

Ministry of Education and Science of Ukraine
**ODESSA NATIONAL ACADEMY OF
FOOD TECHNOLOGIES**

International Competition of
Student Scientific Works

**BLACK SEA
SCIENCE 2021**
PROCEEDINGS



ODESSA, ONAFT 2021

Ministry of Education and Science of Ukraine
Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2021

Proceedings

Odessa, ONAFT 2021

Recommended for print by the Academic Council of
Odessa National Academy of Food Technologies
on April 6, 2021, Protocol No. 13

Editorial board:

Prof. B. Iegorov, D.Sc., Professor, Rector of the Odessa National Academy of Food Technologies, Editor-in-chief

Prof. M. Mardar, D.Sc., Professor, Vice-Rector for Scientific and Pedagogical Work and International Relations, Editor-in-chief

Dr. I. Solonytska, Ph.D., Assoc. Professor, Director of the M.V. Lomonosov Technological Institute of Food Industry, Head of the jury of «Food Science and Technologies»

Dr. Yu. Melnyk, D.Sc., Assoc. Professor, Director of the G.E. Weinstein Institute of Applied Economics and Management, Head of the jury of «Economics and Administration»

Dr. S. Kotlyk, Ph.D., Assoc. Professor, Director of the P.M. Platonov Educational-Scientific Institute of Computer Systems and Technologies “Industry 4.0”, Head of the jury of «Information Technologies, Automation and Robotics»

Prof. B. Kosoy, D.Sc., Professor, Director of the V.S. Martynovsky Institute of Refrigeration, Cryotechnology and Ecoenergetics, Head of the jury of «Power Engineering and Energy Efficiency»

Prof. G. Krusir, D.Sc., Professor, Head of the Department of Ecology and Environmental Protection Technologies, Head of the jury of «Ecology and Environmental Protection»

Dr. V. Kozhevnikova, Ph.D., Assoc. Professor, of the Department of Hotel and Catering Business, ONAFT, Technical Editor

Black Sea Science 2021: Proceedings of the International Competition of Student Scientific Works / Odessa National Academy of Food Technologies; B. Iegorov, M. Mardar (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2021. – 731 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2021» contain the works of winners of the competition.

The author of the work is responsible for the accuracy of the information.

Organizing committee:

Prof. Bogdan Iegorov, D.Sc., Rector of Odessa National Academy of Food Technologies, Head of the Committee

Prof. Maryna Mardar, D.Sc., Vice-Rector for Scientific and Pedagogical Work and International Relations of Odessa National Academy of Food Technologies, Deputy Head of the Committee

Prof. Stefan Dragoev, D.Sc., Vice-Rector for Scientific Work and Business Partnerships of University of Food Technologies (Bulgaria)

Prof. Baurzhan Nurakhmetov, D.Sc., First Vice-Rector of Almaty Technological University (Kazakhstan)

Prof. Mircea Bernic, Dr. habil., Vice-Rector for Scientific Work of Technical University of Moldova (Moldova)

Prof. Jacek Wrobel, Dr. habil., Rector of West Pomeranian University of Technology (Poland)

Prof. Michael Zinigrad, D.Sc., Rector of Ariel University (Israel)

Dr. Mei Lehe, Ph.D., Vice-President of Ningbo Institute of Technology, Zhejiang University (China)

Prof. Plamen Kangalov, Ph.D., Vice-Rector for Academic Affairs of “Angel Kanchev” University of Ruse (Bulgaria)

Dr. Alexander Sychev, Ph.D., Assoc. Professor of Sukhoi State Technical University of Gomel (Belarus)

Dr. Hanna Lilishentseva, Ph.D., Assoc. Professor, Head of the Department of Merchandise of Foodstuff of Belarus State Economic University (Belarus)

Prof. Heinz Leuenberger, Ph.D., Professor of the Institute of Ecopreneurship of University of Applied Sciences and Arts (Switzerland)

Prof. Edward Pospiech, Dr. habil., Professor of the Institute of Meat Technology of Poznan University of Life Sciences (Poland)

Prof. Lali Elanidze, Ph.D., Professor of the Faculty of Agrarian Sciences of Iakob Gogebashvili Telavi State University (Georgia)

Dr. V. Kozhevnikova, Ph.D., Senior Lecturer of the Department of Hotel and Catering Business of Odessa National Academy of Food Technologies, Secretary of the Committee

4. POWER ENGINEERING **AND ENERGY EFFICIENCY**

COMBINED SMALL-SCALE POWER INSTALLATION FOR GENERATION OF THE HEAT, ELECTRICITY, AND MOISTURE FROM AIR

Author: Zhang Haobo

Advisor: Volovyk Oleksii, PhD
NingboTech University (China)

