Supported by

NEW DEMOCRACY FUND

ALTERNATIVES FOR RENEWABLE HEAT SUPPLY

IN NIZHYN, UKRAINE

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CONTENTS

1. Who we are - PlanEnergi
2. Introduction of the project
3. Background and problem definition
4. Aim and tactics
5. Methodology
6. Results
7. Conclusion
8. Discussion

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WHO WE ARE - PLANENERGI?

- Consulting engineering firm in the engineering field
- Over 38 years of working with sustainable and renewable energy
- 49 employees
- Offices in:
  - Scorping
  - Aarhus
  - Copenhagen
- Turnover in 2021: DKK 35 million
- Capital: DKK 8.3 million
- 11 teams specializing in one area
- Board of 8 members. 5 of which are external and 3 are elected by employees

- Central heating
  - Master plans and fundamental data for decision-making
  - Expansion and conversion of centralized heat supply
  - Large-scale heat pumps
  - Excess heat
  - Central heating with solar batteries
  - Accumulators of thermal energy
  - Hydraulic and thermal analyzes and network optimization
- Strategic power planning
  - Mapping
  - Strategies
  - Action plans
  - Heating planning
- Biogas
- Spatial planning of solar power plants and wind turbines
- International research projects (IEA, Horizon, etc.)

INTRODUCTION

Grounds: part of the Project “Change Agents for a Green Society with Focus on Renewable Energy for District Heating, Ukraine“ supported by the New Democracy Fund

Aim: assessment of partially converting the district heating (DH) supply system in Nizhyn, Ukraine to renewable energy.

Purpose: partially cover the heat demand of consumers in the chosen area with heat supply based on renewable energy sources and thereby transition the existing district heating system towards renewable energy and to increase the energy efficiency of the system by decreasing the utilization of fossil fuel.

Outcome: comparison of the different alternatives for heat supply to outline most feasible solution for the future heat supply.

BACKGROUND AND PROBLEM DEFINITION

BACKGROUND

- Object - 4 boiler houses located in the outskirts of the town which are far from the central part of Nizhyn (see images 1,2,3,4,5,6)
- Chosen boiler houses deliver approx. 13,5% of the total heat supply in the town
- Length of the district heating network covered by the four boiler houses is ca. 11.825 linear meters (see table 1)
- Heating season in the area is estimated to be around six months/year
- The facilities are the property of the Nizhyn Territorial Community
- The vast majority of equipment, heating networks and buildings are owned by the community and leased to LLC "Nizhynteplomerezhi". Part of the equipment is the property of " Nizhynteplomerezhi" LLC
- District heating system of the town of Nizhyn supplies heat to about 35.000 residents, i.e. ca. 52% of the total population
- The number of service personnel in each boiler house is 8 people

BACKGROUND AND PROBLEM DEFINITION

Problem definition

- Threat of providing the population with an insufficient amount due to the lack of fuel and permanent attacks. Martial law.
- Significant fluctuation in global gas prices
- Considerable losses of thermal energy in the network (25-55%)
- The efficiency factor of boilers fan burners is mostly extremely low
- Outdated equipment in boiler houses
- Thermal networks of the thermal district of the boiler house are underground, laid in impassable channels (trays)
- Term of operation of heating networks is significant
- Replacement of pipelines of heating networks with modern pre-insulated pipes was not carried out

BACKGROUND AND PROBLEM DEFINITION

boiler house	Average annual release of thermal energy, Gcal/year	Characteristics of heat networks		Specific indicators of heat transportation	
		Length (in two-pipe measurement) linear meters	Pipe surface m2	Gcal/linear meters year	m2 /Gcal
Prylutska	8264	7527	5005	1.1	0.32
Kotsybinskogo	556	274	149	2.03	0.27
Cosmonautus	6052	3380	2394	1.79	0.4
Haidamatska	1074	644	340	1.67	0.31

Table 1: Characteristics and indicators of heat networks

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BACKGROUND AND PROBLEM DEFINITION

