DEVELOPMENT OF HYBRID LOW-POWER SYSTEMS IN UKRAINE

EDUCATIONAL AND SCIENTIFIC INSTITUTE OF ENERGY SAVING AND ENERGY MANAGEMENT

Our team:

- experienced scientists
- united on joint projects since 2014
- motivated by the result

Olena Yarmoliuk Ph.D., Associate Professor at the Department of Power Supply Institute of Energy Saving and Energy Management

Yuri Veremiichuk Ph.D., Associate Professor at the Department of Power Supply Institute of Energy Saving and Energy Management

Ivan Prytyskach Ph.D., Department of Power Supply Institute of Energy Saving and Energy Management

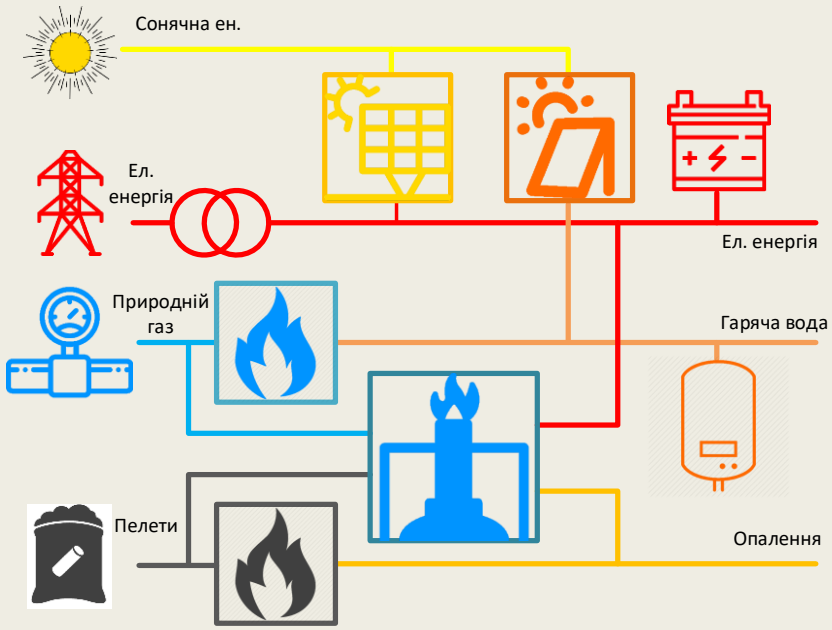
Vitalii Opryshko Ph.D., postdoctoral researcher Institute of Engineering Thermophysics, NAS of Ukraine

Personal and team achievements:

- **2021** – Prize of the Verkhovna Rada of Ukraine for young scientists for the work “Improving the efficiency of final energy consumption by socially important users”
- **2018** – Grant of the President of Ukraine to support research of young scientists for a project "Development of energy hubs optimal functioning model in smart energy supply systems of Ukraine"
- **2018** – Research project "Development of scientific and methodological bases for aggregation and management of virtual power plants and active consumers in the energy market"
- **2017-2019** – Research project "Research of integrated consumers energy supply systems optimal functioning with electric and thermal energy accumulation"
- **2017** – Project "Development and substantiation of the development plan and ways to increase the efficiency of civil electric transport in Chernihiv",
- **2017** – Project "Assessment of the resource potential of solar energy in the Odessa region“
- **2016** – President's Award for Young Scientists for the work "Improving Efficiency of power supply for end user by self-regulation "

Last project: Functioning optimization of consumers integrated energy supply systems

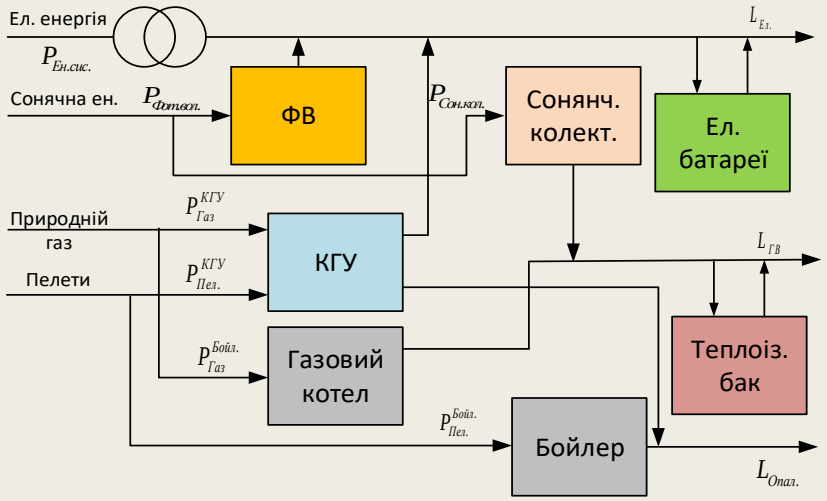
A comprehensive study and scientific solution on possibilities of energy hub concept usage as a part of integrated energy supply system.



