Market uptake of small modular renewable district heating and cooling grids for communities

Project No: 691679

Feasibility Check of a small modular renewable heating and cooling grid in Zajcev Rid, Karposh

Karposh (Macedonia)

District heating in Zajcev Rid, Karposh

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CoolHeating website: www.coolheating.eu

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1 Introduction

The heating and cooling demand in Europe accounts for around half of the EU's final energy consumption. Renewable energy policies often mainly focus on the electricity market, whereas policies for renewable heating and cooling are usually much weaker and less discussed in the overall energy debate. Therefore, it is important to support and promote renewable heating and cooling concepts, the core aim of the CoolHeating project.

The objective of the CoolHeating project, funded by the EU's Horizon2020 programme, is to support the implementation of "small modular renewable heating and cooling grids" for communities in South-Eastern Europe. This is achieved through knowledge transfer and mutual activities of partners in countries where renewable district heating and cooling examples exist (Austria, Denmark, Germany) and in countries which have less development (Croatia, Slovenia, Macedonia, Serbia, Bosnia-Herzegovina). Core activities, besides techno-economical assessments, include measures to stimulate the interest of communities and citizens to set-up renewable district heating systems as well as the capacity building on financing and business models. The outcome is the initiation of new small renewable district heating and cooling grids in five target communities up to the investment stage. These lighthouse projects will have a long-term impact on the development of "small modular renewable heating and cooling grids" at the national levels in the target countries.

For each of the CoolHeating target municipalities one or two potential projects have been identified in which small modular renewable heating and cooling grids could be implemented. For these potential projects, technical concepts and individual business models were elaborated by the projects partners from the target countries in cooperation with experts from Austria, Denmark and Germany.

The current document on "Feasibility Check of a small modular renewable heating and cooling grid in Zajcev Rid, Karposh" presents the results of checking the feasibility of the technical concepts and individual business models of the potential projects. The results are summarized in the executive summaries in English and national language in order to be promoted among decision makers of the target municipalities. Please note this is not a feasibility study (more costly and time-consuming task[1]), and that main purpose of this Feasibility Check is to provide a base for the activities of investment promotion, starting with an information day for attracting the investors, before the investment phase. It is likely that during the direct negotiations in the investment phase the modifications of this Feasibility Check will be needed.

All prices, costs and revenues are without VAT.

[1] Behrens, W., Hawranek, P.M., and Organization, United Nations Industrial Development (1991), Manual for the Preparation of Industrial Feasibility Studies (United Nations Industrial Development Organization).

2 Technology assessment

The technical assessment in Karposh included one potential project in the municipality. For this project, a technical concept was elaborated that includes the heat and cold generation, distribution and use.

The key results of the heat/cold assessment survey (Puksec et al. 2016[2]) shows that 56% of the buildings in the municipality of Karposh are households, 44% apartment buildings, about 39% have outer wall insulation and 30% have insulation on the rooftop. 13% of the buildings have a central heating system and 40% have a district heating system. 37% have individual stoves or electrical heaters in the rooms. About 44% are heating with electricity, 28% with district heating and 25% logwood. 89% of the households are producing their domestic hot water with electricity. 69% of the households have cooling needs.

In the planning and development process of the Municipality of Karposh, the local authorities have acknowledged the high building density in the municipality and are evaluating the possibility to meet the increased housing demand by exploiting the peripheral areas of the municipality. The issue of local air pollution puts an additional burden on the local authorities to provide short term and long term solutions to the problem. That is why the implementation of a small scale renewable district heating/cooling system has been discussed as a possibility for covering the heating and cooling demand. The idea gas gained support from the mayor of Karposh and the representatives from the Council during the discussion phase, undoubtedly showing the level of consent on the issue.

The neighbourhood Zajcev Rid is currently in the planning phase and there are no existing buildings in the area. However, a Detailed Urbanistic Plan (DUP) has been developed for Zajcev Rid. The plan includes residential (225,370 m^2), commercial (533,034 m^2) and public buildings (63,664 m^2).

The **original concept**[3] considered generating heat with 5,000 m^2 flat plate solar thermal collectors, a 55,000 m^3 seasonal storage, a 15 MW_{th} ground water heat pump and a 23 MW_{th} peak load oil boiler. Since the system is only intended to supply space heating and not sanitary hot water, there is no heat demand in the summer time. As a consequence, the stored heat could only be used during the winter heating season. Moreover, the size of the seasonal storage was very large (11m^3 storage per 1m^2 solar thermal collectors), so the feasibility check showed poor economic performance of the project, generally caused by the high investment costs of the large seasonal storage.

The calculations for the new concept within this feasibility check refer to a system **without solar thermal collectors** and also **without a seasonal storage**. The updated concept for the **heat generation** would implement a 15 MW_{th} ground water heat pump and a 23 MW_{th} peak load natural gas boiler, as well as a 100 m^3 thermal buffer storage for the heat pump. The heat pump is operated with electricity from the public grid. The long-term plan is, however, to supply a portion of the electricity with photovoltaics (PV) which could be installed on the rooftops of buildings, if the framework for PV support is in place. It is assumed that households will use electric boilers to cover their sanitary hot water demand. As a result, the grid will be used in the summertime for cooling. The annual simulation of the system was done with EnergyPRO and the heat duration curve is shown in Figure 1.

The **heat generation** concept for Karposh considers a groundwater heat pump, a natural gas peak load boiler and thermal buffer storage.

[2] Pukšec T. et al. (2016) Survey on the energy consumption and attitudes towards renewable heating and cooling in the CoolHeating target communities. – University of Zagreb FSB; CoolHeating Report available at www.coolheating.eu

[3] http://www.coolheating.eu/images/downloads/concepts/Report-D4.4-technical-concept-Karposh.pdf

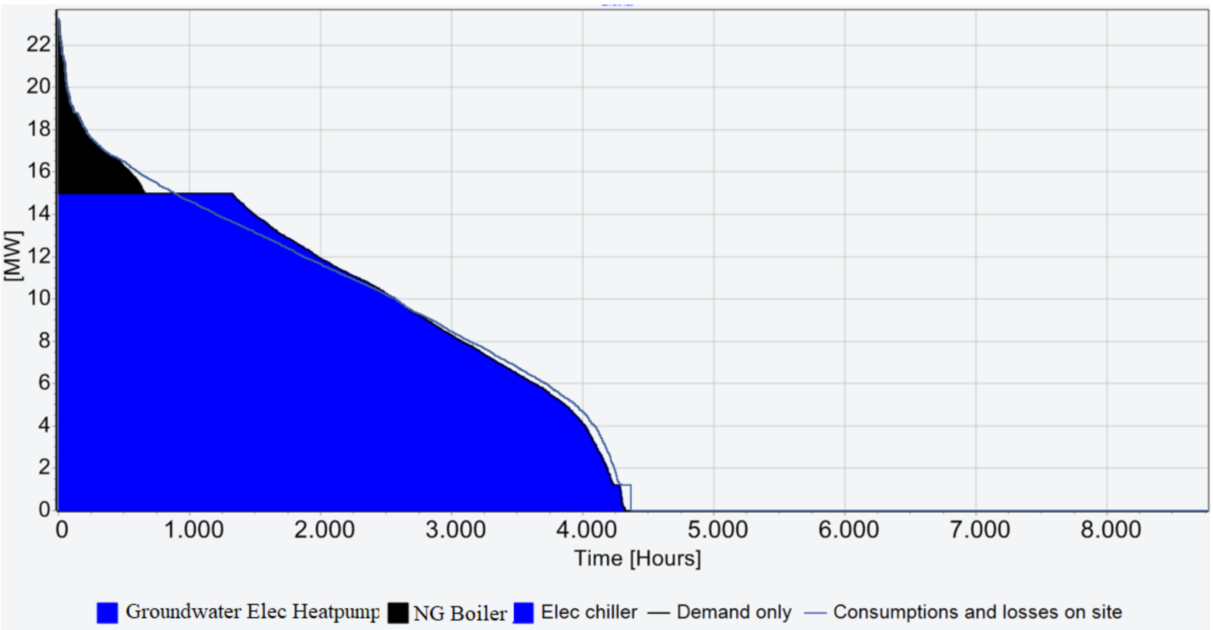


Figure 1: Heat load duration curve, calculated with EnergyPRO

The calculation shows (Table 1) that the groundwater heat pump could cover about 96.5% of the needed heat demand and only 3.5% would be generated by the natural gas boiler. The COP of the heat pump largely affects the electricity consumption and the feasibility of the project. That is why two separate calculations were executed with COP values of 3 and 4, respectively. For a COP of 3 the heat pump would need about 15,391 MWh/a electricity and could reach 3,378 full load hours per year, while for a COP of 4 the electricity consumption of the heat pump would be 11,543 MWh/a. The boiler would need about 159,569 Nm^3 of natural gas per year. The total heat supplied to the DH grid is 47,835 MWh/a.

The size of the heat pump was calculated to cover only a part of the load and heat amount to get higher full load hours and decrease the investment costs.

Table 1: Generation and consumption data

Technology	Heat generation (MWh/a)	Heat generation (%)	Electricity consumption (MWh/a)	Natural gas consumption (Nm^3/a)
Groundwater heat pump	46,174	96.5	15,391/11,543	-
Natural gas boiler	1,668	3.5	-	159,569

**Note: Electricity consumption of 15,391 MWh/a refers to COP = 3; Electricity consumption of 11,543 MWh/a refers to COP = 4.*

The technical challenge would be to get the right amount of groundwater to supply the heat pump, as well as the high power (about 3.75 MW_{el}) of the heat pump. An anticipated risk might be the availability of groundwater.

After the heating season, the grid can be used to supply the customers with **cooling**. Depending on the share of consumers who are interested in cooling with the DHC grid, the following calculation was based on an annual cooling consumption of 9,000 MWh/a. The water cooled by the heat pumps will be used as the energy carrier for this service. The electricity consumption for the heat pumps is about 2,999 MWh/a. It needs to be checked if the heat pump could be used also for cooling in summertime to get a better economic performance.

The estimated length of the **district heating grid** is around 9,500 m (9.5 km pipeline) including house connections, according to the Detailed Urbanistic Plan, shown in Figure 2. Pre-insulated plastic or steel pipes can be used for the different feeders. The grid density is around 4,466 kWh/m per year which is higher than the proposed rule-of-thumb values in Germany, Austria (higher than 900 kWh/m/a) and Denmark.