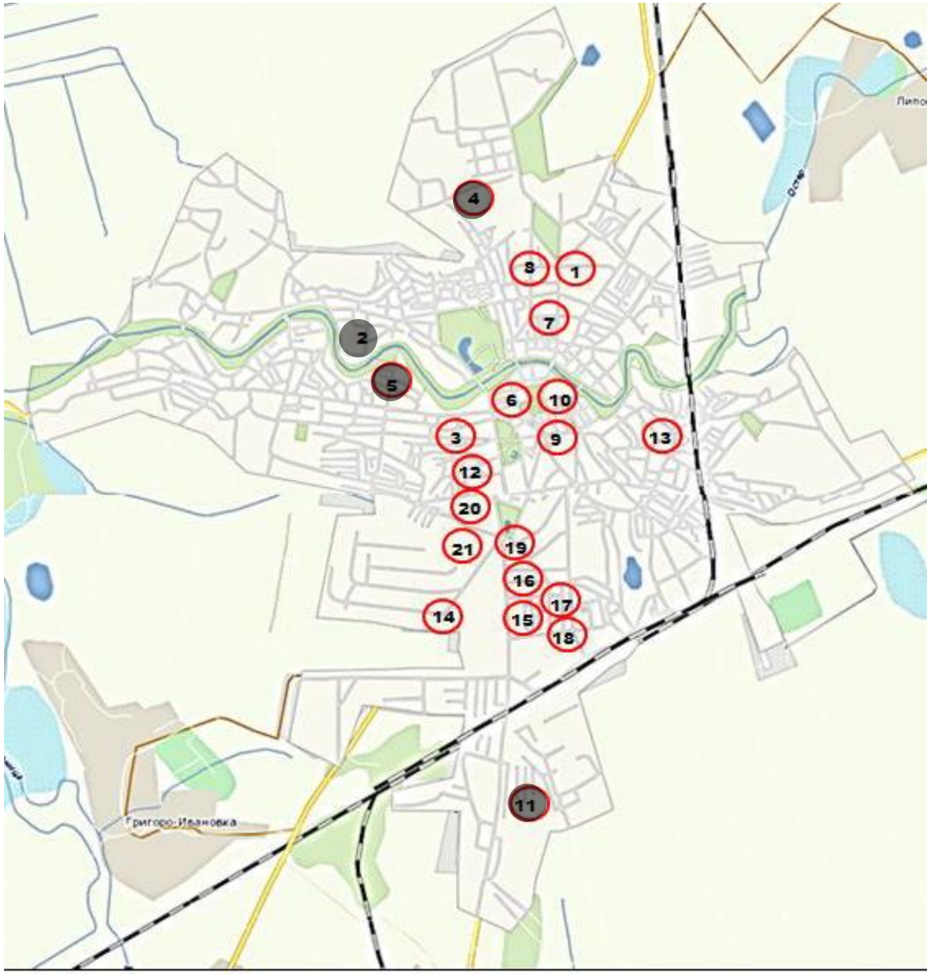

Image 1: Boiler houses’ location in Nizhyn, Ukraine

We are interested in those marked with red.

1 - Котельня по вул. Амосова, 8а
2 - Котельня по вул. Гайдамацька, 25 (Haidamatska)
3 - Котельня по вул. Козача, 3а
4 - Котельня по вул. Космонавтів, 25 (Cosmonauts)
5 - Котельня по вул. Коцюбинського, 1б (Kotsybinsky)
6 - Котельня по вул. Богушевича, 2а
7 - Котельня по вул. Московська, 17
8 - Котельня по вул. Московська, 23
9 - Котельня по вул. Ніжатинська, 18
10 - Котельня по вул. Покровська, 2
11 - Котельня по вул. Прилуцька, 133 (Prylutsk)
12 - Котельня по вул. Синяківська, 75
13 - Котельня по вул. Франка, 89
14 - Котельня по вул. Шевченка15 - ЦТП - 1
16 - ЦТП - 2
17 - ЦТП - 3
18 - ЦТП - 4
19 - ЦТП - 5
20 - ЦТП - 6
21 - ЦТП – 7

BACKGROUND AND PROBLEM DEFINITION

Boiler house

Image 2: Heat supply scheme for Haidamatska 25 Boiler house

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BACKGROUND AND PROBLEM DEFINITION