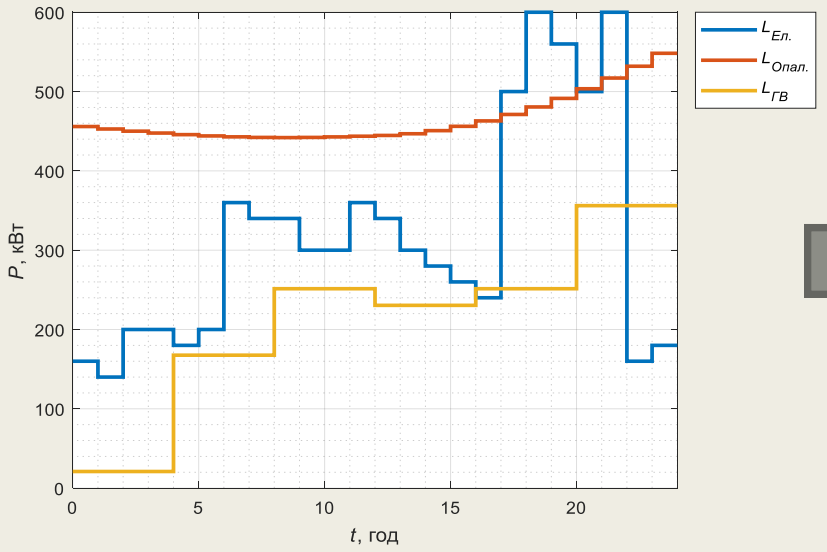
Energy hub publications:

1. Y. Veremiichuk, O. Yarmoliuk, I. Prytyskach, and V. Opryshko, “Energy Sources Selection for Industrial Enterprise Combined Power Supply System,” 2019.
2. Y. Vcremiichuk et al., “Energy Hub Functioning Model Considering Perspectives for Development of Bioenergy in Ukraine,” Proceedings - 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe, EEEIC/I and CPS Europe 2018, pp. 2–7, 2018
3. Y. Veremiichuk, O. Yarmoliuk, I. Prytyskach, and V. Opryshko, “Modeling energy hub operating modes with demand side management usage,” EPE 2018 - Proceedings of the 2018 10th International Conference and Expositions on Electrical And Power Engineering, pp. 972–976, 2018,
4. Y. Veremiichuk, I. Prytyskach, O. Yarmoliuk, and V. Opryshko, “Energy Hub Function Optimization Models During Ukrainian Energy Resources Market Liberalization,” Power and Electrical Engineering, vol. 34, pp. 49–52, 2017,

