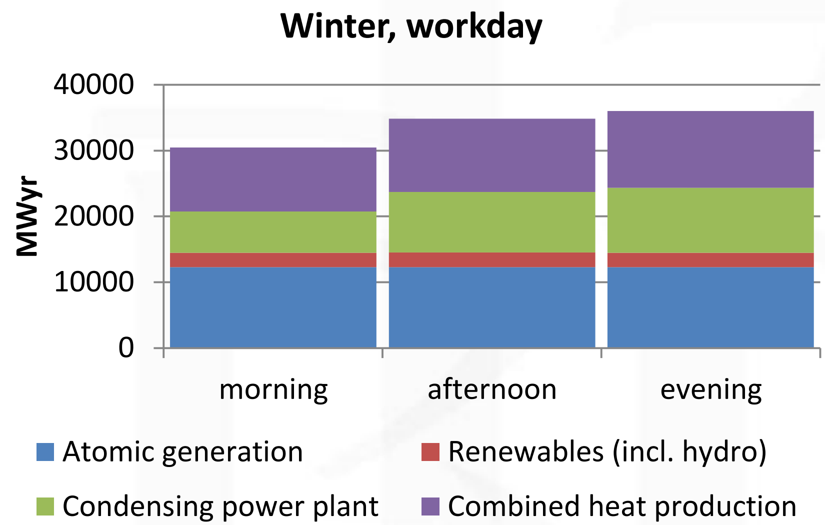


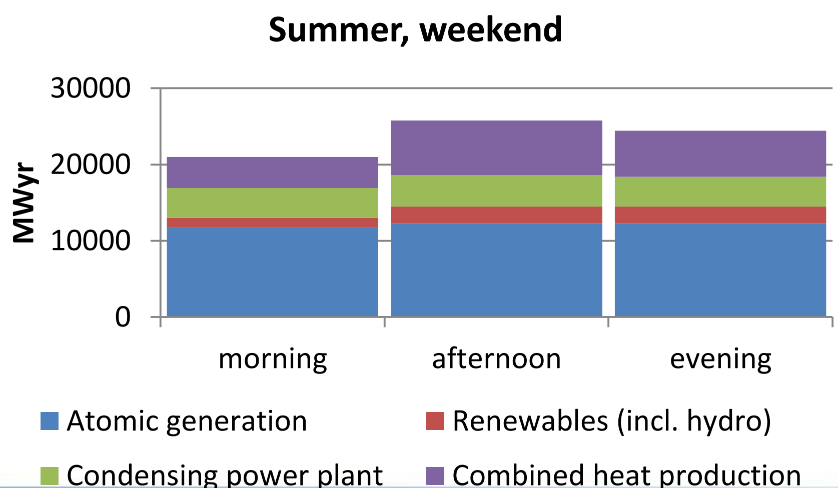


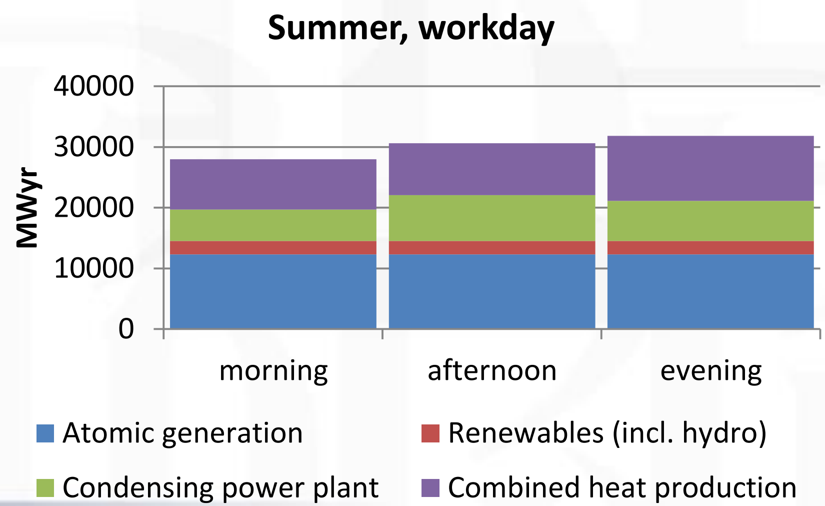


Testing results. Central, lower scenario

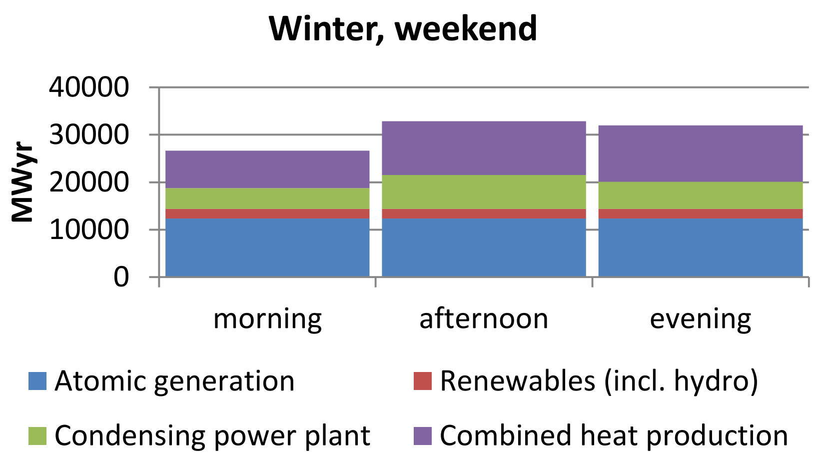


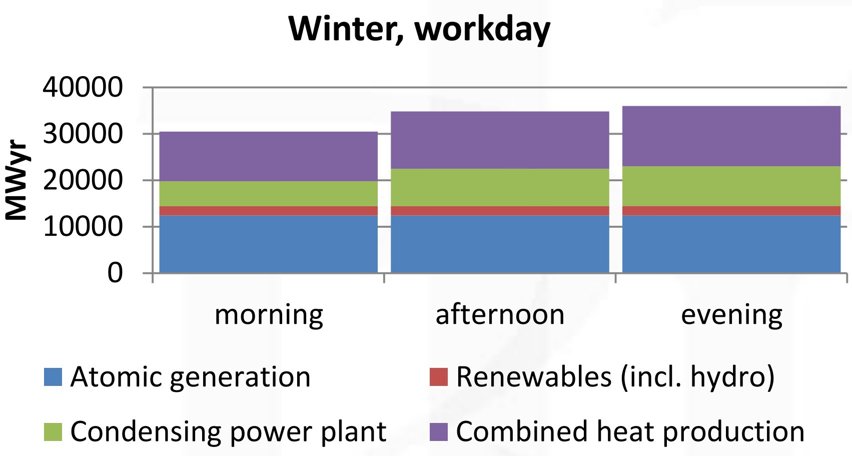


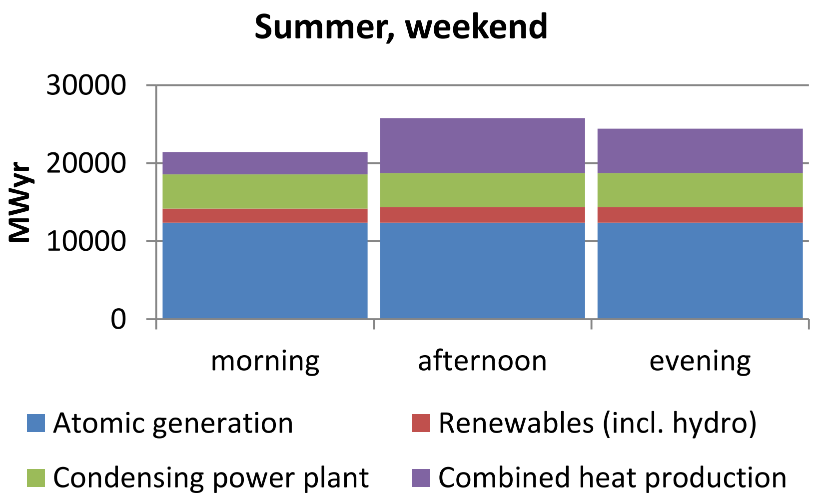


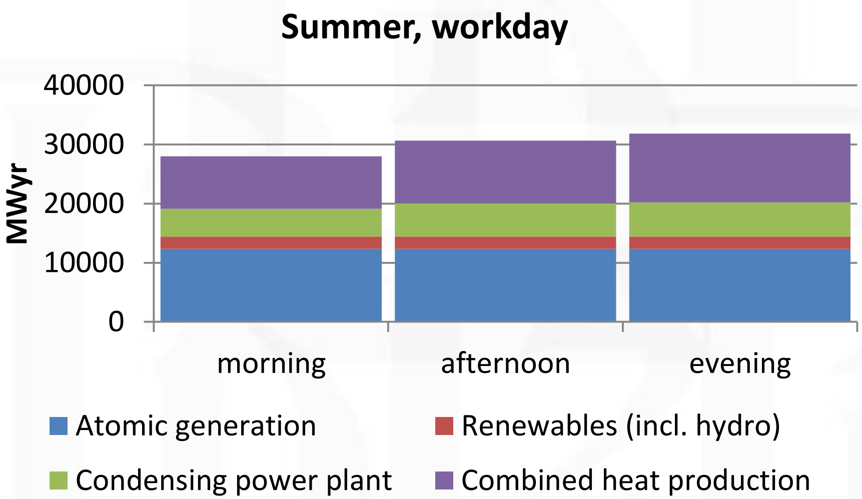


Testing results. Central, upper scenario









Optimization results for two scenarios

lower scenario

Power generation organization	Installed capacity, MW	Produced electricity in 2020, MW	Operation time, hours (optimization results)	Operation time, hours (expected)	Discrepancy, %
INER RAO Group	7370	3095	3798	3805	0
JSC "OGC-2"	7210	2847	3454	3280	5%
E.On Russia	2130	498	2182	2955	**-30%**
Enel OGC-5	2520	996	3461	2998	15%

upper scenario

Power generation organization	Installed capacity, MW	Produced electricity in 2020, MW	Operation time, hours (optimization results)	Operation time, hours (expected)	Discrepancy, %
INER RAO Group	9335	2937	1890	3805	**-50%**
JSC "OGC-2"	7210	2671	3245	3280	0
E.On Russia	2130	448	1840	2955	**-38%**
Enel OGC-5	2520	574	1994	2998	**-33%**

5. Conclusion

Strengths:

- ✓ The methodology converges system development requirements and agents' commercial interests;
- ✓ Optimization model block is separated from the investment decision making block;
- ✓ Applicable under the circumstances of restricted informational availability;
- ✓ Makes it possible to test various scenarios differing on the level of individual investors as well as on the level of macroeconomic parameters;
- ✓ Virtually all processes are unified and can be repeated in other projects

Future studies:

- Agents' "characters" modeling;
- Agents' learning ability modeling.

Thank you for attention!