Abstract. *In this paper a combined small-scale power installation composed of a cogeneration system, and an ejector cooling cycle intended for water harvesting from atmospheric air is proposed. The cogeneration system is a combined heat and power system for electricity generation, heat production, and hot water supply. This system includes a microturbine and two heat recovery units. The water harvesting is provided by using cooling effect obtained in an ejector cooling machine (ECM). The ECM is driven by hot water obtained in the cogeneration system and using refrigerant R1233zd(E). The paper describes a theoretical analysis of the combined small-scale power installation and shows the effect of the operating conditions on the system performance. The results show that the proposed installation has high energy efficiency and provides significant savings in energy resources.*

Keywords: *Combined small-scale power installation; Microturbine, Ejector cooling machine, Hot water supply, Water harvesting, Energy saving, Exergy efficiency.*

I. INTRODUCTION

Currently, there is an increase in the share of decentralized small-scale energy supply systems for the simultaneous electricity and heat production (cogeneration systems) based on highly efficient internal combustion engines and microturbines [1]. The main reasons for this process are the rise in prices for energy resources from centralized energy supply systems, caused by the rejection of the use of fossil fuel, as well as restrictions associated with new requirements for environmental safety.

The cogeneration systems have a short payback period (on average 3–5 years) with a long service life of engines and turbines (up to 200,000 hours or 25 years). This makes the small-scale energy supply systems a reliable source of uninterrupted power supply [2,3]. At the same time, the autonomy of such systems that produce electricity and heat at the point of consumption provides a guarantee against interruptions or emergency shutdowns of conventional electric and heating systems.

In addition, along with the generation of electricity and heat energy the consumers in regions with limited or extremely scarce water resources require uninterrupted water supply to meet various needs. If it is impossible to provide water using traditional methods (wells, springs, etc.), the most accessible source of moisture is atmospheric air. The combined use of the small-scale energy system and the system for obtaining moisture from atmospheric air is a promising way to provide the consumer with electrical energy, heat, hot water, and water for various needs. At the same time, all necessary electric and heat energy required for the cogeneration

systems produced by the system itself, which also makes it independent of centralized energy supply systems.

At present, despite the existing technical solutions the issue of creating a highly efficient cogeneration system still remains relevant and requires further study in this direction. The solution to this issue is complicated by the need to take into account the specific conditions presented by the consumer, which often requires an individual approach to the design and development of such systems.

II. LITERATURE ANALYSIS

An analysis of theoretical and experimental studies shows that the proposed variants of the cogeneration systems are various combinations of power plants (engines and turbines) and heat recovery modules for producing a heat medium. Moreover, the range of electrical power and heat loads of such systems is very wide and can be from tens of kilowatts to several megawatts [4–7].

The schematic diagram of the cogeneration system is shown in Fig.1 [8].

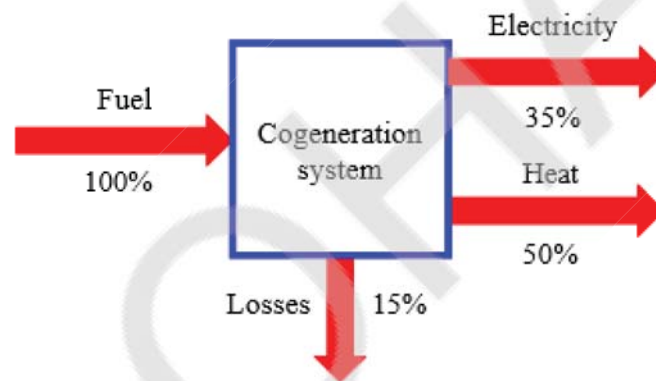


Fig.1. Schematic diagram of the cogeneration system

As follows from Fig.1, in the cogeneration system the production of electrical energy is approximately 35% and heat energy is 50%. The losses in the system are 15%. Thus, the presence of a large amount of waste heat makes it possible to implement various ways using of it to obtain a hot medium, to operate different heat-driven cooling systems, etc. One of the promising areas for using the waste heat of the cogeneration system can be the water harvesting from atmospheric air using a heat-driven cooling machine, in particular, an ejector cooling machine (ECM).

Currently, there are the following methods for harvesting water from atmospheric air:

- condensation method;
- adsorption method;
- absorption method;
- combined method.

In the condensation method, water vapor in the air is cooled to a temperature below the dew point of the air and liquefied using cold sources. As a result, the method is difficult to apply in natural cooling, and therefore active cooling methods are required such as mechanical compression cooling cycle [9,10], thermoelectric cooling [11] and adsorption cooling [12].

