POWER SYSTEM OPTIMIZATION WITH DISTRIBUTED GENERATION IN ON-LINE MODE

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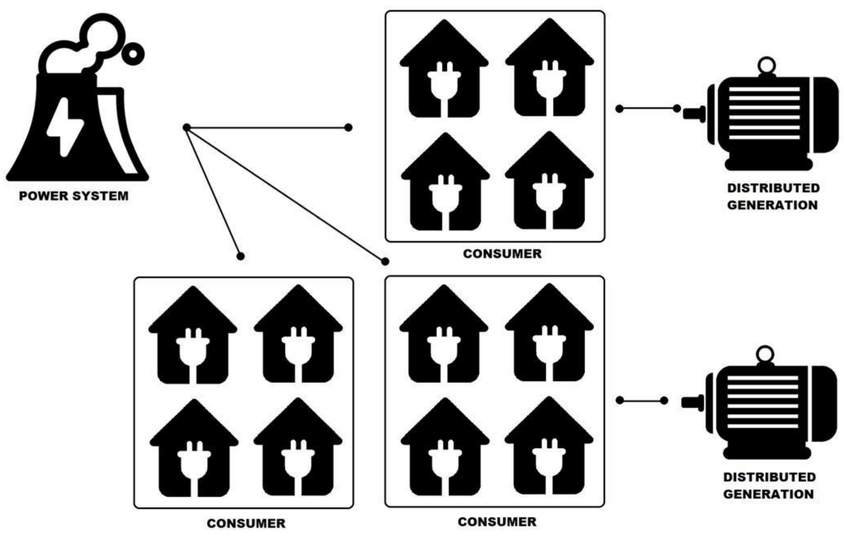


SUMMARY

In according to the national technological initiative, which started in Russia at the end of 2014. It planes to design a new image of power system and energy market of the future that meets the current and future challenges. The concept assumes the development of distributed generation (DG) technology. Wide DG development creates difficulties in power system control. Consumption always changes so unit commitment is actual problem. Taking into account the distributed generation particularities, it is necessary to solve in on-line mode.

For example, the parallel work of distributed generation (cogeneration power plant) with power system is considered. In parallel mode, part of the generators produce power to the grid, other ones supply its own load consumption.

In most cases, load schedule has stochastic and hard-variable nature. Due to its nature the gas powered electrical generator cannot meet the sharp increasing and decreasing of the load normally this value is equal to 5-7% of the unit rated power. So, irregular fluctuations in the load damp by the power system, and power station provides the regular part of the load schedule by itself. Besides electrical power consume the power station has thermal consumer who gets heat from gas boiler and also from cogeneration. Thermal load schedule is sharply unsteady for residential energy consumption during the year. This feature imposes certain constraints when choosing the number of the units and generation level. In the paper, the influence of the heat load schedule to constraints while optimizing power systems with DG is researched.

Materials and methods: The study main instruments are methods of mathematical analysis, mathematical modelling, simulation modelling and optimization.

Results: The main technical, technological and economic constraints were exposed for the problem solving of unit number and generation level in systems with distributed generation in on-line mode.

Conclusions: On the basis of the received results a functioning automation algorithm for power systems with distributed generations will create for power system control. Which will be based on the using of artificial intelligence with the possibility of models update if it is necessary. a

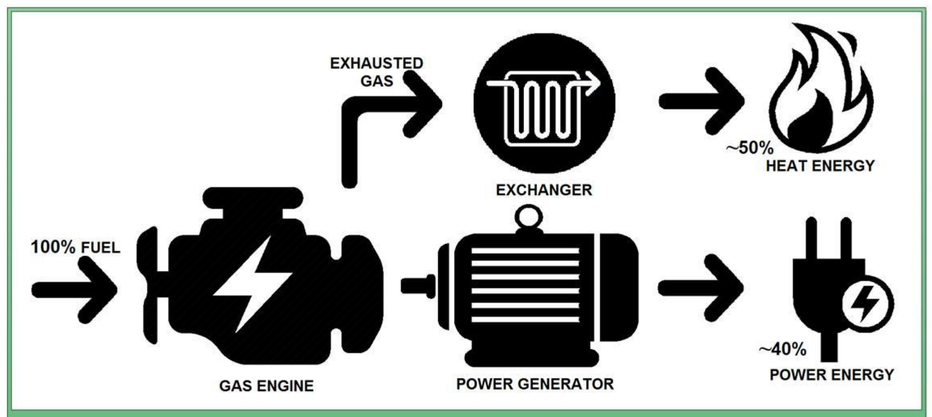
The **constraints** for solving optimization problem were determine in case
- *Parallel mode* of distributed generation
- Cogeneration technology