Boiler house

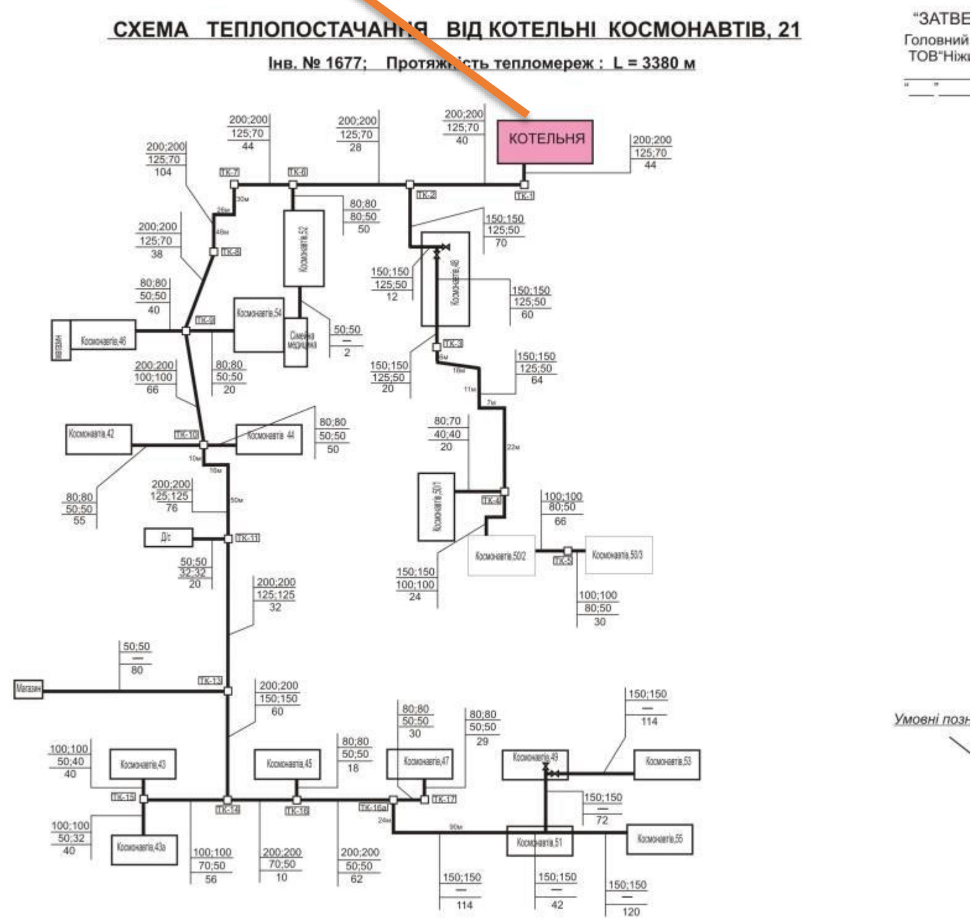

Image 3: Heat supply scheme for Cosmonavtiv Boiler house

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BACKGROUND AND PROBLEM DEFINITION

