

# AN ALGORITHM TO SUBSTANTIATE THE MULTI-ENERGY SYSTEM COST-EFFECTIVENESS

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The components of energy systems that allow storage and conversion of different energy types into one another, along with highly developed information systems, make it relevant to develop such a technology as integrated energy supply systems. The multi-energy systems make it possible to improve a whole range of performance indices of the energy system, i.e. to optimize the load curves of generating plants and network infrastructure, improve the power quality, and enhance the energy supply reliability.

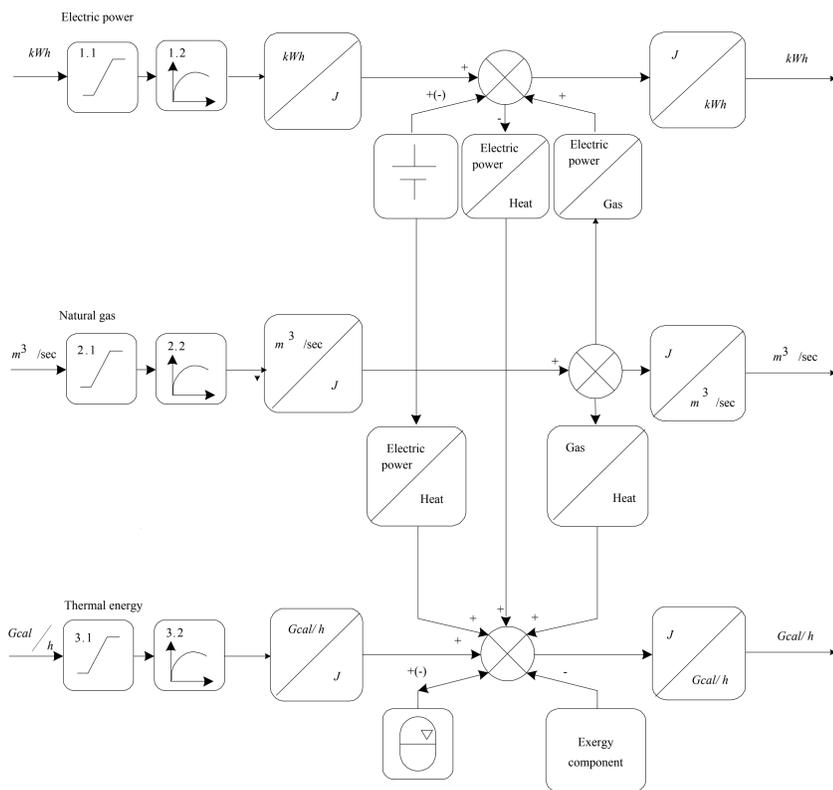
## Notion of a multi-energy system

Multi-energy systems make electricity, heat, cooling, fuel, etc. optimally interact with one another at different levels (for example, within an area, a city or a region). They are of great technological, economic and environmental importance. The sectors of these systems are considered independently. They interact both at operative level and in the stage of planning. Such systems form individual systems with distributed generation with a large number of energy flows (distributed multi-generation). The use of the multi-energy systems will enable us to decarbonize the energy sector. However, the approaches necessary to model such systems and respective tools for their analysis are very complicated. Also, it is rather difficult to identify the systems which can properly consider the costs and benefits related to the multi-energy systems according to various criteria.