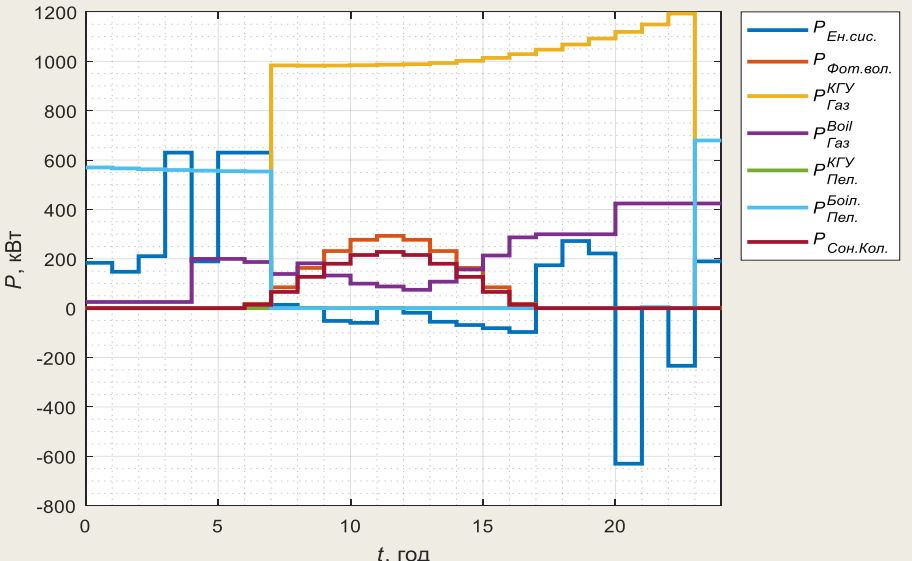
MODELING OF ENERGY HUB FUNCTION MODES



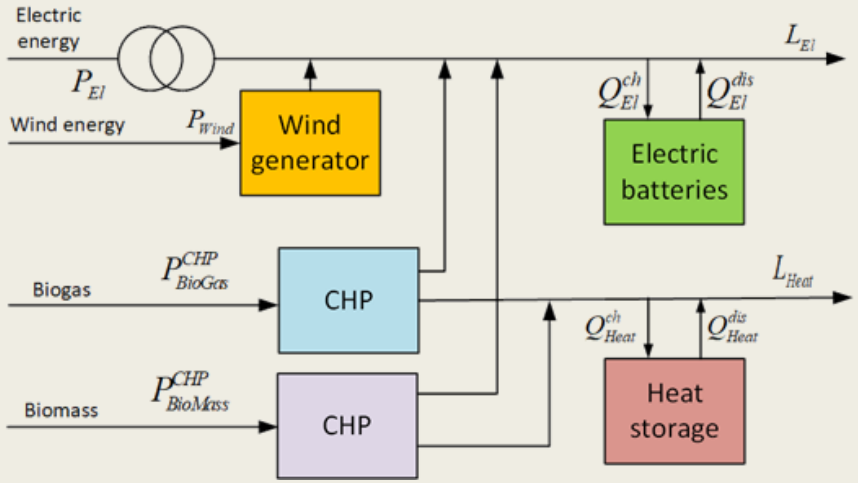
$$\mathbf{P} = \begin{bmatrix} P_{PowSys} \\ P_{PhVol} \\ P^{CHP}_{Gas} \\ P^{Boil}_{Gas} \\ P^{CHP}_{FuelPel} \\ P^{Boil}_{FuelPel} \\ P_{SolCol} \end{bmatrix}; \quad \mathbf{L} = \begin{bmatrix} L_{El} \\ L_{Heat} \\ L_{HW} \end{bmatrix} \quad \mathbf{Q}^{ch} = \begin{bmatrix} Q^{ch}_{El} \\ 0 \\ Q^{ch}_{HW} \end{bmatrix}; \quad \mathbf{Q}^{dis} = \begin{bmatrix} Q^{dis}_{El} \\ 0 \\ Q^{dis}_{HW} \end{bmatrix}$$

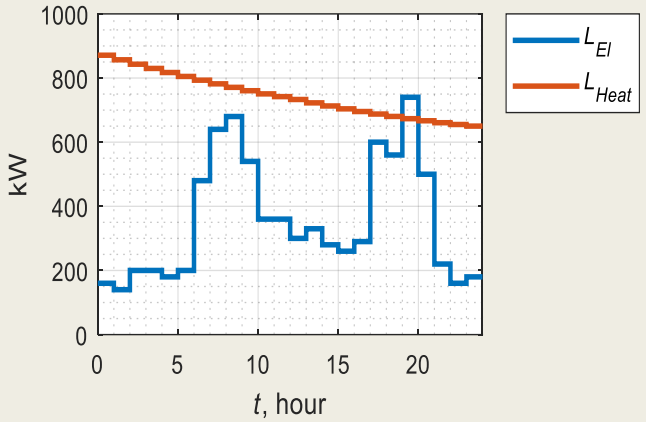


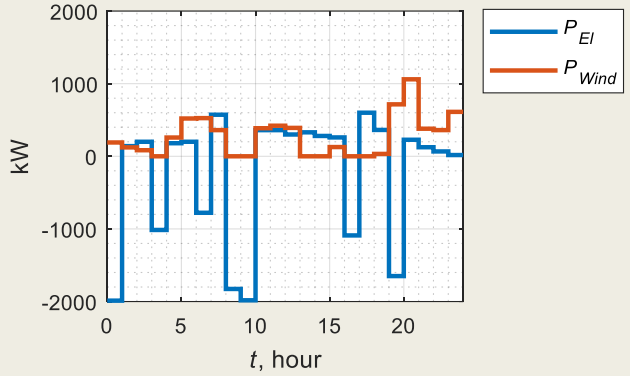
opt



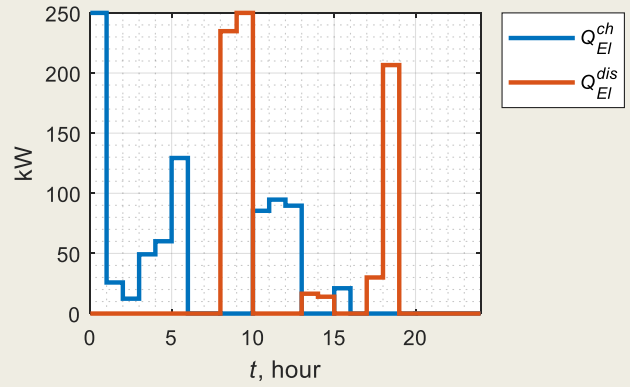
ENERGY HUB FUNCTIONING TAKING INTO ACCOUNT THE AVAILABLE POTENTIAL OF RENEWABLE ENERGY SOURCES