Adsorption and absorption methods involve the water harvesting from air by using of adsorption materials [13,14] and solutions [15]. In the adsorption method a porous adsorbent adsorbs water vapor from cold air at night. During the daytime, the material is heated by solar energy to release the adsorbed water, and the vapor is carried away by the air flow. Then this vapor which then condenses in coolers to form water. Therefore, this method inherently has a problem of periodic operation.

Combined methods for obtaining water from atmospheric air use a combination of the methods presented above. In particular, some studies are being carried out on systems that combine the use of a mechanical compression cooling cycle and a desiccant wheel [16] and membranes [17]. In this case, the desiccant wheel and membranes are used to humidify the treated air before dehumidifying it using the mechanical compression cooling cycle.

Existing studies shows that the condensation method is suitable for humid climates. However, in areas with a dry climate the effectiveness of the condensation method is significantly reduced due to the low cooling temperature. The adsorption method can only work during the daytime with sufficient solar radiation, and the daily collection of water is relatively low. Taking into account the advantages and disadvantages of the methods described above, it can be concluded that the proposed method of water harvesting using ECM driven by waste heat of the cogeneration system can occupy its niche in this direction and become widespread in real small-scale energy systems.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of study is a combined small-scale power installation based on a microturbine and the ECM intended for water harvesting from atmospheric air.

The subject of study is the thermodynamic processes in the combined small-scale power installation based on the microturbine and the ECM.

The research methods are thermodynamic analysis and numerical simulation of processes in the proposed combined small-scale power installation, comparison of the simulation results with the results of existing experimental studies.

The schematic diagram of the proposed combined small-scale power installation is shown in Fig.2. The installation consists of a cogeneration system and an ejector cooling system. The cogeneration system includes a microturbine with an alternator for generating electrical energy and two heat recovery units installed on the microturbine exhaust system. Some part of the generated electricity is used to drive all the system components with electric power consumption (pumps, fans), and the remaining part of the electricity is transmitted to the consumer's power system. The heat recovery unit 1 is designed to obtain hot water for various consumer needs and provides a reduction in the temperature of exhaust gases. Heat recovery unit 2 is used to obtain hot water for provide a heat load on the ECM's generator, thereby ensuring the operation of the heat-driven cooling system. The proposed solution can significantly reduce the consumption of primary fuel with the maximum use of the available potential of waste heat.

The water harvesting from atmospheric air is provided by the ECM using refrigerant R1233zd(E). The proposed ECM is operated through the use of hot water

obtained in the heat recovery unit 2. The heating medium enters the ECM generator in which the refrigerant R1233zd(E) is heated and boiled due to heat exchange. In this case, the circulation of the hot water is carried out according to a two-circuit scheme using a hot water storage and two water pumps, which ensures stable operation of the generator. Water is obtained in the ECM's air cooler, in which the atmospheric air is cooled to a temperature below the dew point temperature under specified operating conditions. The obtained condensate accumulates in the tank and is then sent to the consumer. In addition, it is possible, if necessary, to supply part of the obtained water to hot water storages to recover losses.