It is assumed that the flow temperature of the DH system is 60°C and the return temperature is between 35 °C to 40 °C. The annual heat losses of the grid were calculated to be 11.3%, or 5,400 MWh/a.

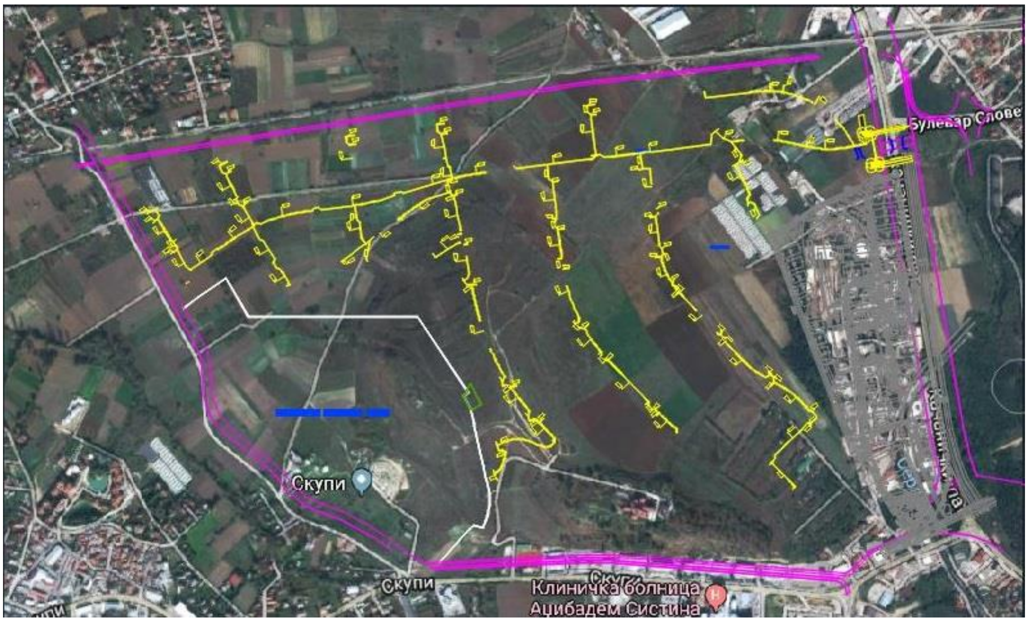


Figure 2: Layout of DH pipes (yellow) in Zajcev Rid

It should be considered that the temperature difference at the heating grid could be about 20 °C while the temperature difference for cooling could be 8 °C. This would result in flows during summer that 2.5 times higher than those in winter, causing higher pressure drops for the pumps. Clearly, the district heating grid is the limiting factor for cooling in summer time. As a consequence, the cooling consumption is limited and only a fixed number of consumers could use this system. This needs to be assessed in detail in further steps.

The load duration curve for the **consumers**, shown in Figure 3, has been obtained from the EnergyPRO software used to evaluate the technical concept. The result shows a peak load of about 23 MW. There is no heat demand in summer time. The total annual heat consumption is estimated to be 42,435 MWh/a. It is planned that the residential, commercial and public buildings could be supplied with about 60°C with a direct connection to the grid. That is why the buildings should be built within these temperature levels. With high grid density and low total energy losses the system shows promising economic indicators.

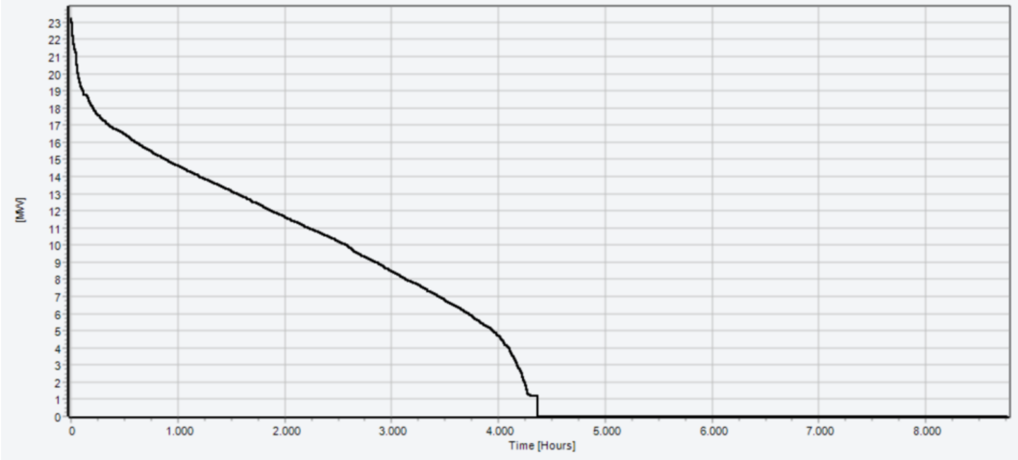


Figure 3: Generated heat load duration curve for the potential consumers

The project's **modularity** is evident both in the supply and demand side of the system. The neighbourhood Zajcev Rid will not be built at once. As new buildings are being constructed, the total demand for heating and cooling will rise. Each increase in demand would thus be met by a corresponding capacity increase in the heat generation system. In total, the system will supply 96.5% of the heating using the renewable local resources through the heat pump and only 3.5% by the natural gas boiler.

3 Business assessment

The business assessment in Zajcev Rid, Karposh included several scenarios showing the possible outcomes of the project development in the municipality. The business model is based on the new technical concept elaborated in this document. On that account, when performing the feasibility check, different variations were tested until a satisfactory balance was achieved between the technical and economic performance of the system.

Current costs and practices

A study issued by the district heating operator BEG in Skopje focuses on the optimal way to cover the heating need of Skopje[4]. Taking into account the techno-economic specification of each solution as well as the environmental impacts, the study shows that a large majority of the city could be covered by the district heating system. Nevertheless, it does not consider the case of Zajcev Rid, because, as of the time being, there is no heat demand in the settlement. The study provides certain specific heating costs of consumers that could be used as reference. For example, one highly opted for solution when it comes to heating is the use logwood. The specific heat price for the case of logwood with a 25% humidity, specific heat of 13,000 kJ/kg, density of 450 kg/m^3 and a logwood price of around 55 EUR/m^3 is calculated. For different efficiencies of the implemented boilers, the unit price of heat is provided in Table 2. The prices for heating do not include additional costs for depreciation, maintenance etc. Currently, many of the biomass boilers used in households are old and inefficient.

[4] http://beg-snabduvanje.com.mk/wp-content/uploads/2017/03/BEG-studija-MFS-MACEF.pdf

Table 2: Heat amount and share of heat generation

Efficiency (%)	50	60	70	80
Unit price of heat (EUR/MWh)	64.10	53.5	46.00	40.00

Another reference value of heat prices can be taken from the annual report[5] of the Energy Regulatory Commission of the Republic of Macedonia. For an apartment with a floor area of 50 m^2, annual heat consumption of 7,500 kWh and an installed capacity of 6.25 kW, the average unit cost of heat supplied by the district heating system in July 2016 was around 45 EUR/MWh.

Since there are currently no buildings in Zajcev Rid that could serve as reference for the costs of consumers and the practices employed for heating and cooling, the results from the survey conducted in Karposh can be used in outlining the status of the heating sector. The type of heating system used in the settlements in Karposh largely depends on the local infrastructure and whether the neighbourhood is dominantly filled by houses or collective apartment buildings. As an example, many dwelling in the communities Karposh 1 – 4 are connected to the existing district heating system, while the residents of Zlokukjani use individual stoves and other technologies. The annual costs of the surveyed dwellings are summarized in Figure 4. It shows that approximately 50% of households have annual costs for heating larger than 500 EUR.

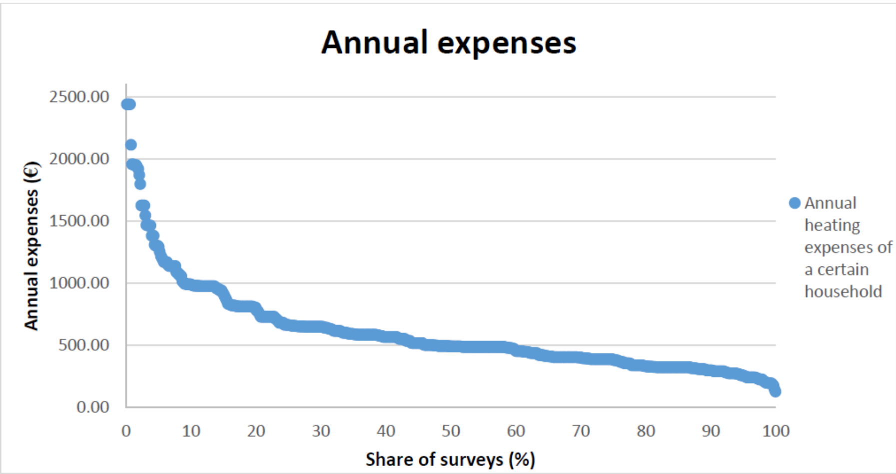


Figure 4: Sorted annual expenses of households in the Municipality of Karposh

Initial investment and operating costs of the project

The investment for the district heating in Zajcev Rid, Karposh is equal to **5,407,000 EUR**. It includes the costs for the equipment/machinery, building and construction works and project and investment documentation. A detailed overview of the investments is provided in the business model report for Karposh. The equipment/machinery costs represent the highest share, around 89% of the total investment costs. They include the pipes for the heat distribution network, heat pumps, natural gas boiler, storage unit, heat exchangers and stations etc. The municipality is obligated to develop the infrastructure for the settlement, so the land costs were assumed to be zero. The costs for building and construction works cover the wells for the

[5] http://www.erc.org.mk/odluki/2017.03.30_Godisen%20izvestaj%20za%20rabota%20na%20Regulatornata%20komisija%20za%20energetika%20na%20RM%20za%202016%20godina-final.pdf

groundwater heat pumps, the construction work for the network, the connection to the consumers and other unforeseen costs. This category represents about 10% of the total investment costs. At last, the project and investment documentation are assumed to cost around 20,000 EUR.