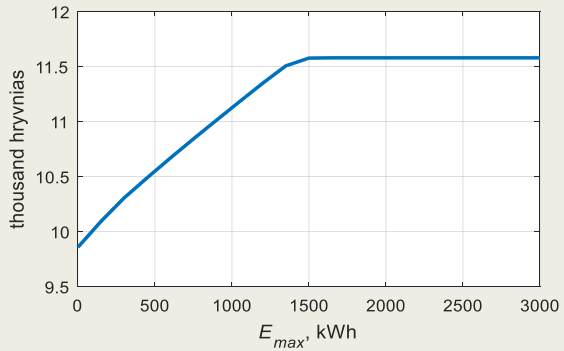




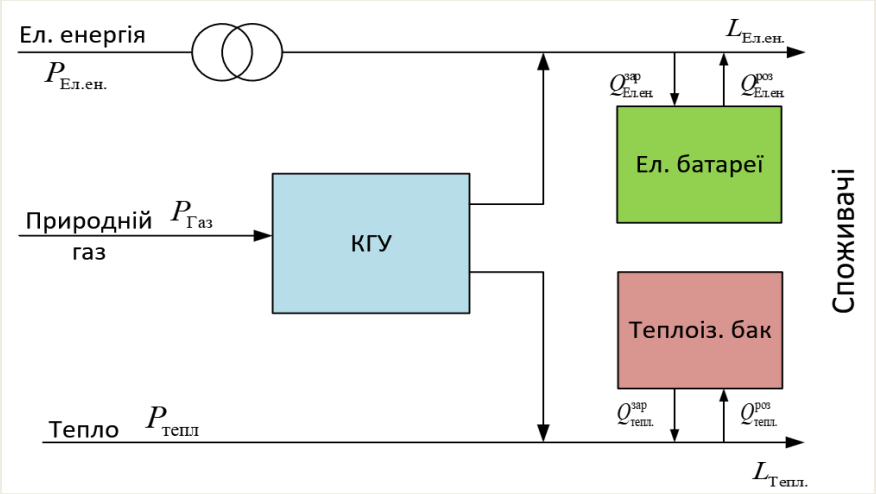


$$\sum_{k=0}^{T-1} c_{El}^{S}(k)P_{El}^{S}(k) - c_{El}^{In}(k)P_{El}^{In}(k) \rightarrow \max$$





ANALYSIS AND OPTIMIZATION OF ENERGY HUB OPERATING MODES TAKING INTO ACCOUNT ECONOMIC AND ENVIRONMENTAL FACTORS



$$c_{Ел.ен.}(k), c_{Тепл.}(k), c_{Газ.}(k) \qquad P_{Ел.ен.}(k), P_{Тепл.}(k), P_{Газ.}(k) \qquad \alpha_{Ел.ен.}, \alpha_{Тепл.}, \alpha_{Газ.}$$

$$\sum_{k=0}^{T-1}\left(c_{Ел.ен.}(k)P_{Ел.ен.}(k)+c_{Тепл.}(k)P_{Тепл.}(k)+c_{Газ.}(k)P_{Газ.}(k)\right)\to \min$$

$$\alpha_{Ел.ен.}\sum_{k=0}^{T-1}P_{Ел.ен.}(k)+\alpha_{Тепл.}\sum_{k=0}^{T-1}P_{Тепл.}(k)+\alpha_{Газ.}\sum_{k=0}^{T-1}P_{Газ.}(k)\to \min$$

$$\min \sum_{k=0}^{T-1}\mathbf{c}(k)\mathbf{P}(k)$$

$$\mathbf{E}(k+1)=\mathbf{E}(k)+\mathbf{A}^{ch}\mathbf{Q}^{ch}(k)-\mathbf{A}^{dis}\mathbf{Q}^{dis}(k)-\mathbf{E}_L,$$