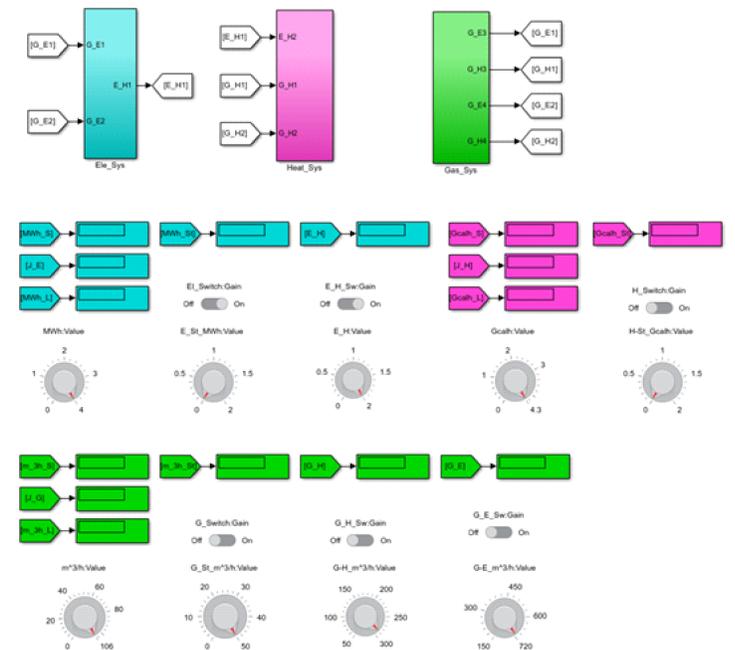
## Price and non-price areas



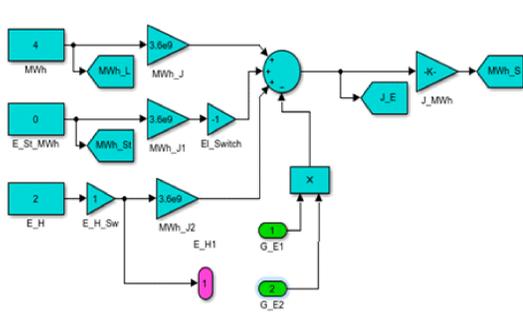
## Functional scheme of a generic multi-energy system



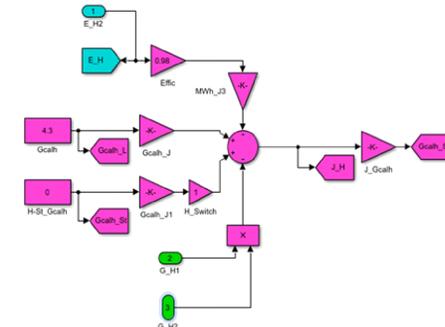
## Software implementation of a multi-energy system in MatLab



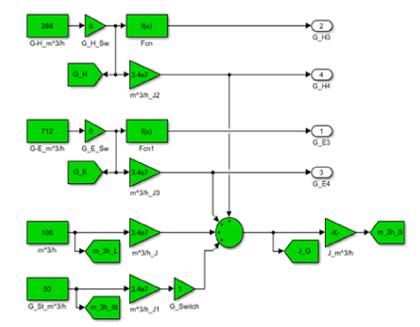
## A subsystem implementing an electricity flow



## A subsystems implementing a heat flow



## A subsystem implementing a gas flow



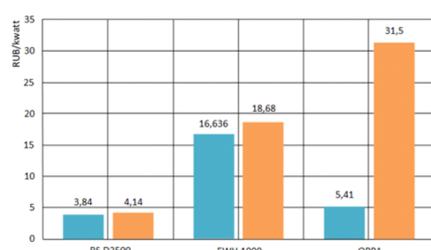
## RS D2500 water heater costs

Nr	Costs of a gas-fired water heater	Value
1.	Cost of the gas-fired water heater, RUR	558000
2.	Depreciation charges, RUR	3989,7
4.	Repair costs, RUR	1000
5.	Others (1% of the cost),	5580
6.	Service life, year	40
7.	Depreciation rate, RUR	0,26
8.	Annual costs of year 1, RUR	568569,7
9.	Annual costs of following years, RUR	10569,7
10.	Specific capital investment, RUR	558
11.	Volume of energy generated using basic assets	1000
12.	Installed capacity, kW, annual power generation	2750
13.	Capital costs, RUR	1534500
14.	Electricity cost price, RUR	3,84

## Costs of energy storage system

Nr	Index	Value
1.	Cost of the energy storage system, RUR	43000
2.	Repair costs, RUR	2000
3.	Depreciation charges, RUR	57,333
4.	Others (1% of the cost), RUR	430
5.	Service life, year	15
6.	Depreciation rate	0,067
7.	Specific capital investment	215
8.	Volume of accumulated energy	200
9.	Installed capacity, annual	400
10.	Capital costs, RUR	86000
11.	Costs of year 1, RUR	45487,333
12.	Annual costs of the following years, RUR	2487,333
13.	Total costs of year 1, RUR	614057,033
14.	Total costs, RUR	13057,033

## Power cost price



## Conclusions

The use of energy storage systems and converters in the energy supply systems along with highly developed information systems makes the development of such technologies as integrated energy supply systems relevant. The application of multi-energy systems makes it possible to improve a whole range of the performance characteristics of the energy supply system, namely: to optimize load curves of generating plants and network infrastructure, improve power quality, and enhance energy supply reliability. The paper describes the technical capabilities to implement a multi-energy system. A functional diagram of the multi-energy system implemented in MatLab is presented. Consideration is given to the energy storage system and converters. Multi-energy systems will allow the accomplishment of the following objectives:

- To supply energy to the off-grid areas;
- To supply power to consumers in case of emergencies;
- To improve the environmental situation;
- To vary the cost of energy supply owing to the use of several energy types;
- To receive additional power without construction of new power plants and commissioning of additional transformer substations;
- To collect statistical data.

The research involves the calculation of a power cost price, considering energy storage system. An overview of the performance indices is made.