The heat pumps will generate 46,174 MWh of heat per year and will cover a cooling demand of 9,000 MWh/a. Because electricity plays such a big role in the operating costs, its price significantly affects the feasibility of the project. In the analysis the price of electricity was considered to be 72 EUR/MWh, assuming a 40 EUR/MWh wholesale price of electricity and an additional 32 EUR/MWh costs for transmission and distribution grid tariffs and electricity market operation. The price of natural gas in the analysis is 0.325 EUR/Nm^3, an estimated average of the retail price of natural gas of MAKPETROL PROM-GAS for the period of January 2014 to November 2016. In order to make the analysis as realistic as possible, it was also assumed that only 60% of all consumers will be connected to the system in the initial year and that the demand will increase with a 4% yearly rate. Therefore, the costs for electricity and natural gas follow the same pattern. The operation and maintenance costs for the system are equal to 2% of the total investment, i.e. 107,740 EUR in the first year and increase at a rate of 0.5%. The salaries of five employees have also been considered since there is the need of people that will run and operate the system, deal with technical problems on site and take care of the administrative and financial documentation.

It should be noted that the calculations internalize a margin of pessimism as it is assumed that all of the investments are going to occur in the first year and the revenues will linearly increase with time. This aspect takes the modularity of the project into account.

Price for heating and cooling

In order to provide transparent results of the different outcomes of the project's development through time, three different scenarios were analysed. The scenarios explore how different COP values of the heat pump and how the rate of consumer connection affect the project. Besides depending on the price of electricity, the feasibility on the project also largely depends on the COP of the heap pumps. A lower COP would imply a higher electricity consumption and higher expenses. If the heat pumps are more efficient, the electricity consumption would be lower, and the costs for the system operation would drop as well. In the calculations, equal values for the heating and cooling prices were considered.

In the first scenario, the COP of the heat pumps is equal to 3 and it is assumed that only 60% of the consumers will be connected in the first year of the project. The electricity consumption for supplying the total heat demand in this case is equal to 15,391 MWh/a while the electricity consumption for the cooling demand is equal to 3,000 MWh/a. The **breakeven price** of energy sold for heating and cooling, assuming an equal price for both, is 39 EUR/MWh. In order to obtain an internal rate of return (IRR) of 10.69% and a payback period of 11 years **the price for heating and cooling** should be equal to **50 EUR/MWh**.

In the second scenario, the COP is of the heat pump is equal to 4 and the consumption follows the same trend as in the previous scenario. Experience in Karposh has shown that a COP of 4 is highly possible. The electricity consumption for supplying the total heat demand is about 11,543 MWh/a, while electricity consumed for the cooling demand remains unchanged (the COP for cooling is 3 in this case as well). The lower electricity consumption reduces the operating expenses for electricity. As a result, the **breakeven price** is lowered to 34 EUR/MWh. In order to have a payback of around **11 years** and an internal rate of return (IRR) of 11%, the **price for heating and cooling** should be equal to **45 EUR/MWh**.

The third scenario included the most optimistic assumptions and sets a boundary case – COP of 4 and all of the consumers connecting to the system in the first year of the project. These assumptions result in low operating costs of the system and high revenues. The **breakeven price** is 27 EUR/MWh. For a **price for the heating and cooling** of **40 EUR/MWh** an IRR of 14.12% is obtained and the payback period is **8.11 years**. This price makes the system highly competitive with the other available alternatives and would be a significant motivation for consumers to connect. It is clear that connecting as many consumers as possible early on positively affects the profitability of the project.

Financing options

In order to finance the investments for the project in the neighborhood Zajcev Rid in Karposh, the municipality could use the revenues from the communal taxes from investors that have decided to initiate construction. The total floor area of all buildings is around 822,070 m^2. An estimate of these revenues, assuming a 40 EUR/m^2 equals to around 32.8 million euros. Hence, the total investment of the project is less than 17% of the revenues obtained by this mechanism. In the analysis it was assumed that the municipality would be able to cover the whole investment in this manner. The system could then be operated by a **public utility** owned by the municipality or the City of Skopje. The public utility can form a **public-private partnership** with companies responsible for the implementation of the system. There are financing models available from the Macedonian Bank for Development and Promotion, credits for investments in SMEs and other priority projects from the European Investment Bank, as well as programs such as WebGEFF, Green for Growth Fund etc.

Licenses and permits required

At the time of writing of this report, a draft text for the new Energy Law in the Republic of Macedonia has been proposed and made public on 30.11.2017. The conclusions regarding licenses and permits in this document are thus based on the content of that draft.

Since the total installed capacity of the system is lower than 80 MW, one entity will be able to have licenses for generation, distribution and supply of heat. The **regulated producer** of heat obtains a license that is issued by the Energy Regulatory Commission which announces a public call. The regulated producers should:

- own or have the right to use heat generating facilities with a capacity higher than two thirds of the total capacity of the connected consumers in the year preceding the public call;
- be able to maintain the temperature levels of the heat generation facilities and the necessary pressure according to the grid code for heat distribution;
- provide evidence of the financial capability for the purchase of the necessary fuel for the generation of heat;
- have organizational structure and experts that enable a reliable, safe and uninterrupted generation of heat with a predefined quality.

The Energy Regulatory Commission defines the compensation of the regulated producer of heat based on the fixed and variable costs, as well as a reasonable return of capital. The compensation consists of two parts: a fee for providing system services and system reserve and a regulated price for he produced heat.

To be able to initiate the construction of the heat generating facilities a **building permit** should be obtained. The decision for the development of new or expansion of existing heat generating facilities is made by the council of the Municipality. The criteria for obtaining this authorization are secure supply, safety of the system, protection of the public health and security, protection of the environment, energy efficiency, the type of primary energy used, the contribution of the facility to the reduction emissions etc.

The construction of new heat distribution systems on the territory of local self-governments is carried out on the basis of an agreement for the establishment of a **public-private partnership** awarded by the council of the local self-government or by the **public enterprises and other legal entities** established for this purpose by the local self-government.

Socio-environmental cost/benefits

The district heating/cooling system in Zajcev Rid will provide high comfort to the consumers supplied with heating and cooling energy. More importantly, its development will serve as a lighthouse example of a system based on renewable energy sources. According Annex VII of the Directive 2009/28/EC on the promotion of the use of energy from renewable source, the energy generated by electrically driven heat pumps with a seasonal performance factor (SPF) of at least 2.5 is considered renewable[6].

As first of its kind, the project will overcome many of the administrative, technical and regulatory barriers on a national and local level, thus paving the way for other project to come. The direct involvement of the municipality in the project development will strengthen the local technical and administrative capacities. Moreover, by disseminating the experience from Karposh the project can stimulate the market uptake of small district heating and cooling system in other communities.

By implementing heat pumps for the generation of heat, there are no local emissions of particulate matter in the neighborhood. The system has other environmental benefits as well. For instance, the implementation of the proposed DHC system instead of a system based on oil would result in total CO_2-eq emission reductions of 876 tons per year. This value has been calculated assuming the default IPCC conversion factors provided in Table 3 and global warming potentials of 21 and 310 for CH_4 and N_2O, respectively. As a result of the dominantly lignite based electricity generation in Macedonia, the grid factor is relatively high. A value of 0.9 tCO_2/MWh was assumed in the calculations[7]. However, the integration of RES in the electricity mix may additionally reduce this value in the future.

Table 3: Heat amount and share of heat generation

	kgCO_2/TJ	kgCH4/TJ	kgN2O/TJ
Oil	78,467	3.00	0.60
Natural gas	55,066	1.00	0.19

In summary, the realization of this project will result in the following direct and indirect benefits on a local level:

- reduction of CO_2 emissions by 876 tons annually;
- reduction of emissions of particulate matter in comparison with using old biomass/oil boilers;
- employment of 3-5 people for the operation of the system;
- supporting the local economy by involving local companies in the development of the project;
- local capacity building in the area of renewable DHC systems.

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0114&from=EN
[7] http://www.ebrd.com/downloads/about/sustainability/cef.pdf

4 Executive summary for policy makers (in English)

Recent national and local experiences have shed light on the impact of the heating sector on the local air pollution. Skopje in particular is one of the most polluted cities in Europe, with PM2.5 and PM10 concentrations ranking high above the allowed maximum limits. One of the largest contributors to this cause is the heating sector with the use of inefficient technologies and the combustion of fossil fuels, fuel wood, as well as some toxic materials. The poor air quality is considered to cause most of the common diseases in Skopje and stresses the need for comprehensive national and local strategies for resolving the issue. However, the poor air quality is only aspect of the issue. As an aspiring EU country, the Republic of Macedonia must harmonize its legislation with the European acquis. One area that requires a significant effort for this to be achieved is related to the heating and cooling sector.

Heating and cooling represent a large share of the total energy consumption in communities. Although the settlement Zajcev Rid in Karposh, a municipality in Macedonia’s capital Skopje, is still in the planning phase, it will be no exception once it is built. The overarching vision for developing the neighborhood as an exemplary energy efficient community that uses renewable energy sources cannot be achieved without considering sustainable ways to supply the heating and cooling demand in buildings.

With that in mind, this document elaborates a feasibility check of a renewable district heating and cooling system for Zajcev Rid in Karposh. It explores different scenarios regarding the development of the project. More specifically, it provides and overview on how the efficiency of the used technologies and the rate of consumers connecting to the system affect its feasibility. The concept for the heat generation includes a 15 MW_{th} groundwater heat pump and a 23 MW_{th} peak load natural gas boiler, as well as a 100 m^3 thermal buffer storage for the heat pump. The technical challenge would be to get the right amount of groundwater to supply the heat pump. To make sure that the local resources are sufficient, an in-depth study has to be conducted. This is crucial for the feasibility of the project. In addition to the heat demand, part of the connected consumers could use the system in the summer time to meet their cooling demand. Hence, the system will supply heating and cooling to residential, commercial and public consumers with a total floor area of 822,070 m^2. Experiences can be drawn from similar systems, such as the district heating system in Braedstrup, Denmark, which includes a heat pump, an electric boiler, solar thermal collectors and a thermal storage unit.

Three scenarios were explored, each of them with a payback period lower than 11 years. Assuming that 60% of all consumers will connect to the system in the first year and that the annual rate of increase in consumption will be 4%, consumers will be charged 50 EUR/MWh for heating and cooling in order for it to be possible to pay off the project in 11 years. If more efficient technologies are employed, this price could drop to around 45 EUR/MWh, making it more competitive with other alternatives. The rate at which consumers connect to the system highly affects the economic parameters of the project. Therefore, if all consumers are connected in the first year of its implementation, consumers can be charged only 40 EUR/MWh and the project would still have a payback period of around 8 years.