$$\mathbf{L}(k)=\mathbf{\Theta P}(k)-\mathbf{Q}^{ch}(k)+\mathbf{Q}^{dis}(k),$$

$$\mathbf{P}(k)^{\min}\le\mathbf{P}(k)\le\mathbf{P}(k)^{\max},$$

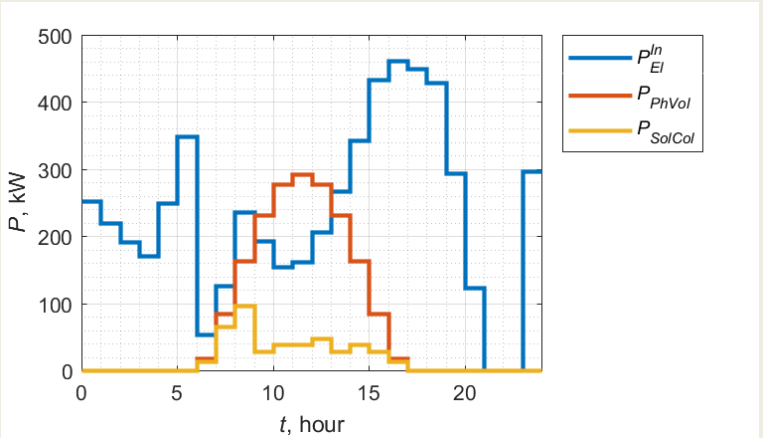
$$0\le Q_i^{ch}(k)\le\delta_i^{ch}(k)Q_i^{\max}(k) \qquad i=1,\dots,M,$$

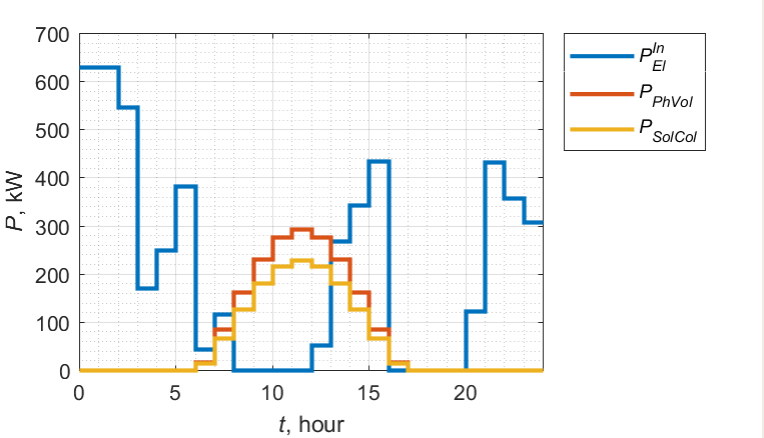
$$0\le Q_i^{dis}(k)\le\delta_i^{dis}(k)Q_i^{\max}(k) \qquad i=1,\dots,M,$$

$$\delta_i^{ch}(k)+\delta_i^{dis}(k)\le 1 \qquad i=1,\dots,M,$$

$$\mathbf{E}(k)^{\min}\le\mathbf{E}(k)\le\mathbf{E}(k)^{\max},$$

$$\mathbf{E}_0=\mathbf{E}_T$$





Current project: Development of demand management and energy supply tools using hybrid low-power systems

- The aim of the project is to increase the flexibility and reliability of the power system in terms of rapid development and implementation of low-power renewable energy sources.
- Recently, the rapid growth of demand for electricity and the shortage of traditional energy resources, the active use of low-capacity RES and energy storage systems require the formation of a new segment in the energy sector, which is developing rapidly worldwide - hybrid renewable energy system.
- Project will explore the regime characteristics of electricity generation, storage and consumption objects in the hybrid renewable energy system, as well as solving the forecast problem and optimization tasks for demand management and rational use of renewable energy with increasing energy system's reliability

Tasks to be done include:

1. Complex analysis of design, development and functioning of hybrid electric power systems on the basis of low power RES and BESS.

2. Formalization of general approaches of BESS effective operation in Ukrainian power grids, which will increase their flexibility, reliability and stability.

3. Development, approbation and implementation of daily generation forecasting methods for hybrid low power generation systems with BESS.

4. Determining methods and approaches of demand management for hybrid power systems optimal operation in the structure of the UES of Ukraine and ENTSO-E.

5. Development of implementation models for generation, accumulation and consumption management for power system participants with low power hybrid systems.

6. Formalization of management methods for hybrid renewable systems in general, and their individual elements, taking into account the presence in their composition of BESS systems, actual, forecast and / or typical energy consumption profiles.

Thank you for your attention.
We look forward for possible cooperation and research activities.
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