The object of distributed generation with cogeneration gas-reciprocating units have been considered, power of the each unit is *Pg*. The station connects to the power system. There are gas boilers on station for supplying the heat load *Q* (in addition to heat from cogeneration). The station supplies micro-district of the city with dramatically uneven schedule of electrical load *Pload*.

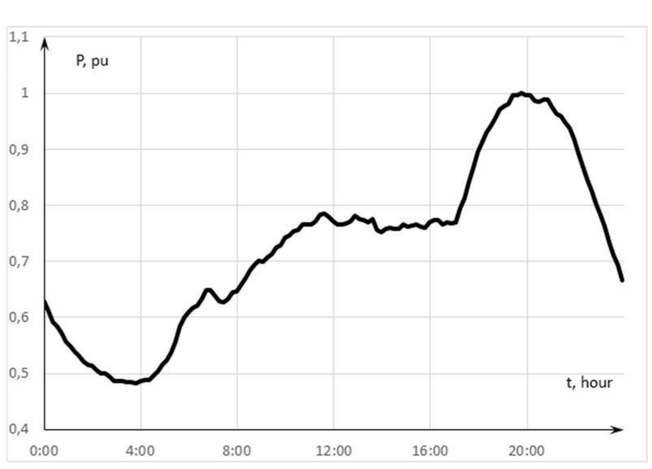
The *objective function* is minimization of production cost: $C_p \rightarrow min$

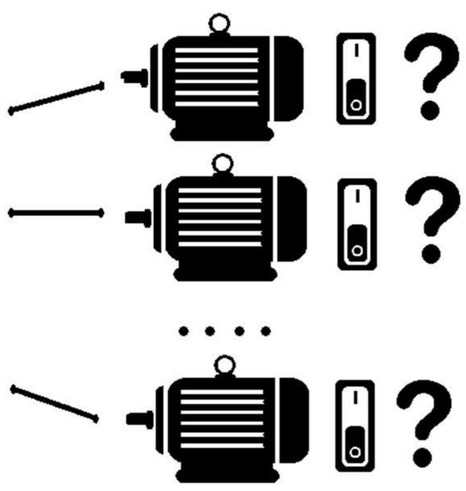
The unit number and their power level have to determined.

When solving any optimization problem is very important the formulation and correct constraint account. For stations with cogeneration technology optimization of production costs associated with the generation of two products heat and electricity. And constraint accounting only electricity does not provide a global minimum



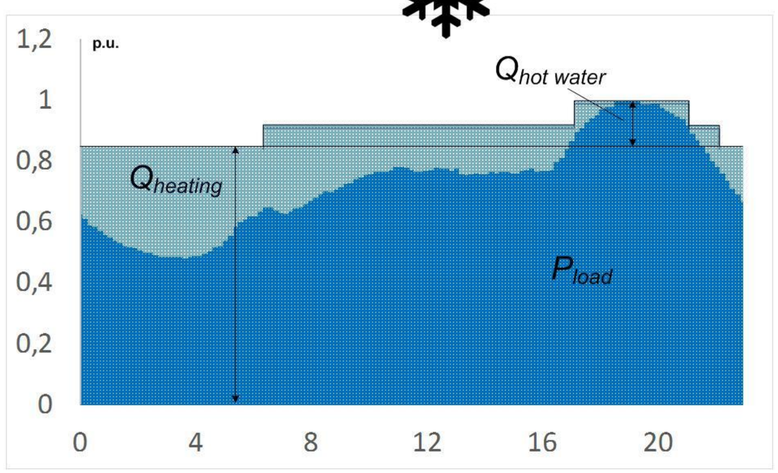
Cogeneration technology is the combined generation of electricity and heat energy. Cogeneration technology allows to use the heat of exhaust gas takes off in special heat exchangers, thereby the overall coefficient of fuel utilization increases and harmful influence on the environment reduces