The total investment for the project is estimated to be around 5,407,000 EUR. To cover the investment costs, the municipality could use a portion of the revenues from the communal taxes payed by investors. This assumption has been considered in the feasibility check. It is estimated that the investments of the project can be covered by less than a 17% of the total revenues from communal taxes. There are different possibilities when it comes to the business model for the ownership and operation of the system. For this project, a public utility formed either by the municipality of Karposh or in collaboration with the City of Skopje can be in charge of the system. The public utility will contract a public-private partnership with companies (manufacturers/installers of equipment etc.), thus making use of the expertise and the private capital of the private sector.

The development of this district heating and cooling project will serve as a lighthouse example of a system based on renewable energy sources. Being a first project of its kind, it would overcome many of the administrative, technical and regulatory barriers on a national and local level, thus paving the way for other project to come. The direct involvement of the municipality in the development of the project will contribute in the strengthening of the local technical and administrative capacities. Moreover, the project realization could provide a number of other benefits such as the reduction of local air pollution, employment of staff and supporting the local economy.

5 Executive summary for policy makers (in Macedonian)

Од година во година проблемот со локалното загадување во зимскиот период во Република Македонија станува сè поизразен. За ова сведочат и искуствата во Скопје каде концентрациите на PM2.5 и PM10 честички неколкукратно ги надминуваат максимално дозволените граници. Примената на неефикасни технологии за согорување на фосилни горива и огревно дрво, но и согорувањето на други материјали значително придонесуваат за влошување на и онака алармантната состојба. Дополнително загрижува и тоа што најголем дел од респираторните заболувања кај граѓаните се должат токму на локалното загадување. Очигледно е дека се неопходни јасни национални и локални стратегии за справување со овој проблем, но оваа горлива тема открива само дел од крупната слика. Како земја со европски аспирации, Република Македонија мора да го хармонизира своето законодавство со европското *acquis*. Тоа подразбира и усогласување на законската рамка што го регулира секторот за греење и ладење со европските регулативи и директиви.

Најголем дел од енергија што ја трошат домаќинствата се користи за греење и ладење. Според тоа, може да се очекува дека населбата Зајчев Рид во Карпош нема да биде исклучок од овој тренд. Целокупната визија за развој на Зајчев Рид како енергетски ефикасна населба која го задоволува својот конзум од обновливи извори на енергија ќе стане реалност само тогаш кога ќе се обезбеди одржлив систем за греење и ладење на објектите.

Имајќи го тоа предвид, анализите во овој документ служат за проверка на изводливоста на систем за централно греење и ладење базиран на обновливи извори на енергија во Зајчев Рид, Карпош. Во документот се разгледуваат последиците од различни развојни сценарија, т.е. се анализира како ефикасноста на користените технологии и етапноста со која потрошувачите се приклучуваат на системот влијаат врз неговата изводливост. Системот за производство на топлина се состои од 15 MW_{th} топлински пумпи, 23 MW_{th} котел на природен гас и топлински резервоар од 100 m^3. За да се елиминираат однапред потенцијални проблеми, неопходно е да се направи детална анализа на расположливоста на подземни води потребни за работа на топлинските пумпи. Покрај топлинскиот конзум, дел од потрошувачите би можеле да го користат системот и за ладење во текот на летниот период. Така, системот би обезбедил греење и ладење на станбени, комерцијални и јавни објекти со вкупна површина од 822,070 m^2. Поуки за планирањето и работењето на системот може да се влечат од други слични системи во Европа. Таков е, на пример, системот за централно греење во Бредструп, Данска, во кој се користат топлински пумпи, електричен котел, соларни термални колектори и сезонски резервоар на топла вода.

Во секое од трите анализирани сценарија времето за коешто се враќаат инвестираните средства е пократко од 11 години. Ако 60% од потрошувачите се приклучат во првата година, а конзумот расте со 4% годишно, крајната цена за греење и ладење (без ДДВ) при која системот се исплаќа за приближно 11 години е 50 EUR/MWh. Примената на поефикасни технологии (топлински пумпи со COP = 4) ја намалува оваа цена на 40 EUR/MWh, па системот станува поконкурентен во однос на претходното сценарио. Етапноста на приклучување на потрошувачите има изразено влијание врз исплатливоста и конкурентноста на системот. Така, ако сите потрошувачи се приклучат во првата година, системот би се исплатил за околу од 8 години, дури и ако цената за греење и ладење изнесува само 40 EUR/MWh.

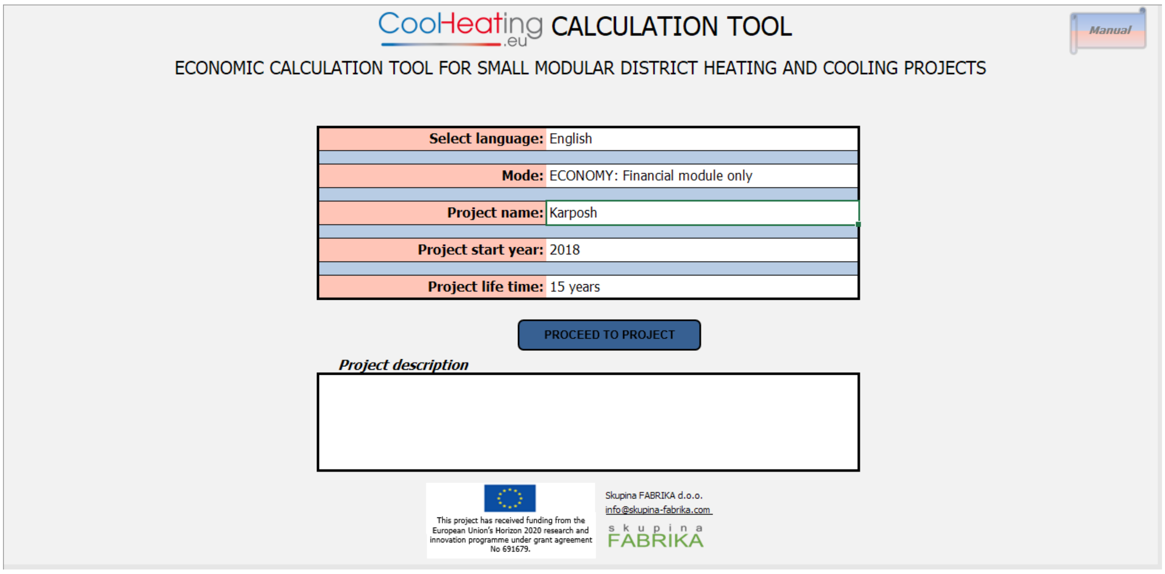
Се проценува дека вкупните инвестиции за проектот ќе бидат околу 5.407.000 евра. За да ги покрие овие трошоци, општината може да искористи дел од приходите од комуналии, како што е претпоставено во пресметките на овој документ. Се проценува дека инвестициските трошоци за целиот систем може да се покријат со помалку од 17% од вкупните приходи на општината од комуналии. Сопственоста на системот, неговото управување и обврските на сите правни лица зависат од усвоениот бизнис модел. Во конкретниов случај, Општина Карпош може да формира општинско јавно претпријатие или јавно претпријатие во соработка со Град Скопје кои би било одговорно за системот.

Јавното претпријатие ќе склучи договор за јавно-приватно партнерство со компанија од приватниот сектор (производител на опрема/изведувач итн.), со што ќе обезбеди разумно искористување на административните, техничките и финансиските капацитети на договорните страни.

Развојот на овој систем ќе служи како светол пример за користење на обновливи извори на енергија во секторот за греење и ладење. Низ процесот на негова имплементација ќе се надминат многу технички и регулаторни бариери на национално и локално ниво. Директната вклученост на општината во развојниот процес, пак, ќе придонесе за јакнење на нејзините технички и административни капацитети. Како резултат на тоа, проектот ќе биде водилка која дефинира јасна патека за слични проекти во иднина.

6 Appendix

6.1 Simulations from Economic calculation tool for small modular district heating and cooling projects



15 year project life-time period is considered for all calculations and for the simulation period.

7% discount rate was employed in the simulations of the economic performance of the project. This is the discount rate often used in the analysis of national strategies and action plans.

The tables bellow providec the detailed economic calculations for the optimistic scenario (COP of 4 and consumers connected in the first year) and the project summary tables for all of the other scenarios as well.

Scenario: Consumers connected in first year, heat pump COP = 4

Projected investment cost in €	Value	Share %
1. Buildings and construction works	541,000	10.0%
2. Plot	0	0.0%
3. Equipment/Machinery	4,846,000	89.6%
A. PROPERTY, PLANT AND EQUIPMENT	**5,387,000**	**99.6%**
B. PROJECT AND INVESTMENT DOCUMENTATION	**20,000**	**0.4%**
C. INTANGIBLE ASSETS	**0**	**0.0%**
D. INVESTMENT COST (A+B+C)	**5,407,000**	**100.0%**
E. INITIAL WORKING CAPITAL	**0**	**0.0%**
F. TOTAL INVESTMENT COST (D+E)	**5,407,000**	**100.0%**

Sources of investment cost financing in €	Value	Share %
A. PRIVATE EQUITY	**5,407,000**	**100.0%**
B. BANK LOANS	**0**	**0.0%**
C. CONNECTION FEES	**0**	**0.0%**
D. INVESTMENT SUBSIDIES	**0**	**0.0%**
E. TOTAL FINANCING (A+B+C+D)	**5,407,000**	**100.0%**

Source of revenue in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. ELECTRICITY REVENUES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. HEAT REVENUES	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400
3. OPERATING SUBSIDIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A. GROSS OPERATING REVENUES	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**
1. INVESTMENT SUBSIDIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. FINANCIAL REVENUES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. OTHER REVENUES	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100
B. OTHER SOURCES OF REVENUES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**100**	**100**	**100**	**100**	**100**
C. TOTAL REVENUES (A + B)	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,400**	**2,057,500**	**2,057,500**	**2,057,500**	**2,057,500**	**2,057,500**