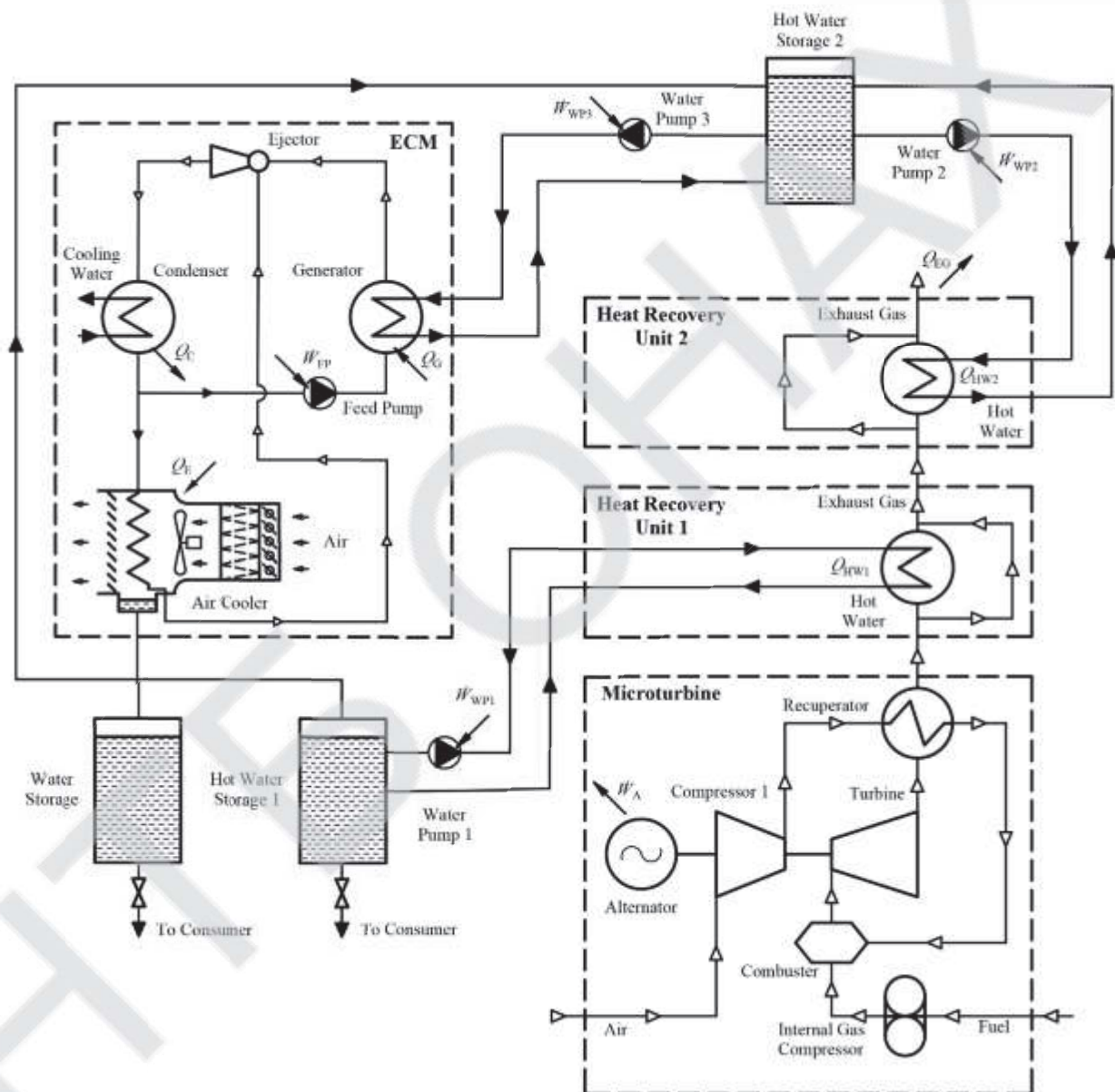


Fig. 2. Schematic diagram of the combined small-scale power installation

IV. RESULTS

The proposed combined small-scale power installation has been designed and investigated for a small business, farm or public building in Hangzhou City, Zhejiang Province. The outdoor parameters are as follows [18]:

- design summer air temperature: $T_a^s = 35.7 \text{ }^\circ\text{C}$;
- design summer relative air humidity: $RH_s = 59\%$;
- design winter air temperature: $T_a^w = -4.0 \text{ }^\circ\text{C}$;
- design winter relative air humidity: $RH_w = 78 \%$.

1. Microturbine

In this study the C30 microturbine from Capstone (USA) is adopted as the power plant of the combined system [3]. The external view of the ready-for-use unit and engine components are shown in Fig.3 and Fig.4, respectively, and its technical characteristics are presented in Table 1.



Fig. 3 – General view of the Capstone C65 unit (USA)