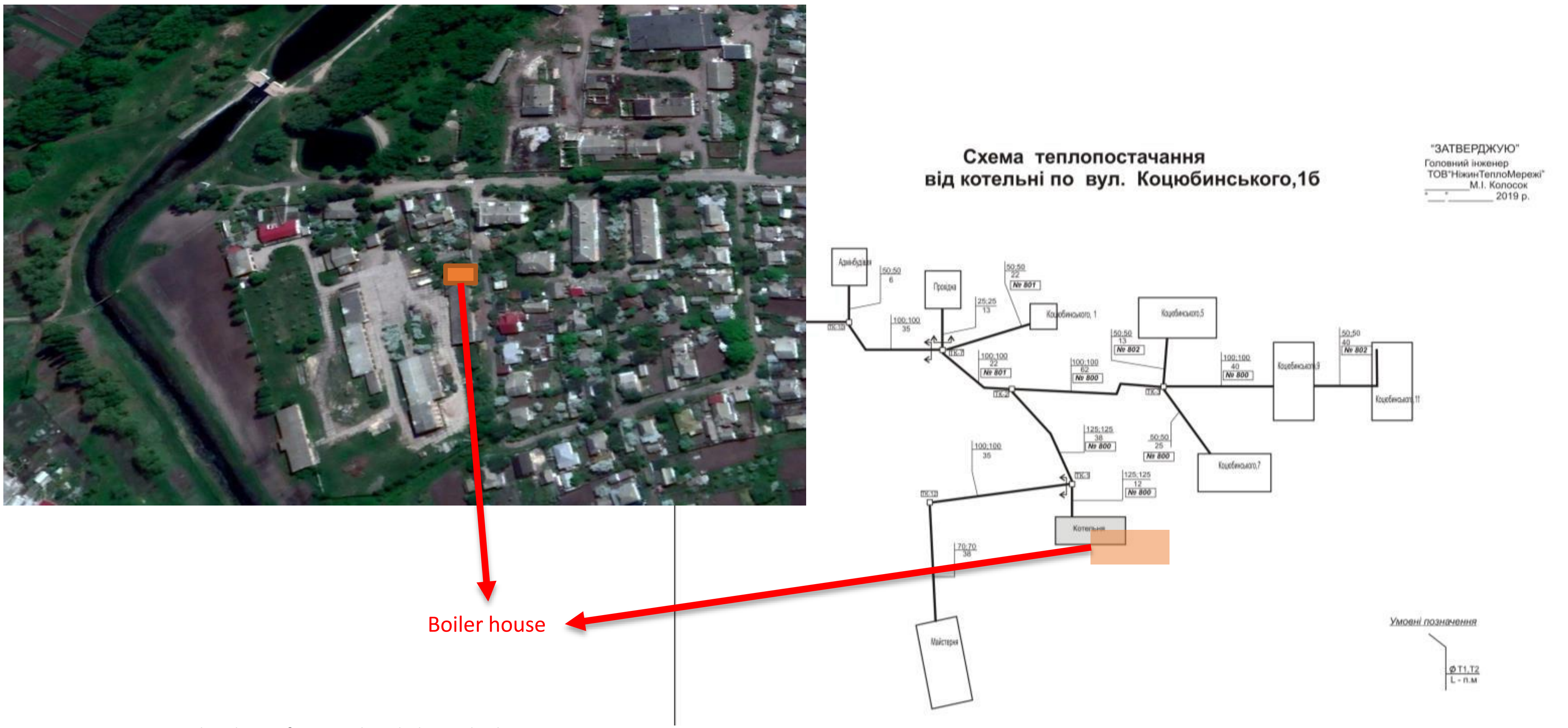
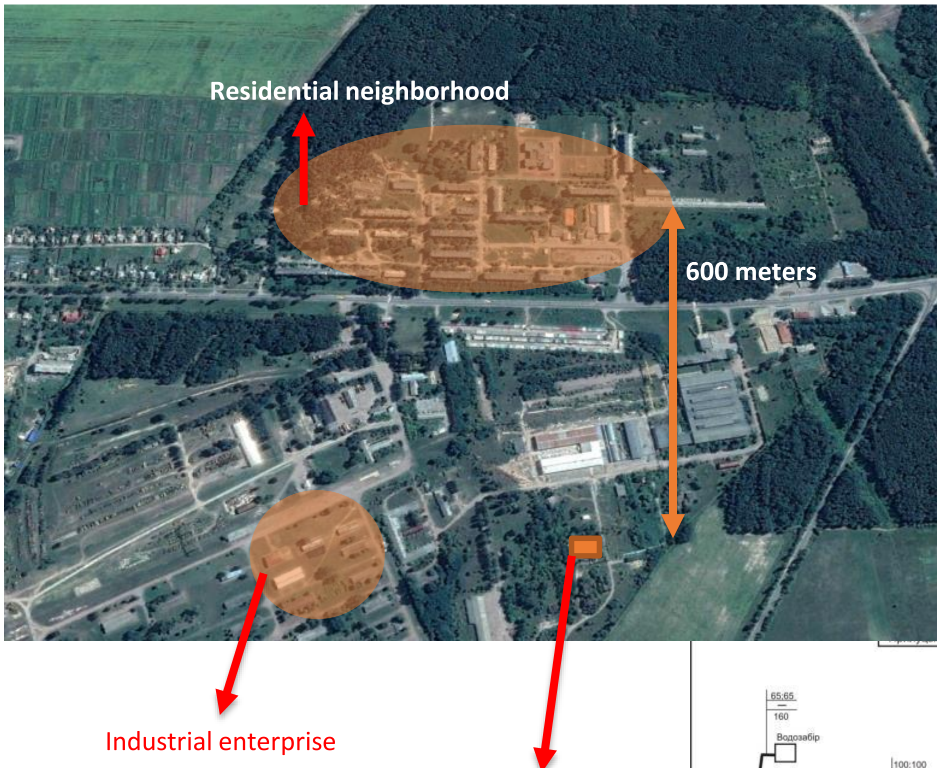