Cost type in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Energy source costs	882,953	891,523	900,178	908,917	917,743	926,656	935,657	944,747	953,925	963,195	972,556	982,009	991,555	1,001,195	1,010,930
2. Operation and maintainance costs	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740
A. TOTAL OPERATING COSTS (1+2)	**990,693**	**999,263**	**1,007,918**	**1,016,657**	**1,025,483**	**1,034,396**	**1,043,397**	**1,052,487**	**1,061,665**	**1,070,935**	**1,080,296**	**1,089,749**	**1,099,295**	**1,108,935**	**1,118,670**
1. Cost of management, insurance and lease	10,774	11,043	11,319	11,602	11,892	12,190	12,495	12,807	13,127	13,455	13,792	14,136	14,490	14,852	15,223
2. Cost of promotional activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Cost of other services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. TOTAL COSTS OF SERVICES (1+2+3)	**10,774**	**11,043**	**11,319**	**11,602**	**11,892**	**12,190**	**12,495**	**12,807**	**13,127**	**13,455**	**13,792**	**14,136**	**14,490**	**14,852**	**15,223**
C. COSTS OF LABOUR	**42,500**	**42,606**	**42,713**	**42,820**	**42,927**	**43,034**	**43,141**	**43,249**	**43,357**	**43,466**	**43,575**	**43,683**	**43,793**	**43,902**	**44,012**
D. DEPRECIATION AND AMORTIZATION COSTS	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**
E. FINANCIAL COSTS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
F. OTHER EXPENSES AND LOSSES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
G. INCOME TAXES	**74,308**	**73,414**	**72,510**	**71,597**	**70,675**	**69,743**	**68,802**	**67,851**	**66,890**	**65,919**	**64,949**	**63,958**	**62,957**	**61,946**	**60,924**
H. TOTAL COSTS (A+B+C+D+E+F+G)	**1,388,625**	**1,396,676**	**1,404,810**	**1,413,026**	**1,421,327**	**1,429,713**	**1,438,185**	**1,446,743**	**1,455,390**	**1,464,125**	**1,472,961**	**1,481,877**	**1,490,885**	**1,499,985**	**1,509,180**

Inventories in stock and resources needed in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. Average days of inventory	60.0														
B. Inventory turnover ratio	6.08														
C. INVENTORIES IN STOCK ON 31ST OF DECEMBER	26,235	26,278	26,321	26,364	26,407	26,450	26,494	26,538	26,582	26,626	26,671	26,716	26,761	26,806	26,852
D. RESOURCES NEEDED TO FINANCE INVENTORIES	4,313	4,320	4,327	4,334	4,341	4,348	4,355	4,362	4,370	4,377	4,384	4,392	4,399	4,406	4,414

Accounts receivable and resources needed in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. Accounts receivable collection period	30.0														
B. Accounts receivable turnover ratio	12.17														
C. ACCOUNTS RECEIVABLE ON 31ST OF DECEMBER	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101
D. RESOURCES NEEDED TO FINANCE THE ACCOUNTS RECEIVABLE	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899
E. LONG-TERM ACCOUNTS RECEIVABLE ON 31ST OF DECEMBER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annual depreciation rates in % Calculation of planned depreciation	
A. INTANGIBLE ASSETS	10.0%
B. PROPERTY, PLANT AND EQUIPMENT	
1. Buildings and constructions	5.0%
2. Equipment, plant, vehicles, mechanization	5.0%

Depreciation cost in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. INTANGIBLE ASSETS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1. Buildings and constructions	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050
2. Equipment, plant, vehicles, mechanization	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300
B. TOTAL PROPERTY, PLANT AND EQUIPMENT (1+2)	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**
C. TOTAL (A+B)	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**	**270,350**

Fixes assets value on 31st of December in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. INTANGIBLE ASSETS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1. Buildings and constructions	513,950	486,900	459,850	432,800	405,750	378,700	351,650	324,600	297,550	270,500	243,450	216,400	189,350	162,300	135,250
2. Equipment, plant, vehicles, mechanization	4,622,700	4,379,400	4,136,100	3,892,800	3,649,500	3,406,200	3,162,900	2,919,600	2,676,300	2,433,000	2,189,700	1,946,400	1,703,100	1,459,800	1,216,500
B. TOTAL PROPERTY, PLANT AND EQUIPMENT (1+2)	**5,136,650**	**4,866,300**	**4,595,950**	**4,325,600**	**4,055,250**	**3,784,900**	**3,514,550**	**3,244,200**	**2,973,850**	**2,703,500**	**2,433,150**	**2,162,800**	**1,892,450**	**1,622,100**	**1,351,750**
C. TOTAL (A+B)	**5,136,650**	**4,866,300**	**4,595,950**	**4,325,600**	**4,055,250**	**3,784,900**	**3,514,550**	**3,244,200**	**2,973,850**	**2,703,500**	**2,433,150**	**2,162,800**	**1,892,450**	**1,622,100**	**1,351,750**

Accounts payable and deliveries financed by suppliers in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. Days payable	30.0														
B. Accounts payable turnover ratio	12.17														
C. ACCOUNTS PAYABLE ON 31ST OF DECEMBER	82,312	83,039	83,773	84,515	85,264	86,021	86,786	87,558	88,339	89,128	89,925	90,730	91,544	92,366	93,197
D. DELIVERIES FINANCED BY SUPPLIERS	6,765	6,825	6,885	6,946	7,008	7,070	7,133	7,197	7,261	7,326	7,391	7,457	7,524	7,592	7,660
E. LONG-TERM ACCOUNTS PAYABLE ON 31ST OF DECEMBER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Working capital requirements in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Resources needed to finance inventories	4,313	4,320	4,327	4,334	4,341	4,348	4,355	4,362	4,370	4,377	4,384	4,392	4,399	4,406	4,414
2. Resources needed to finance the accounts receivable	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899	13,899
3. Deliveries financed by suppliers	6,765	6,825	6,885	6,946	7,008	7,070	7,133	7,197	7,261	7,326	7,391	7,457	7,524	7,592	7,660
A. WORKING CAPITAL SURPLUS (+) OR DEFICIT (-) (3-2-1)	**-11,446**	**-11,393**	**-11,340**	**-11,286**	**-11,232**	**-11,177**	**-11,121**	**-11,065**	**-11,008**	**-10,950**	**-10,892**	**-10,833**	**-10,774**	**-10,713**	**-10,653**

Shareholders equity in € on 31st of December	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Owner's equity	5,407,000	6,075,775	6,736,499	7,389,089	8,033,462	8,669,535	9,297,222	9,916,437	10,527,094	11,129,104	11,722,378	12,306,918	12,882,541	13,449,156	14,006,671
2. Retained earnings	668,775	660,724	652,590	644,374	636,073	627,687	619,215	610,657	602,010	593,275	584,539	575,623	566,615	557,515	548,320
TOTAL EQUITY (1 to 2)	**6,075,775**	**6,736,499**	**7,389,089**	**8,033,462**	**8,669,535**	**9,297,222**	**9,916,437**	**10,527,094**	**11,129,104**	**11,722,378**	**12,306,918**	**12,882,541**	**13,449,156**	**14,006,671**	**14,554,991**

Acquisition and consumption of investment subsidies in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Subsidies	0														
2. Subsidized fixed assets on 31st of December	5,407,000	5,136,650	4,866,300	4,595,950	4,325,600	4,055,250	3,784,900	3,514,550	3,244,200	2,973,850	2,703,500	2,433,150	2,162,800	1,892,450	1,622,100
3. Share of subsidies in subsidized fixed assets	0.0%														
4. Depreciation cost	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350
5. Other sources of revenues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LONG-TERM ACCRUED COSTS AND DEFERRED REVENUES ON 31ST OF DECEMBER	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Income statement in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. Total operating income	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400
2. Investment subsidies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Total cost of goods and services	1,001,467	1,010,306	1,019,237	1,028,260	1,037,376	1,046,586	1,055,892	1,065,293	1,074,793	1,084,390	1,094,087	1,103,885	1,113,785	1,123,787	1,133,894
a) Total operating costs	990,693	999,263	1,007,918	1,016,657	1,025,483	1,034,396	1,043,397	1,052,487	1,061,665	1,070,935	1,080,296	1,089,749	1,099,295	1,108,935	1,118,670
1. Energy source costs	882,953	891,523	900,178	908,917	917,743	926,656	935,657	944,747	953,925	963,195	972,556	982,009	991,555	1,001,195	1,010,930
2. Operation and maintainance costs	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740	107,740
b) Total cost of operating services	10,774	11,043	11,319	11,602	11,892	12,190	12,495	12,807	13,127	13,455	13,792	14,136	14,490	14,852	15,223
1. Cost of management, insurance and lease	10,774	11,043	11,319	11,602	11,892	12,190	12,495	12,807	13,127	13,455	13,792	14,136	14,490	14,852	15,223
2. Cost of promotional activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Cost of other services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Cost of labour	42,500	42,606	42,713	42,820	42,927	43,034	43,141	43,249	43,357	43,466	43,575	43,683	43,793	43,902	44,012
EBITDA	***49.26%***	***48.82%***	***48.38%***	***47.94%***	***47.49%***	***47.04%***	***46.58%***	***46.12%***	***45.65%***	***45.18%***	***44.70%***	***44.22%***	***43.74%***	***43.24%***	***42.75%***
5. Depreciation and amortization	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350
1. Intangible assets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Property, plant and equipment	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350
2.1. Buildings and constructions	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050	27,050
2.2. Equipment, plant, vehicles, mechanization	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300	243,300
EBIT	***36.12%***	***35.68%***	***35.24%***	***34.80%***	***34.35%***	***33.90%***	***33.44%***	***32.98%***	***32.51%***	***32.04%***	***31.56%***	***31.08%***	***30.60%***	***30.10%***	***29.61%***
6. Revenues from financial activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Financial costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Other revenues and gains	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100
9. Other expenses and losses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. INCOME BEFORE TAXES	**743,083**	**734,137**	**725,100**	**715,971**	**706,747**	**697,430**	**688,017**	**678,507**	**668,900**	**659,194**	**649,488**	**639,581**	**629,573**	**619,461**	**609,244**
EBT	***36.12%***	***35.68%***	***35.24%***	***34.80%***	***34.35%***	***33.90%***	***33.44%***	***32.98%***	***32.51%***	***32.04%***	***31.57%***	***31.09%***	***30.60%***	***30.11%***	***29.61%***
11. Income taxes	74,308	73,414	72,510	71,597	70,675	69,743	68,802	67,851	66,890	65,919	64,949	63,958	62,957	61,946	60,924
12. NET INCOME	**668,775**	**660,724**	**652,590**	**644,374**	**636,073**	**627,687**	**619,215**	**610,657**	**602,010**	**593,275**	**584,539**	**575,623**	**566,615**	**557,515**	**548,320**
13. Number of employees	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