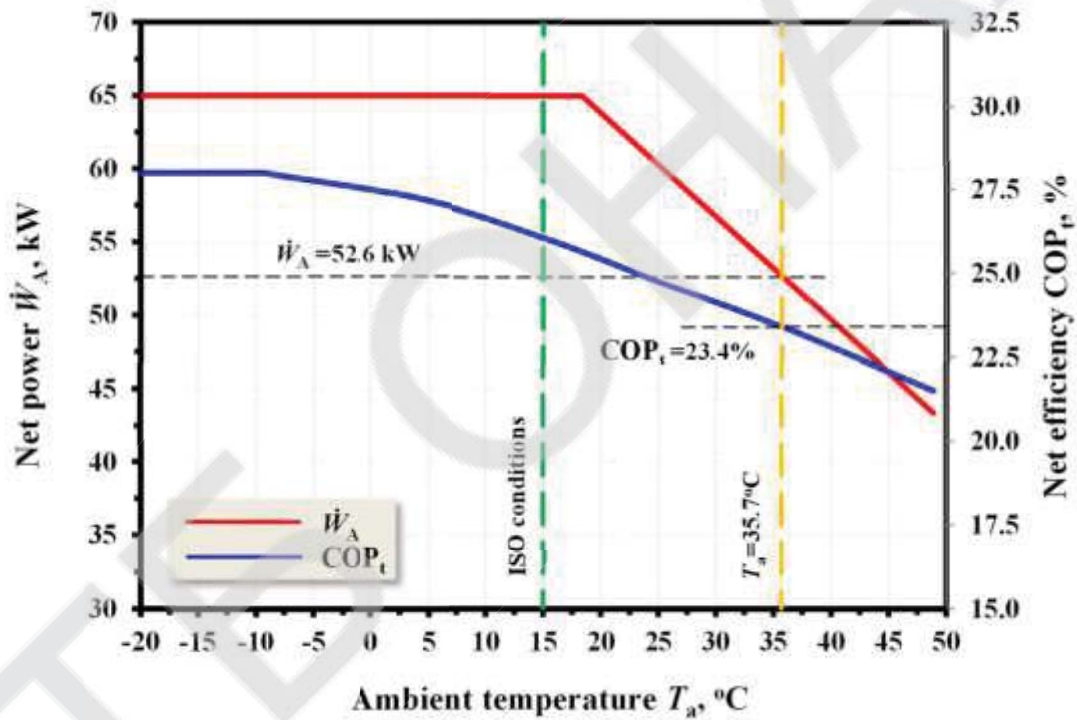


Fig. 4 –Capstone C65 engine components

Table 1. Technical characteristics of the microturbine Capstone C65

Characteristic	Value
Fuel	Natural gas
Net electric power, \dot{W}_A , kW	65
Fuel mass flow rate, \dot{m}_f , $\text{kg}\cdot\text{s}^{-1}$	0,00454
Air mass flow rate, \dot{m}_a , $\text{kg}\cdot\text{s}^{-1}$	0,48546
Exhaust temperature, T_{eg} , $^{\circ}\text{C}$	309

The microturbine produces 52.6 kW of electric energy with efficiency of 23.4% when operating in design conditions at the air temperature of $T_a^s = 35.7^{\circ}\text{C}$ (Fig.5).


 Fig. 5 – Variation of \dot{W}_A and COP_t with T_a [3]

The amount of exhaust gases heat is determined by equation:

$$Q_{eg,t} = \frac{\dot{W}_A \cdot \text{COP}_{\text{RHE}}}{\text{COP}_t}, \text{ kW},$$

(1)

where COP_{RHE} is the heat exchanger efficiency, $\text{COP}_{\text{RHE}} = 0.75$,

$$Q_{eg,t} = \frac{52.6 \cdot 0.75}{0.234} = 168.6 \text{ kW}.$$

2. Heat recovery unit 1

The heat recovery unit 1 is intended for heating water for various consumer needs. Water flow rate is 300 l/h (0.139 kg·s⁻¹). Initial water temperature is $T_{w11} = 28\text{ }^{\circ}\text{C}$; water temperature after heating is $T_{w21} = 70\text{ }^{\circ}\text{C}$.

The amount of heat required for heating water is determined by equation:

$$Q_{w1} = \dot{m}_{w1} \cdot c_{p,w1} \cdot (T_{w21} - T_{w11}), \text{ kW}, \quad (2)$$

where $c_{p,w1}$ is the specific heat of the water, $c_{p,w1} = 4.18\text{ kJ}/(\text{kg}\cdot^{\circ}\text{C})$.

$$Q_{w1} = 0.083 \cdot 4.18 \cdot (70 - 28) = 14.6\text{ kW}.$$

The amount of exhaust gases heat after the heat recovery unit 1:

$$Q_{eg,1} = Q_{eg,t} - Q_{w1} = 168.6 - 14.6 = 154.0\text{ kW}. \quad (3)$$

According to the water flow rate two MAGNA3 25-40 circulation pumps from Grundfos (Denmark) were selected. The power consumption of the pump \dot{W}_{wp1} is 0.027 kW.

3. ECM

The proposed ECM is designed for water harvesting from atmospheric air due to its cooling in an air cooler to a temperature below the dew point temperature. The water condensate is formed on the heat exchange surface of the air cooler. The cooled air can be used for the storage chamber. The calculation of the ejector with conical-cylindrical mixing chamber and ECM is carried out according to the method proposed by Shestopalov et al. [19]. The results of calculations of the ECM are presented in Table 2. Refrigerants R1233zd(E) is used as the working fluids for ECM.