Image 4: Heat supply scheme for Kotsubynskoho Boiler house

BACKGROUND AND PROBLEM DEFINITION



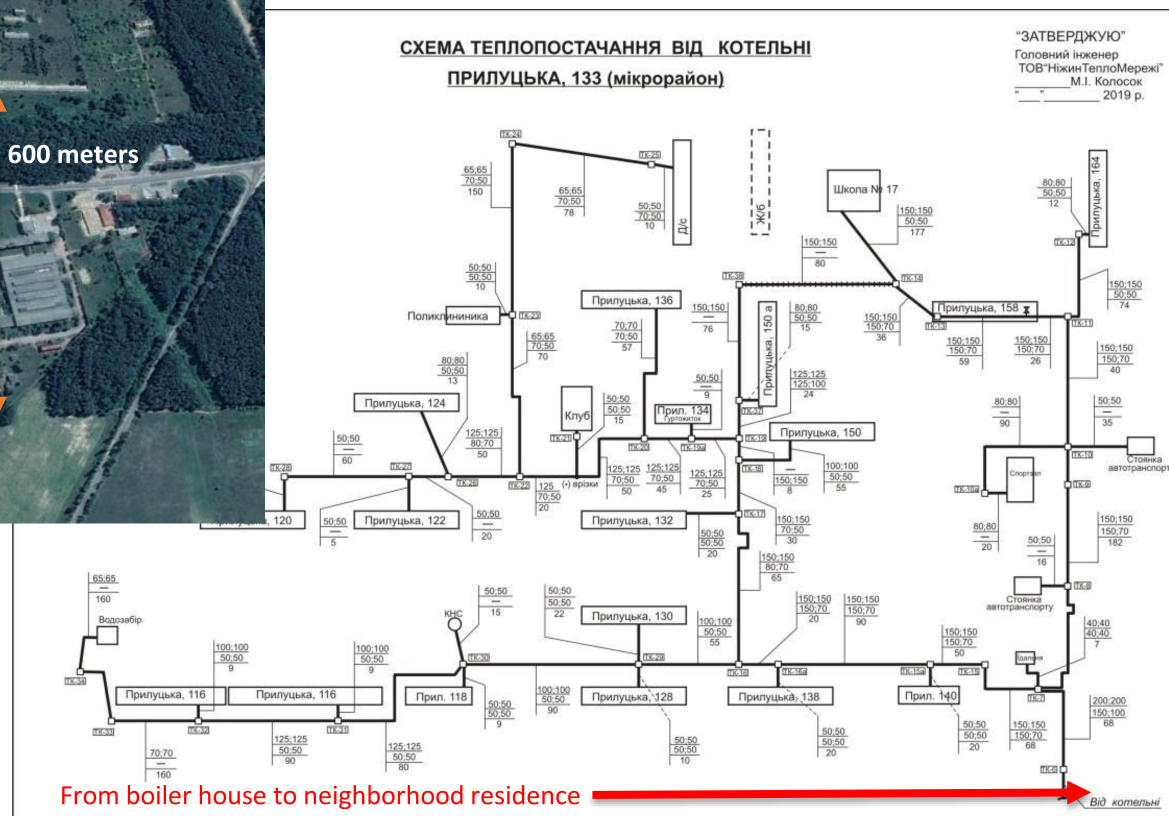


Image 5: Heat supply scheme for Prylutska Boiler house (1)

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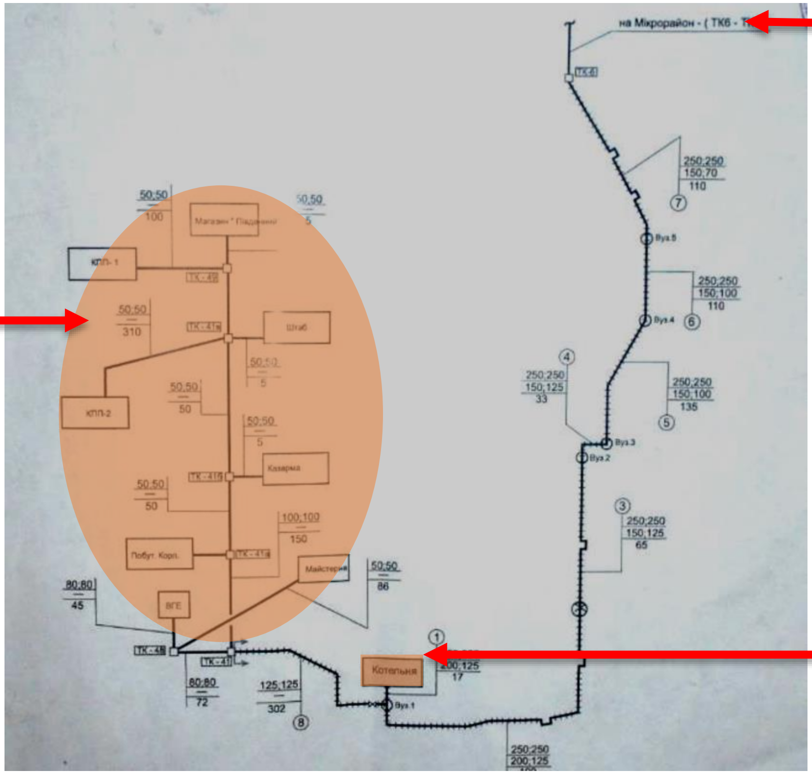
BACKGROUND AND PROBLEM DEFINITION

From boiler house to neighborhood residence

Industrial enterprise



Boiler house

Image 6: Heat supply scheme for Prylutska Boiler house (2)

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AIM AND TACTICS

- The project definition: To study alternatives for renewable heat supply in Nizhyn Ukraine - stable energy supply and effective use of natural resources.
- The possibilities of converting the DH supply system using different sources of energy are to be estimated

The following scenarios are calculated and compared:

1. **Reference:** Operation with the current centralized heat supply, based on natural gas
2. **Scenario 1:** Combination of heat pumps and current gas boilers: Establishment of centralized renewable energy production with heat pumps to cover the base load. Supplementary use of the current production units to cover the peak load.
3. **Scenario 2:** Combination of heat pumps and biomass boilers: Establishment of centralized renewable energy production with heat pumps to cover the base load and the peak load.