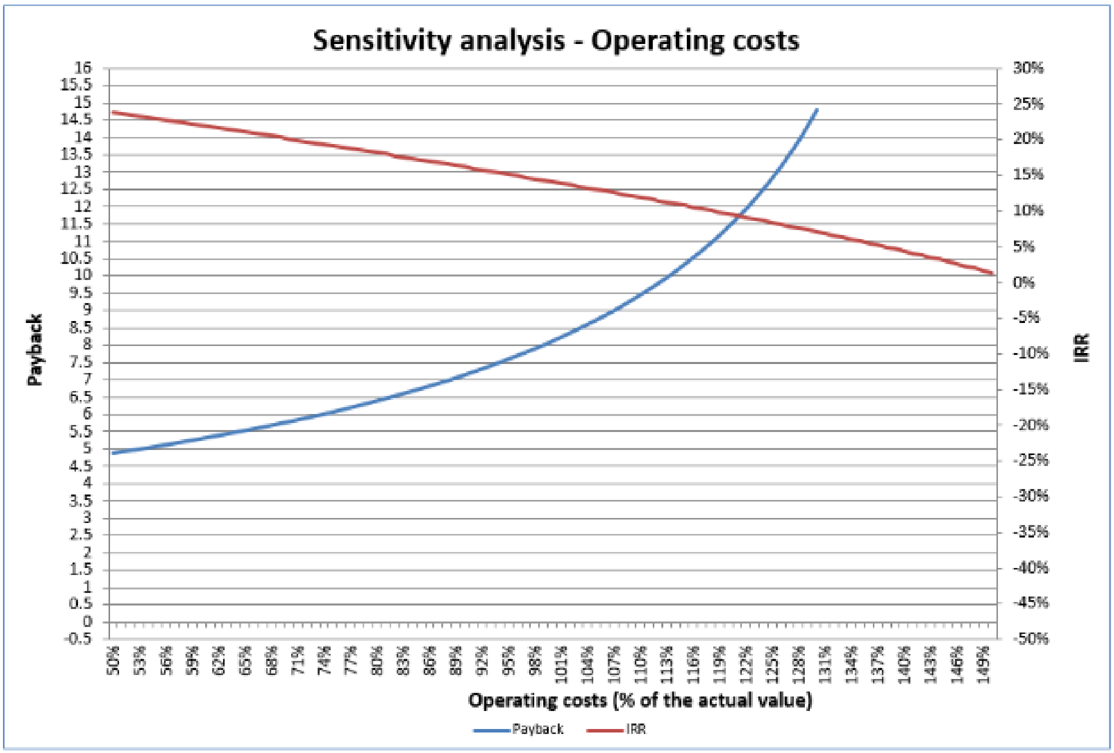
Balance sheet on 31st of December in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. FIXED ASSETS	**5,136,650**	**4,866,300**	**4,595,950**	**4,325,600**	**4,055,250**	**3,784,900**	**3,514,550**	**3,244,200**	**2,973,850**	**2,703,500**	**2,433,150**	**2,162,800**	**1,892,450**	**1,622,100**	**1,351,750**
I. Intangible assets and long-term deferred costs and accrued revenues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II. Property, plant and equipment	5,136,650	4,866,300	4,595,950	4,325,600	4,055,250	3,784,900	3,514,550	3,244,200	2,973,850	2,703,500	2,433,150	2,162,800	1,892,450	1,622,100	1,351,750
1. Buildings and constructions	513,950	486,900	459,850	432,800	405,750	378,700	351,650	324,600	297,550	270,500	243,450	216,400	189,350	162,300	135,250
2. Equipment, plant, vehicles, mechanization	4,622,700	4,379,400	4,136,100	3,892,800	3,649,500	3,406,200	3,162,900	2,919,600	2,676,300	2,433,000	2,189,700	1,946,400	1,703,100	1,459,800	1,216,500
III. Long-term accounts receivable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. CURRENT ASSETS	**1,021,437**	**1,953,238**	**2,876,912**	**3,792,377**	**4,699,549**	**5,598,343**	**6,488,673**	**7,370,452**	**8,243,593**	**9,108,006**	**9,963,693**	**10,810,471**	**11,648,250**	**12,476,937**	**13,296,438**
I. Inventories	26,235	26,278	26,321	26,364	26,407	26,450	26,494	26,538	26,582	26,626	26,671	26,716	26,761	26,806	26,852
II. Accounts receivable	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101	169,101
III. Cash and cash equivalents	826,101	1,757,859	2,681,490	3,596,912	4,504,041	5,402,791	6,293,078	7,174,813	8,047,909	8,912,279	9,767,920	10,614,654	11,452,388	12,281,030	13,100,485
TOTAL ASSETS	**6,158,087**	**6,819,538**	**7,472,862**	**8,117,977**	**8,754,799**	**9,383,243**	**10,003,223**	**10,614,652**	**11,217,443**	**11,811,506**	**12,396,843**	**12,973,271**	**13,540,700**	**14,099,037**	**14,648,188**
A. OWNER'S EQUITY	**6,075,775**	**6,736,499**	**7,389,089**	**8,033,462**	**8,669,535**	**9,297,222**	**9,916,437**	**10,527,094**	**11,129,104**	**11,722,378**	**12,306,918**	**12,882,541**	**13,449,156**	**14,006,671**	**14,554,991**
B. PROVISIONS AND LONG-TERM ACCRUED COSTS AND DEFERRED REVENUES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
C. LONG-TERM LIABILITIES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
I. Long-term financial liabilities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II. Long-term accounts payable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. CURRENT LIABILITIES	**82,312**	**83,039**	**83,773**	**84,515**	**85,264**	**86,021**	**86,786**	**87,558**	**88,339**	**89,128**	**89,925**	**90,730**	**91,544**	**92,366**	**93,197**
I. Short-term financial liabilities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II. Accounts payable	82,312	83,039	83,773	84,515	85,264	86,021	86,786	87,558	88,339	89,128	89,925	90,730	91,544	92,366	93,197
TOTAL LIABILITIES AND OWNER'S EQUITY	**6,158,087**	**6,819,538**	**7,472,862**	**8,117,977**	**8,754,799**	**9,383,243**	**10,003,223**	**10,614,652**	**11,217,443**	**11,811,506**	**12,396,843**	**12,973,271**	**13,540,700**	**14,099,037**	**14,648,188**

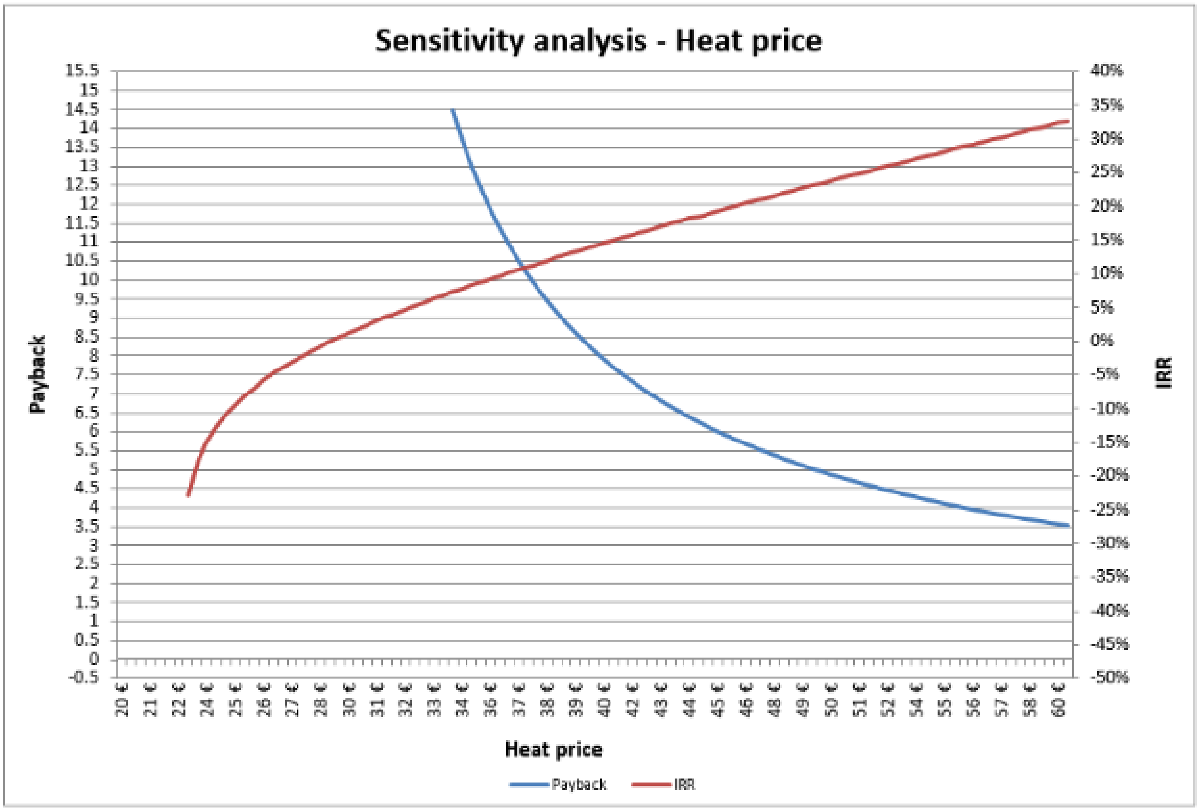
Cash-flow statement in €	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
A. CASH FLOW FROM OPERATING ACTIVITIES															
1. Income before taxes	743,083	734,137	725,100	715,971	706,747	697,430	688,017	678,507	668,900	659,194	649,488	639,581	629,573	619,461	609,244
2. Depreciation and amortization	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350	270,350
3. Income taxes	-74,308	-73,414	-72,510	-71,597	-70,675	-69,743	-68,802	-67,851	-66,890	-65,919	-64,949	-63,958	-62,957	-61,946	-60,924
4. Decrease (- increase) in accounts receivable	-169,101	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Decrease (- increase) in inventories	-26,235	-43	-43	-43	-43	-43	-44	-44	-44	-44	-45	-45	-45	-45	-45
6. Increase (- decrease) in accounts payable	82,312	727	734	742	749	757	765	773	781	789	797	805	814	822	831
7. Financial costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Income related to long-term accrued costs and deferred revenues (subsidies)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net cash flow from operating activities	**826,101**	**931,758**	**923,631**	**915,422**	**907,129**	**898,750**	**890,286**	**881,735**	**873,097**	**864,369**	**855,642**	**846,734**	**837,734**	**828,641**	**819,455**