The air flow through the air cooler is 1700 m³/h. The cooling capacity of the ECM is determined by the expression:

$$Q_E = \dot{m}_a \cdot c_{p,a} \cdot (h_{a2} - h_{a1}), \text{ kW}, \quad (4)$$

$$Q_{w1} = 0.562 \cdot 1.005 \cdot (92.1 - 33.7) = 33.0\text{ kW}.$$

Table 2. Design specifications of the ECM

Parameter	Value
Cooling capacity Q_E , kW	33.0
Evaporating temperature T_E , $^{\circ}\text{C}$	9
Condensing heat load, Q_C , kW	174.0
Condensing temperature, T_C , $^{\circ}\text{C}$	40
Generating heat load, Q_G , kW	141.0
Generating temperature, T_G , $^{\circ}\text{C}$	96
Entrainment ratio, ω	0.315
Design COP _{THERM} = Q_E/Q_G	0.234
Feed pump power input, \dot{W}_{MECH} , kW	0.79
Feed pump coefficient of efficiency, η_{FP}	0.5
Design area ratio $\beta = \beta_{opt} \beta_t$	5.74
Design optimal area ratio $\beta_{OPT} = \beta_{opt} \beta_3$	1.5

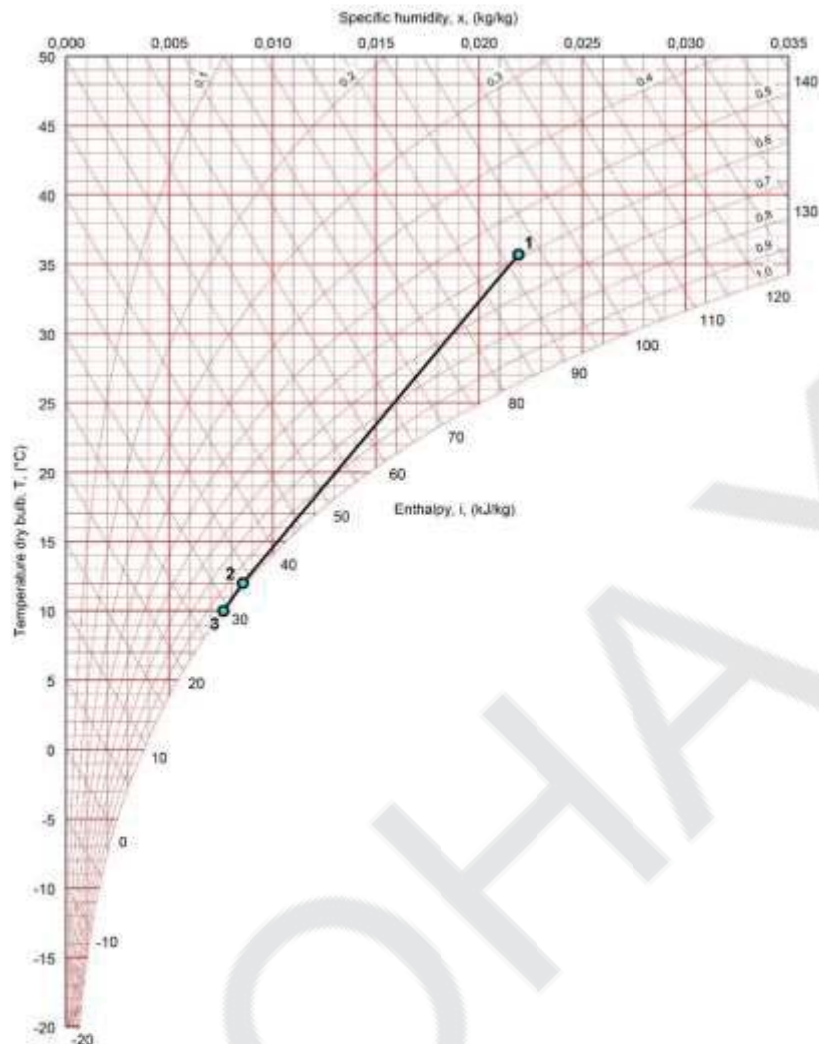


Fig. 5 – Dehumidification process in the psychometric chart

The process of obtaining moisture in the ECM's air cooler is shown in Fig.5. The amount of moisture is calculated by the following equation:

$$W = \dot{m}_{w1} \cdot c_{p,w1} \cdot (d_{w2} - d_{w1}) \cdot 3600, \text{ kg} \cdot \text{s}^{-1}, \quad (5)$$

$$W = 0,567 \cdot 1,005 \cdot (0,0291 - 0,0086) \cdot 3600 = 27,3 \text{ kg} \cdot \text{s}^{-1} \text{ (28 l/h)}.$$

The air leaving the air cooler with a temperature of 12 °C can be used for airconditioning or in storage chambers for cooled food.