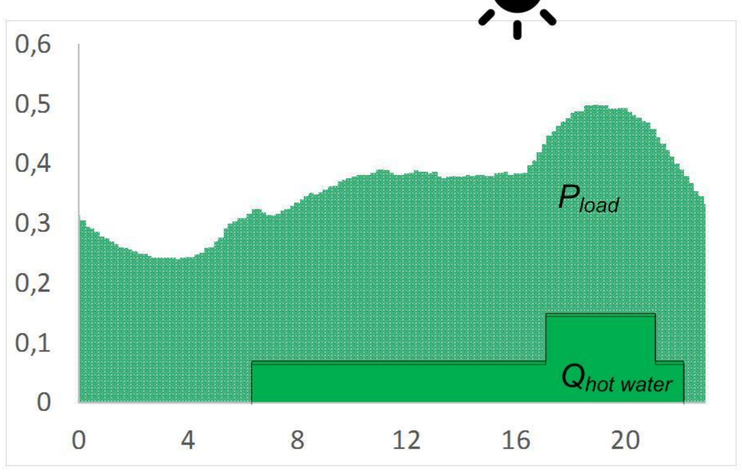


The limitations associated with the production of **electric power** are:
- a balance equation:
$$P_{g\Sigma} = P_{load} + P_{loss}$$
- the unit power range:
$$0{,}4P_{nom} < P_g \le P_{nom}$$
- the sharp fluctuations of the load:
$$\Delta P_{load} \ge 0{,}05 \div 0{,}07\ P_{nom.g}$$
- the number of working units:
$$N+1$$
- the limitation of the station output active power
$$P_{g\Sigma} \le P_{max\_output\ lines}$$
- the limitation by the duration of unit using is limitation by the time period in the units cold reserve before starting or operation duration before stopping the unit.

Winter



Summer



If energy cost in power system **<** production cost of electricity by distributed generation

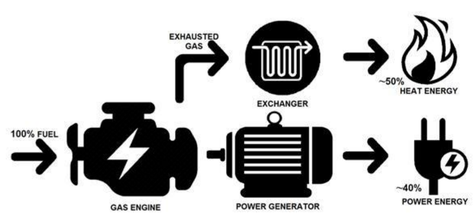
→ produce only the amount of electric power, which equals the heat consumption, and miss electrical power will be purchased from power grid

$$P_g = Q_{load}$$
$$P_{load} = P_g + P_{network}$$

If energy cost in power system **>** production cost of electricity by distributed generation

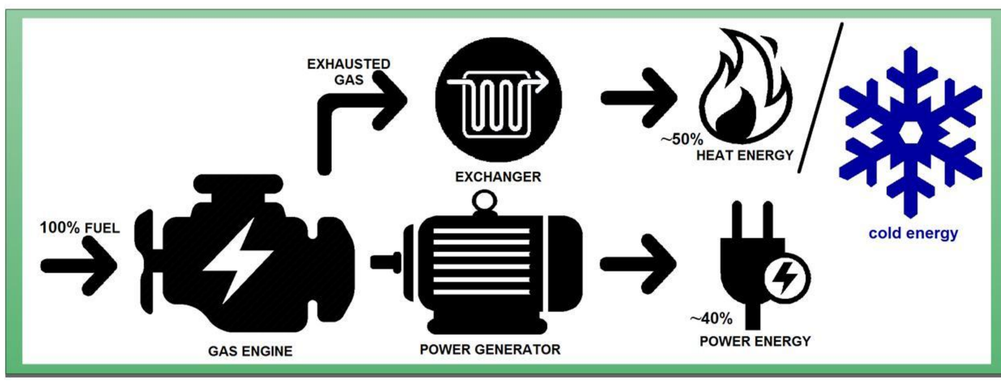
→ produce the amount of power energy that is required for consumer $P_g = P_{load}$ those the extra heat energy (producing from cogeneration technology) don't use and waste Q with exhaust gasses to the atmosphere

produce heat energy by cogeneration as much as possible $Q_{cogen} \rightarrow max$



Increase energy producing to maximum for supply heat consumer

If the excess of power energy occurs, it can be sold to the grid. The volume of power energy, which sold to the grid, can be regulate by the contract between the network organization and the owner of the power station, and it is another constraint. The missing heat energy can be produced in the thermal gas boilers



THREEGENERATION
- increase coefficient of fuel utilization
- economy
- decrease atmosphere emission