B. CASH FLOW FROM INVESTING ACTIVITIES															
1. Receipts (+) and disbursements (-) in intangible assets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Receipts (+) and disbursements (-) in property, plant and equipment	-5,407,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net cash flow from investing activities	**-5,407,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
C. CASH FLOW FROM FINANCING ACTIVITIES															
1. Receipts from capital pay-in (+) and dividends paid (-)	5,407,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Receipts (+) and disbursements (-) in financial liabilities and accrued costs and deferred revenues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net cash flow from financing activities	**5,407,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
D. NET BALANCE IN CASH AND CASH EQUIVALENTS															
1. Net cash flow	826,101	931,758	923,631	915,422	907,129	898,750	890,286	881,735	873,097	864,369	855,642	846,734	837,734	828,641	819,455
2. Cash and cash equivalents, beginning of year	0	826,101	1,757,859	2,681,490	3,596,912	4,504,041	5,402,791	6,293,078	7,174,813	8,047,909	8,912,279	9,767,920	10,614,654	11,452,388	12,281,030
3. Cash and cash equivalents, end of year	**826,101**	**1,757,859**	**2,681,490**	**3,596,912**	**4,504,041**	**5,402,791**	**6,293,078**	**7,174,813**	**8,047,909**	**8,912,279**	**9,767,920**	**#######**	**#######**	**#######**	**#######**

Profitability	Cash flow
Initial capital investment (discounted for received subsidies)	5,407,000.00
Private equity invested	5,407,000.00
Equity net present value (NPV)	**2,607,245.56**
Equity internal rate of return (IRR)	**14.09%**

CASH FLOW in €		**Discount rate:** 7.00%
Year	**Cash flow**	**Discounted Cash flow**
C0	-5,407,000	-5,407,000
CF1	826,101	772,057
CF2	931,758	813,833
CF3	923,631	753,958
CF4	915,422	698,371
CF5	907,129	646,770
CF6	898,750	598,875
CF7	890,286	554,426
CF8	881,735	513,178
CF9	873,097	474,907
CF10	864,369	439,401
CF11	855,642	406,509
CF12	846,734	375,960
CF13	837,734	347,630
CF14	828,641	321,361
CF15	819,455	297,008
TOTAL	**7,693,485**	**Payback: 8.12 years**





Project performance in €	2018	2019	2020	2021	2022
1. Total income	2,057,400	2,057,400	2,057,400	2,057,400	2,057,400
2. Total costs of goods and services	1,001,467	1,010,306	1,019,237	1,028,260	1,037,376
3. Cost of labour	42,500	42,606	42,713	42,820	42,927
4. Depreciation and amortization	270,350	270,350	270,350	270,350	270,350
5. Financial costs	0	0	0	0	0
6. Other costs	0	0	0	0	0
7. EBT	743,083	734,137	725,100	715,971	706,747

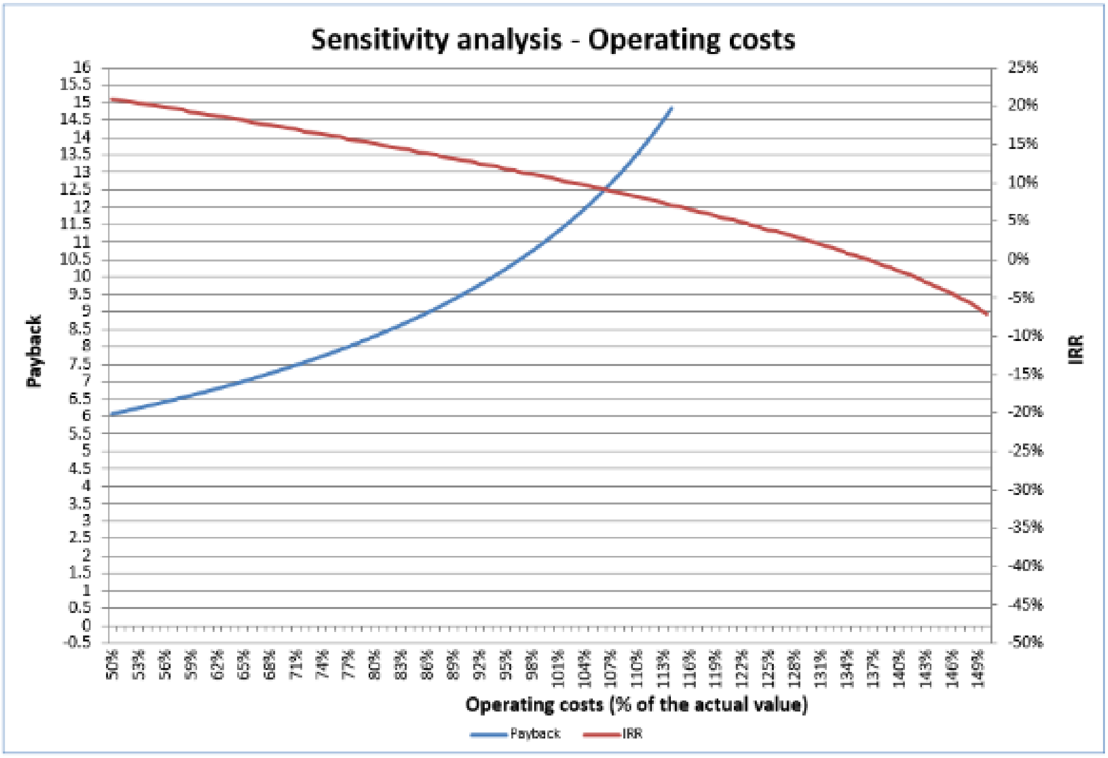
Balance sum	6,158,087	6,819,538	7,472,862	8,117,977	8,754,799
Cash Flow	826,101	931,758	923,631	915,422	907,129
Cost of MWh heat sold	27	27	27	27	28
Cost of MWh energy sold (heat + electricity)	27	27	27	27	28

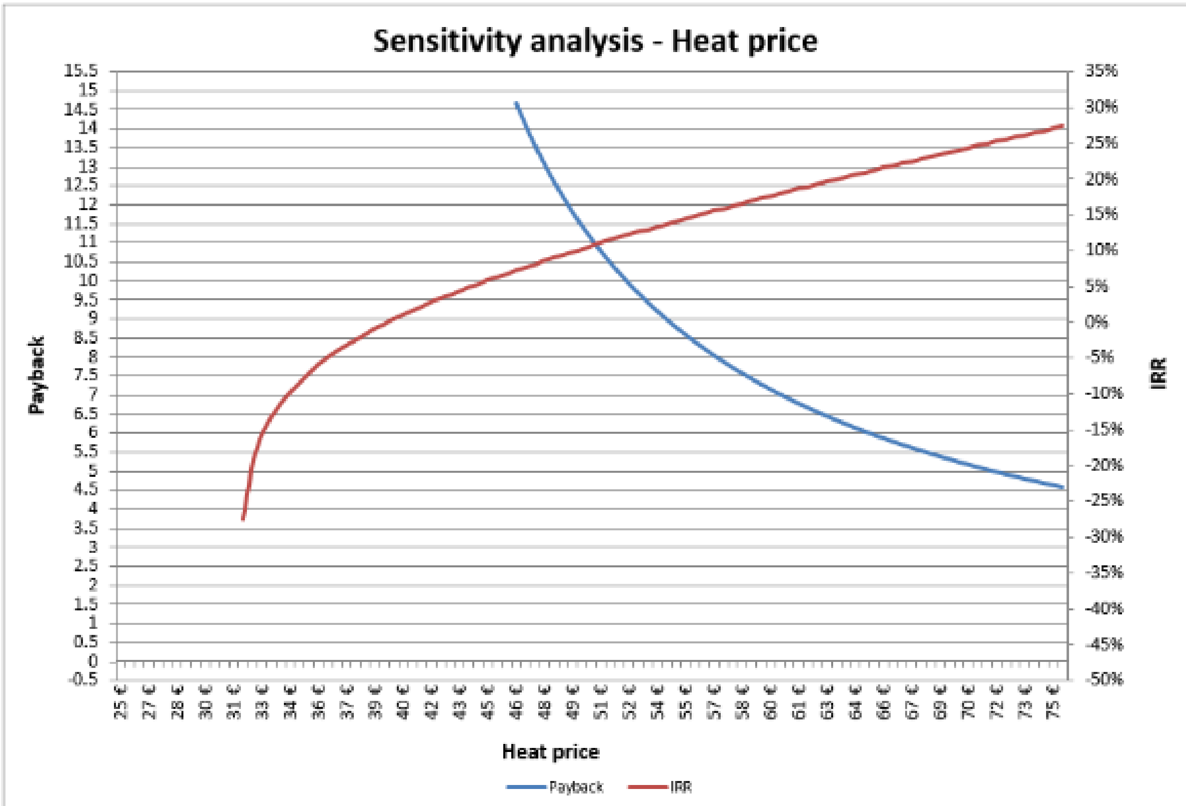
Private equity invested	5,407,000 €
Net present value (NPV)	2,607,246 €
Equity internal rate of return (IRR)	14.09%
Payback (discount rate: 7%)	8.12 years

Scenario: 60% of consumers connected in first year, consumption increases 4% annually, heat pump COP = 3

Profitability	Cash flow
Initial capital investment (discounted for received subsidies)	5,407,000.00
Private equity invested	5,407,000.00
Equity net present value (NPV)	**1,455,107.31**
Equity internal rate of return (IRR)	**10.66%**