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AIM AND TACTICS

In case if sustainable development and reduction of dependence on natural gas availability and prices are considered as main goals of the study, the possibility of replacing old and damaged pipelines to modern pre-insulated pipes should also be considered.

Such solution could significantly reduce costs of heat production and heat loss in the future, making the whole system more efficient and sustainable.

Using waste heat from local enterprises should be also considered as an option and to be investigated additionally.

METHODOLOGY

The capital costs are calculated by accounting for the withdrawal of an annuity loan at a certain annual level of interest. Annuity means that a loan which is taken is paid back in equal amounts over the agreed loan period. The capital costs for the project scenario are calculated with a 20-year annuity loan for the investment, with a nominal interest rate of 5 %. The economic calculation also includes the option of receiving a grant payment, covering a share of the investment costs for the project.

Once both the operation and capital costs are determined, the business-economy of the project scenario in comparison to the reference is assessed. The economic calculation compares the operation expenses in the scenarios and estimates the operation savings when comparing the project scenario to the reference. Afterwards, the capital costs, incurred from the investments made in the project scenario, are subtracted from the operation savings.
A calculation of the net savings (operation savings – capital costs) in the project scenario, compared to the reference, is then carried out. A sum of the operation and capital costs for each scenario divided by the total heat demand then yields the heat production price in each scenario. Both the net savings and the heat production price in the scenarios are computed and compared, with the purpose of determining whether there is an improvement compared to the reference scenario.

The key parameters characterising the project scenario as an improvement over the reference, are positive net savings and a decrease in the heat production price. If the project scenario yields net savings and decreases the heat production price compared to the reference, it is considered to be feasible for implementation

RESULTS

A business-economic calculation for all scenarios is carried out. The calculation of the economic consequences is made by comparing the annual costs for heat production in the reference and the alternative scenario.

The end-result is a comparison of the calculations, outlining the implications that the alternative has from economic and technical standpoint, in comparison to the reference.

First, an economic assessment of the current situation is made.
Operation expenses for centralized heat supply are calculated considering the energy system as it is.

Operation expenses for each scenario are calculated in the energy system modelling tool energyPRO [1].
The electricity costs for operating the heat pumps and electric boilers as well as gas consumption are calculated based on data provided by the partner.

[1] https://www.emd-international.com/energypro/

RESULTS

As shown in Figure 1, in the reference scenario the heat supply is solely provided by natural gas-based central heating. In the project scenario 1 the consumption of natural gas is mostly replaced by heating provided by individual heat pumps together with electric boilers. And in project scenario 2 the consumption of natural gas is completely replaced by heating provided by individual heat pumps together with biomass boilers.

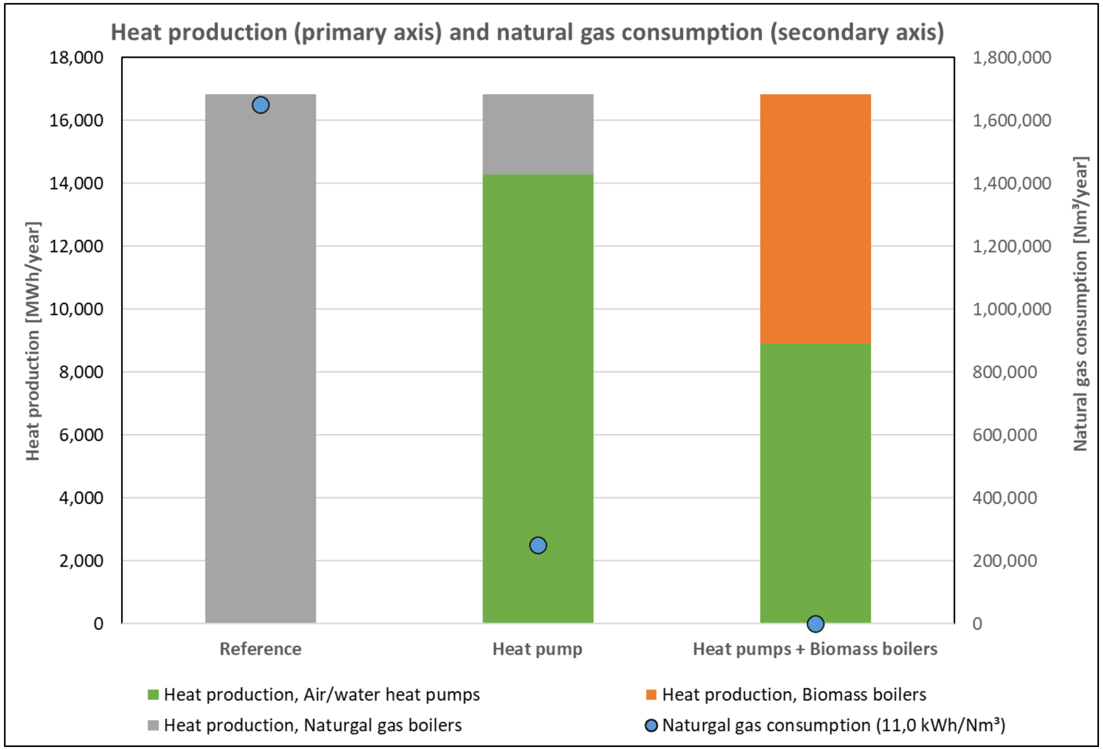

Figure 1: Heat production and natural gas consumption for the two scenarios.