4. Heat recovery unit 2

The heat recovery unit 2 is intended for heating water for operation of the ECM and it is used in combination with the heat medium circulation circuit through generator of the ECM. Hot water storage and two circulating water pumps are provided in this circuit. Initial water temperature is $T_{w12} = 98 \text{ }^\circ\text{C}$; water temperature after heating is $T_{w22} = 100 \text{ }^\circ\text{C}$.

The amount of heat required for heating water is equal to the amount of generating heat of the ECM:

$$Q_{w2} = Q_G = 141,0 \text{ kW}. \quad (6)$$

The amount of exhaust gases heat after the heat recovery unit 2:

$$Q_{eg,2} = Q_{eg,1} - Q_{w2} = 154,0 - 140,0 = 14,0 \text{ kW}. \quad (7)$$

The water flow in the flow circuit is determined by equation:

$$\dot{m}_{w2} = \frac{Q_{w2}}{c_{p,w2} \cdot (T_{w12} - T_{w21})}, \text{ kg} \cdot \text{s}^{-1}, \quad (8)$$

where $c_{p,w2}$ is the specific heat of the water, $c_{p,w2} = 4.209 \text{ kJ}/(\text{kg} \cdot ^\circ\text{C})$.

$$\dot{m}_{w2} = \frac{140.0}{4.209 \cdot (100 - 98)} = 16.63 \text{ kg} \cdot \text{s}^{-1} \text{ (60476 l/h)}.$$

According to the water flow rate two MAGNA3 40-80 F circulation pumps from Grundfos (Denmark) were selected. The power consumption of each pump is

1.564 kW, the total power consumption \dot{W}_{wp2} is 3.128 kW.

The amount of electricity supplied to the consumer's power grid taking into account the own needs of the trigeneration system is determined by equation:

$$\begin{aligned} \dot{W}_{A,con} &= \dot{W}_A - \dot{W}_{MECH} - \dot{W}_{wp1} - \dot{W}_{wp2} - \\ &= 52.60 - 0.79 - 0.027 - 3.128 - 48.66 \text{ kW}. \end{aligned} \quad (9)$$

V. CONCLUSIONS

1. The proposed combined small-scale power installation allows the consumer to obtain 56.6 kW of electricity, 300 l/h of hot water with a temperature of 70 °C, 28 l/h water from atmospheric air and 33 kW of cold (evaporating temperature is 9 °C) for the storage chamber.

2. The proposed combined system also produces for its own needs and directly uses 3.45 kW of electricity, 60476 l/h of hot water with a temperature of 100 °C.

3. The proposed trigeneration system is an effective solution for the simultaneous production of heat, electrical energy, water and cold and meets modern environmental requirements.

VI. REFERENCES

1. Rahbar, K., Mahmoud, S., Al-Dadah, R. K., Moazami, N., & Mirhadizadeh, S. A. (2017, 2017/02/15/). Review of organic Rankine cycle for small-scale applications. *Energy Conversion and Management*, 134, 135-155.
2. www.engines.man.eu
3. www.capstoneturbine.com
4. Ameli, S. M., Agnew, B., & Potts, I. (2007). Integrated distributed energy evaluation software (IDEAS): Simulation of a micro-turbine based CHP system. *Applied Thermal Engineering*, 27, 2161-2165.
5. Isa, N. M., Tan, C. W., & Yatim, A. H. M. (2018). A comprehensive review of cogeneration system in a microgrid: A perspective from architecture and operating system. *Renewable and Sustainable Energy Reviews*, 81, 2236-2263.
6. Onovwiona, H. I., & Ugursal, V. I. (2006). Residential cogeneration systems: review of the current technology. *Renewable and Sustainable Energy Reviews*, 10, 389-431.
7. Uchman, W., Kotowicz, J., & Li, K. F. (2021). Evaluation of a micro-cogeneration unit with integrated electrical energy storage for residential application.

Applied Energy, 282, 116196.

8. Amidpour, M., & Khoshgoftar Manesh, M. H. (2021). Chapter 1 - Cogeneration and polygeneration. In M. Amidpour & M. H. Khoshgoftar Manesh (Eds.), *Cogeneration and Polygeneration Systems* (pp. 1-12): Academic Press.

9. Magrini, A., Cattani, L., Cartesegna, M., & Magnani, L. (2015). Production of Water from the Air: The Environmental Sustainability of Air-conditioning Systems through a More Intelligent Use of Resources. The Advantages of an Integrated System. *Energy Procedia*, 78, 1153-1158.