CASH FLOW in €		Discount rate: 7.00%
Year	**Cash flow**	**Discounted Cash flow**
C0	-5,407,000	-5,407,000
CF1	547,973	512,124
CF2	648,421	566,356
CF3	670,330	547,189
CF4	692,740	528,488
CF5	715,652	510,250
CF6	739,065	492,470
CF7	762,978	475,144
CF8	787,386	458,266
CF9	812,287	441,830
CF10	837,674	425,831
CF11	863,629	410,304
CF12	889,964	395,155
CF13	916,759	380,422
CF14	944,000	366,099
CF15	971,673	352,179
TOTAL	**6,393,529**	**Payback: 11.1 years**





Projected investment cost in €	Amount	Share %
A. PROPERTY, PLANT AND EQUIPMENT	5,387,000	99.6%
B. PROJECT AND INVESTMENT DOCUMENTATION	20,000	0.4%
C. INTANGIBLE ASSETS	0	0.0%
D. INVESTMENT COST (A+B+C)	5,407,000	100.0%
E. INITIAL WORKING CAPITAL	0	0.0%
F. TOTAL INVESTMENT COST (D+E)	5,407,000	100.0%

Sources of investment cost financing in €	Amount	Share %
A. PRIVATE EQUITY	5,407,000	100.0%
B. BANK LOANS	0	0.0%
C. CONNECTION FEES	0	0.0%
D. INVESTMENT SUBSIDIES	0	0.0%
E. TOTAL FINANCING (A+B+C+D)	5,407,000	100.0%

Project performance in €	2018	2019	2020	2021	2022
1. Total income	1,655,200	1,721,408	1,790,264	1,861,875	1,936,350
2. Total costs of goods and services	944,076	986,331	1,030,676	1,077,218	1,126,065
3. Cost of labour	42,000	42,105	42,210	42,316	42,422
4. Depreciation and amortization	270,350	270,350	270,350	270,350	270,350
5. Financial costs	0	0	0	0	0
6. Other costs	0	0	0	0	0
7. EBT	398,774	422,622	447,028	471,991	497,513

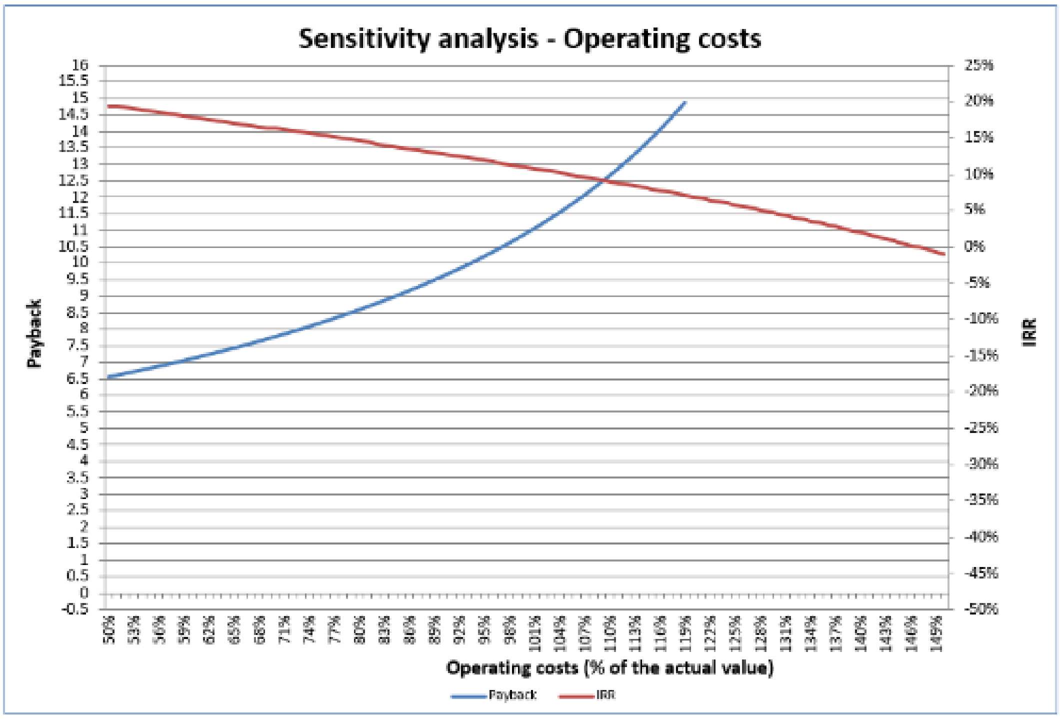
Balance sum	5,843,492	6,227,325	6,633,294	7,061,912	7,513,689
Cash Flow	547,973	648,421	670,330	692,740	715,652
Cost of MWh heat sold	39	39	39	39	38
Cost of MWh energy sold (heat + electricity)	39	39	39	39	38

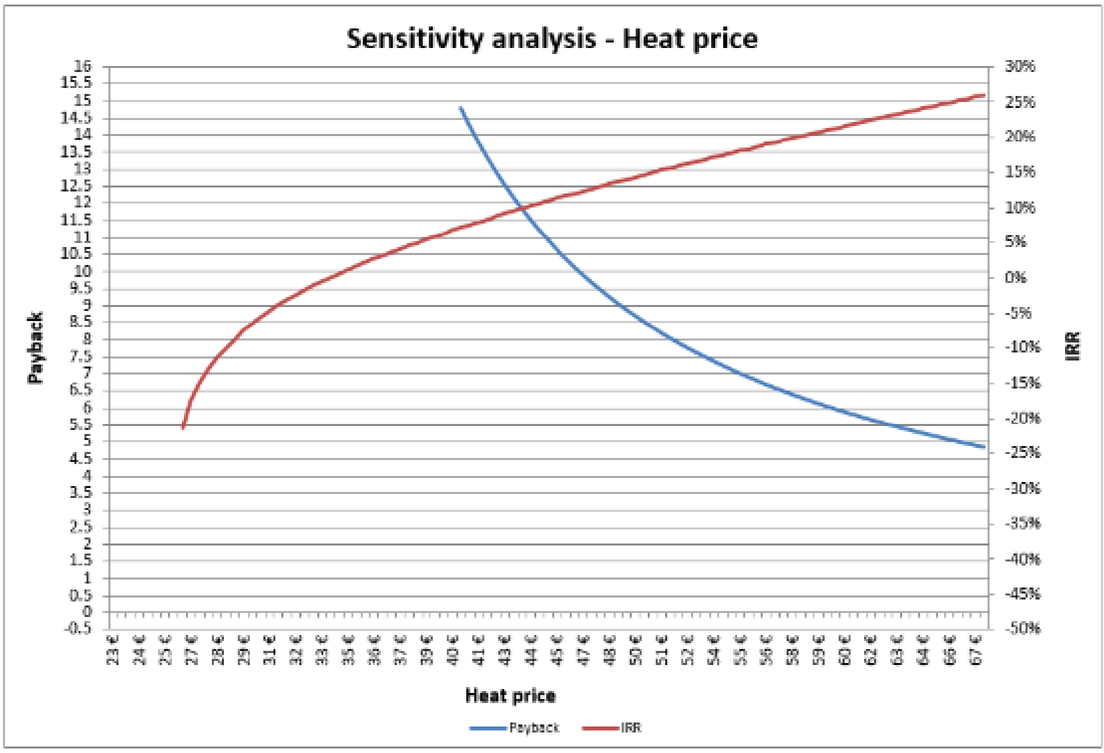
Private equity invested	5,407,000 €
Net present value (NPV)	1,455,107 €
Equity internal rate of return (IRR)	10.66%
Payback (discount rate: 7%)	11.1 years

Scenario: 60% of consumers connected in first year, consumption increases 4% annually, heat pump COP = 4

Profitability	Cash flow
Initial capital investment (discounted for received subsidies)	5,407,000.00
Private equity invested	5,407,000.00
Equity net present value (NPV)	**1,598,948.01**
Equity internal rate of return (IRR)	**10.96%**

CASH FLOW in €		Discount rate: 7.00%
Year	**Cash flow**	**Discounted Cash flow**
C0	-5,407,000	-5,407,000
CF1	548,059	512,205
CF2	650,525	568,194
CF3	674,627	550,697
CF4	699,384	533,557
CF5	724,806	516,776
CF6	750,902	500,358
CF7	777,683	484,302
CF8	805,157	468,609
CF9	833,333	453,278
CF10	862,219	438,309
CF11	891,912	423,741
CF12	922,238	409,484
CF13	953,292	395,582
CF14	985,079	382,031
CF15	1,017,603	368,826
TOTAL	**6,689,819**	**Payback: 10.9 years**





Projected investment cost in €	Amount	Share %
A. PROPERTY, PLANT AND EQUIPMENT	5,387,000	99.6%
B. PROJECT AND INVESTMENT DOCUMENTATION	20,000	0.4%
C. INTANGIBLE ASSETS	0	0.0%
D. INVESTMENT COST (A+B+C)	5,407,000	100.0%
E. INITIAL WORKING CAPITAL	0	0.0%
F. TOTAL INVESTMENT COST (D+E)	5,407,000	100.0%

Sources of investment cost financing in €	Amount	Share %
A. PRIVATE EQUITY	5,407,000	100.0%
B. BANK LOANS	0	0.0%
C. CONNECTION FEES	0	0.0%
D. INVESTMENT SUBSIDIES	0	0.0%
E. TOTAL FINANCING (A+B+C+D)	5,407,000	100.0%

Project performance in €	2018	2019	2020	2021	2022
1. Total income	1,489,680	1,549,267	1,611,238	1,675,687	1,742,715
2. Total costs of goods and services	777,900	811,240	846,247	883,004	921,598
3. Cost of labour	42,500	42,606	42,713	42,820	42,927
4. Depreciation and amortization	270,350	270,350	270,350	270,350	270,350
5. Financial costs	0	0	0	0	0
6. Other costs	0	0	0	0	0
7. EBT	398,930	425,070	451,928	479,514	507,841
Balance sum	5,829,974	6,215,278	6,624,890	7,059,474	7,519,703
Cash Flow	548,059	650,525	674,627	699,384	724,806
Cost of MWh heat sold	34	34	34	33	33
Cost of MWh energy sold (heat + electricity)	34	34	34	33	33

Private equity invested	5,407,000 €
Net present value (NPV)	1,598,948 €
Equity internal rate of return (IRR)	10.96%
Payback (discount rate: 7%)	10.9 years