RESULTS

Figure 2 shows positive Net savings in case of high prices for natural gas, equivalent to highest price given by Naftogaz Trading Gas Supply Company LLC “for other needs”. In 2 other cases where prices for gas are at current leve for energy producers (reference) and gas prices assumed to be at level of prices for budgetary institutions (sensitivity analysis) Net savings are negative.

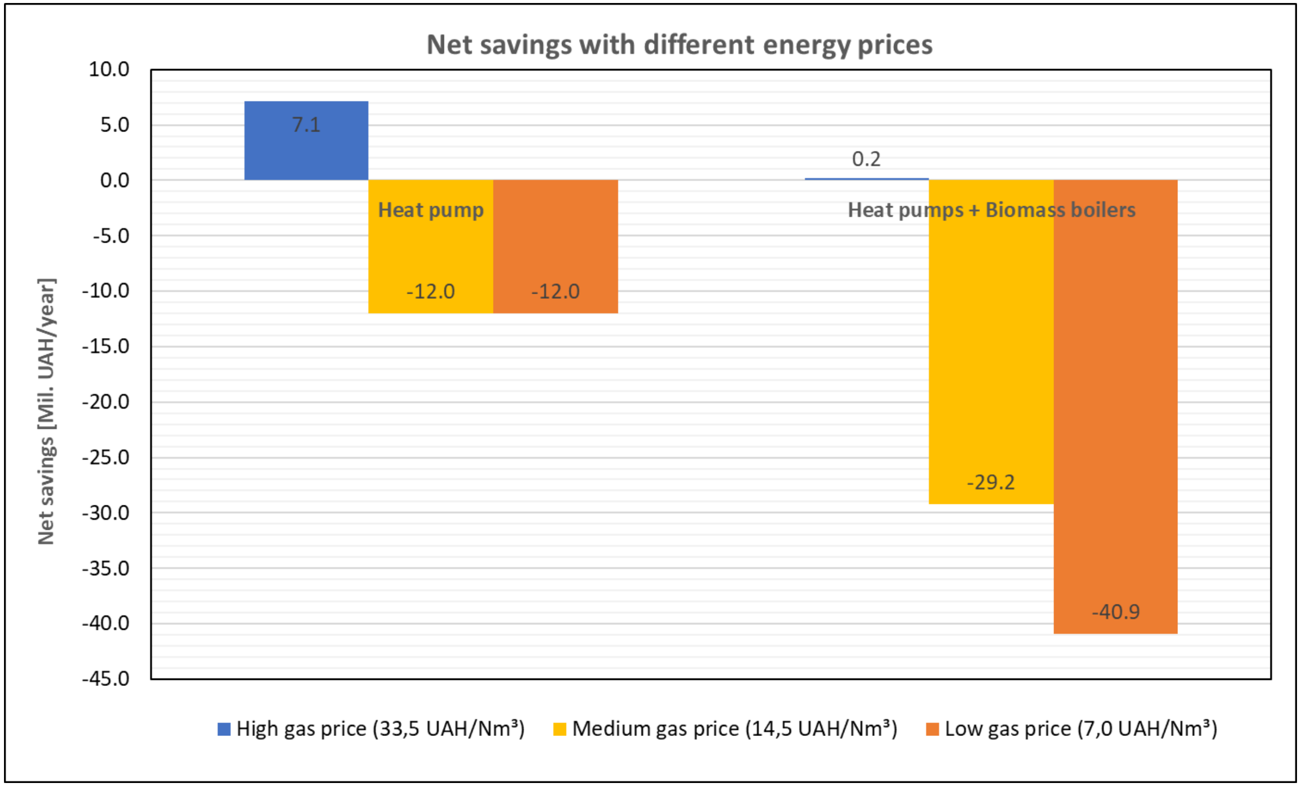

Figure 2: Net savings with different energy prices.

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RESULTS

As seen in Table 2, it is not economically feasible to establish renewable heat supply at 4 chosen boiler houses if gas prices remain at the same level without receiving a grant or other type of public financing. This is due to the fact that the overall capital costs in the project scenario are larger than the operation savings compared to the reference scenario, resulting in a cost increase significantly compared to the reference.
Thereby, alternatives for financing the project need to be investigated, to ensure that it is economically feasible.