10. Zolfagharkhani, S., Zamen, M., & Shahmardan, M. M. (2018). Thermodynamic analysis and evaluation of a gas compression refrigeration cycle for fresh water production from atmospheric air. *Energy Conversion and Management*, 170, 97-107.

11. Eslami, M., Tajeddini, F., & Etaati, N. (2018). Thermal analysis and optimization of a system for water harvesting from humid air using thermoelectric coolers. *Energy Conversion and Management*, 174, 417-429.

12. Ibrahim, N. I., Al-Sulaiman, F. A., & Saidur, R. (2016). Performance assessment of water production from solar cooling system in humid climate. *Energy Conversion and Management*, 127, 647-655.

13. Heidari, A., Roshandel, R., & Vakiloroyaya, V. (2019). An innovative solar assisted desiccant-based evaporative cooling system for co-production of water and cooling in hot and humid climates. *Energy Conversion and Management*, 185, 396-409.

14. Kumar, M., & Yadav, A. (2015). Experimental investigation of solar powered water production from atmospheric air by using composite desiccant material "CaCl₂/saw wood". *Desalination*, 367, 216-222.

15. Talaat, M. A., Awad, M. M., Zeidan, E. B., & Hamed, A. M. (2018). Solar-powered portable apparatus for extracting water from air using desiccant solution. *Renewable Energy*, 119, 662-674.

16. Wang, J. Y., Wang, R. Z., Wang, L. W., & Liu, J. Y. (2017). A high efficient semi-open system for fresh water production from atmosphere. *Energy*, 138, 542-551.

17. Zhao, B., Wang, L.Y., & Chung, T.S. (2019) Enhanced membrane systems to harvest water and provide comfortable air via dehumidification & moisture condensation. *Sep Purif Technol.*

18. 全国主要城市室外气象参数表 (Table of outdoor meteorological parameters of major cities in China).

19. Shestopalov KO, Huang BJ, Petrenko VO, Volovyk OS. Investigation of an experimental ejector refrigeration machine operating with refrigerant R245fa at design and off- design working conditions. Part 1. Theoretical analysis. *Int J Refrigeration* 2015; 55:201-11.

A RESULT-ORIENTED FRAMEWORK TO SUPPORT THE LOW-CARBON TRANSFORMATION OF ENERGY SERVICES MARKET Author: Maria Yevtukhova Advisors: Valeriy Deshko Oleksandr Kovalko National Technical University “KPI” (Ukraine).....	555
COMBINED SMALL-SCALE POWER INSTALLATION FOR GENERATION OF THE HEAT, ELECTRICITY, AND MOISTURE FROM AIR Author: Zhang Haobo Advisor: Volovyk Oleksii NingboTech University (China).....	569
INVESTIGATION OF THE INFLUENCE OF THERMAL MODERNIZATION OF PANEL RESIDENTIAL BUILDINGS IN POLTAVA ON THE HUMIDITY CONDITION OF PANELS IN THE JOINT ZONE Authors: Vitalii Kidenko, Mustafa Omer Mussab Musaad, Pavlo Havrylenko Advisors: Oleg Yurin, Nataliia Mahas National University «Yuri Kondratyuk Poltava Polytechnic» (Ukraine).....	579
HEAT AND MASS TRANSFER IN BIOMASS PYROLYSIS TECHNOLOGIES Authors: Gustaw Kot, Agnieszka Jardel Advisor: prof. Anatolii Pavlenko Kielce University of Technology (Poland).....	592
INCREASING THE EFFICIENCY OF AN AUTONOMOUS POWER SUPPLY SYSTEM BASED ON PHOTOELECTRIC CONVERTERS Author: Kateryna Novyk Advisor: Serhii Stepenko Chernihiv Polytechnic National University (Ukraine).....	598
INCREASING THE LEVEL OF ENERGY EFFICIENCY OF COMBINED POWER SUPPLY SYSTEMS Author: Andrew Yakovenko, Maxim Slavov Advisor: Serhii Dudnikov Petro Vasylenko Kharkiv National Technical University of Agriculture (Ukraine)	615
5. ECOLOGY AND ENVIRONMENTAL PROTECTION.....	628
EFFICIENCY FROM WETLANDS AND AERATED LAGOONS FOR WASTEWATER TREATMENT Authors: Anastasia Lahotska ¹ , Karolina Jozwiakowska ² Advisor: Myroslav Malovanyy ¹ Lviv Polytechnic National University (Ukraine) ² H. Kołłątaj University of Agriculture in Kraków (Poland).....	629