Low gas price **Electricity price 5.241 UAH/MWh$_{el}$** **Natural gas price 7,0 UAH/Nm³** **Biomass price 6.000 UAH/ton**		**0** **Nizhyn** **Reference**	**1** **Nizhyn** **Heat pumps**	**2** **Nizhyn** **Heat pumps +** **biomass boilers**
Investment, Air/water heat pumps	UAH	0	144,800,000	144,800,000
Investment, Biomass boilers	UAH	0	0	158,500,000
Investment, District heating network	UAH	35,400,000	35,400,000	35,400,000
Additional investments	UAH	40,610,000	45,450,000	21,140,000
Total investment costs*	**UAH**	**76,010,000**	**225,650,000**	**359,840,000**
Grant received	**%**	**0%**	**0%**	**0%**
Total annual capital expenses	**UAH/year**	**6,099,239**	**18,106,740**	**28,874,493**
Annual operation expenses	UAH/year	10,859,230	10,859,230	28,964,244
Annual operation savings over the reference	UAH/year		0	-18,105,014
Simple payback period	year	-	-	-
Annual net savings (operation savings - capital expenses)	**UAH/year**		**-12,007,501**	**-40,880,267**
Heat production price incl. capital expenses	UAH/MWh	1,008	1,721	3,437
Reduction in the heat production price	UAH/MWh	-	-713.5	-2,429.0
**) The loan is calculated as a 20 year annuity loan with a real interest rate of 5,0% per year*				

Table 2: Business economy for the main calculation.

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RESULTS

Sensitivity analysis

An alternative economic assessment of the feasibility of the project scenario is made, where it is assumed that prices for gas are at level of highest price given by Naftogaz Trading Gas Supply Company LLC "for other needs". The results from the alternative calculation are shown in Table 3.

High gas price **Electricity price 5.241 UAH/MWh$_{el}$** **Natural gas price 33,5 UAH/Nm³** **Biomass price 6.000 UAH/ton**		**0** **Nizhyn** **Reference**	**1** **Nizhyn** **Heat pumps**	**2** **Nizhyn** **Heat pumps +** **biomass boilers**
Investment, Air/water heat pumps	UAH	0	144,800,000	144,800,000
Investment, Biomass boilers	UAH	0	0	158,500,000
Investment, District heating network	UAH	35,400,000	35,400,000	35,400,000
Additional investments	UAH	40,610,000	45,450,000	21,140,000
Total investment costs*	**UAH**	**76,010,000**	**225,650,000**	**359,840,000**
Grant received	**%**	**0%**	**0%**	**0%**
Total annual capital expenses	**UAH/year**	**6,099,239**	**18,106,740**	**28,874,493**
Annual operation expenses	UAH/year	51,969,171	32,827,789	28,964,244
Annual operation savings over the reference	UAH/year		19,141,382	23,004,927
Simple payback period	year	-	11.8	15.6
Annual net savings (operation savings - capital expenses)	**UAH/year**		**7,133,881**	**229,674**
Heat production price incl. capital expenses	UAH/MWh	3,450	3,026	3,437
Reduction in the heat production price	UAH/MWh	-	423.9	13.6
**) The loan is calculated as a 20 year annuity loan with a real interest rate of 5,0% per year*				

Table 3: Business economy for the alternative calculation.

It is visible from the table above, that if prices for natural gas are high and set up with no dotation provided by the Government, this will result in net savings of approximately 19 141 382 UAH/year for scenario1 and 23 004 927 UAH/year for scenario 2 compared to the refence scenario, which is equal to the reduction in operation costs for the project compared to the reference.

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CONCLUSION

The calculations presented in Table 2 and Table 3 clearly show that the establishment of decentralized heat supply with heat pumps and electric boilers (scenario 1) and heat pumps and biomass boilers (scenario 2) at the boiler houses would not be feasible from a business-economic perspective in case if all prices for energy sources are kept at the present level. This means that there would be a necessity for financial support from the state for the project to become attractive for a possible investor.

In case of converting to RE, combination of heat pumps and biomass boilers shows better results than combination of heat pumps and electric boilers.

Nevertheless, in case if the main purpose is to renovate the entire district heating system, decrease dependence on fossil fuels and their price fluctuation, sustainable development of the system in general it is reasonable to consider converting to RE

It can be concluded that obtaining a grant payment on the investment is of paramount importance for the realization of the project.

All-in-all, the results from this report cannot be directly used for initiating the project, since there are still uncertainties to be clarified. The results from this report are to be used as an indication of the limitations and possibilities of the current system in System. Following further investigation and clarifications, a more detailed and exact assessment should be made.

DISCUSSION?

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