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Title **Economical and organisational aspects Minewater Energy Exploitation**

Subtitle **REMINING-Lowex WP4**

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Summary

This note sets out some of the key issues to examine when starting a Minewater Energy Company (MEC) to distribute heating (and cooling) by way of a district heating network to buildings. The business model and financial forecast for minewater as a commercial energy source is of particular importance. Preferably, all activities for the use of minewater for climate control in buildings are in one hand. In practice, the pumping and distribution can be done by a different entity than the energy consumer.

In case of big area development two entities may be needed to manage the project. First, a Minewater Production Company (MPC) takes care of the distribution of the minewater to energy users. In fact, the MPC is dealing with a thermal half fabricate as the minewater mostly is not directly applicable for heating and cooling in the build environment. Therefore, a Minewater Energy Company (MEC) processes the low-valued energy to the desired temperature levels and delivers it to the HVAC system of end-users. It depends on the local situating whether a MPC and/or MEC should be founded or even can be combined to one entity.

A clear distinction should be made between direct heating and cooling buildings by minewater on the one hand, and minewater as a thermal half fabricate which needs post processing on the other hand. Direct heating and cooling is strongly preferred because of the high energy savings, the clear structure of costs, low investments and less dependency on fossil fuel prices. To balance potential fluctuations of minewater temperature and flow, post processing by heat pumps is an option.

In the whole process there are different stakeholders to deal with. Working together in a team and transparency are the only way to make a MPC and a MEC to a success. Important aspects for the economical and operational feasibility are:

- the technical aspects;
- the financial aspects;
- the urban planning aspects;
- the legal aspects.

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For heating buildings, the minewater needs to be upgraded with a heat pump to 40 ºC under the condition that the building is lowex. That means the building has to be good insulated and have a low temperature heating distribution system.

A cash flow model is a good instrument to investigate the economical feasibility in an early stage of the project and to calculate the internal rate of return (IRR). With a cash flow model there can be made sensitivity analyses. With the sensitivity analyses the risks of the project can be estimated and a good business plan can be made. Most important parameters are:

- the total cost of investment;
- price of installation fees, standing fees and energy price for heating and cooling;
- building guarantees and connection obligations;
- building schedules;
- the increase of energy prices;
- type of buildings and energy demand (e.g. quality of insulation);
- the coefficient of performance of the minewater system.

1. Introduction

Most climates in Europe require a central heating system for warming buildings in cold periods. A central heating system provides warmth to the whole interior of a building (or portion of a building). In residences the system also provides domestic hot water (DHW) for showering and other activities in the house. When combined with other systems in order to control the building climate, the whole system is called a HVAC (heating, ventilation and air conditioning) system.

The most common method of heat generation involves the combustion of a fossil fuel in a furnace or boiler. The resultant heat gets distributed: typically by forced-air through ductwork, by water circulating through pipes, or by steam fed through pipes. In most of the northern European countries, where people seldom require air conditioning in homes due to the temperate climate, most new houses come with central heating installed. Such areas normally use gas heaters, district heating, or oil-fired systems. Steam-heating systems, fired by coal, oil or gas, are primarily used for larger buildings and industry. Electrical heating systems occur less commonly because of the inefficient use of electricity and are only practical when geothermal heat pumps are used.

In order for Europe to reduce its reliance on fossil fuel and decrease CO_2 emissions, there need to be find alternative energy sources. One of these sources is geothermal energy.

Abandoned and flooded mines are a good potential source of geothermal energy; they also offer space for the storage of hot and cold water. Crucially, the minewater can provide a focus for sustainable regeneration of former mining areas, demonstrating a new renewable energy resource that can deliver heating and cooling for sustainable communities. Such schemes can be applied on a community scale, by way of a district heating network, serving the local community.

Image 1: Old abandoned Mines

District heating and cooling involves providing hot or cold water to a number of buildings in an area in order to heat or cool the buildings. Sometimes the hot or cold water is used for an industrial process, but mostly the water flows through pipes to individual buildings and into radiators or a floor heating system designed to transfer heat into a room.

In order to make use of the geothermal energy in the minewater, other low carbon technologies are typically integrated including heat pumps, solar energy systems and Combined Heat & Power (CHP).

This note sets out some of the key issues to examine when starting a Minewater Production Company (MPC) and Minewater Energy Company (MEC) to exploit a heating network to buildings. It draws heavily on the experiences from an EU funded project, the minewater project in Heerlen, the Netherlands. This examines basically all of the issues that must be addressed in order to successfully exploit this resource for heating and cooling buildings.

2. Minewater Energy Company

The business model and financial forecast for minewater as a commercial energy source is of particular importance. Preferably, all activities for the use of minewater for climate control in buildings are in one hand. In practice, the pumping and distribution can be done by a different entity than the energy consumer. In case of big area development a Minewater Energy Company (MEC) is needed to manage the project. This requires clear appointments between the supply and demand side of minewater. Furthermore, the allocation of the cost for optional extra investments like back-up systems and low-exergy system requires negotiations between the supply- and demand side of minewater energy.

The MEC finances, maintains an operates the energy station and the heating and cooling distribution network (DH&C). The installations in the energy station, for example a heat pump, upgrade the minewater to useful heating and cooling. The core business of the MEC is to supply heat and cold to consumers. A MEC is comparable with a Energy Company (EC) that provides electricity and gas. Consumers pay for every unit of heath (GJ or kWh) they use from the system like they pay for every kilo Watt hour (kWh) electricity to an EC.

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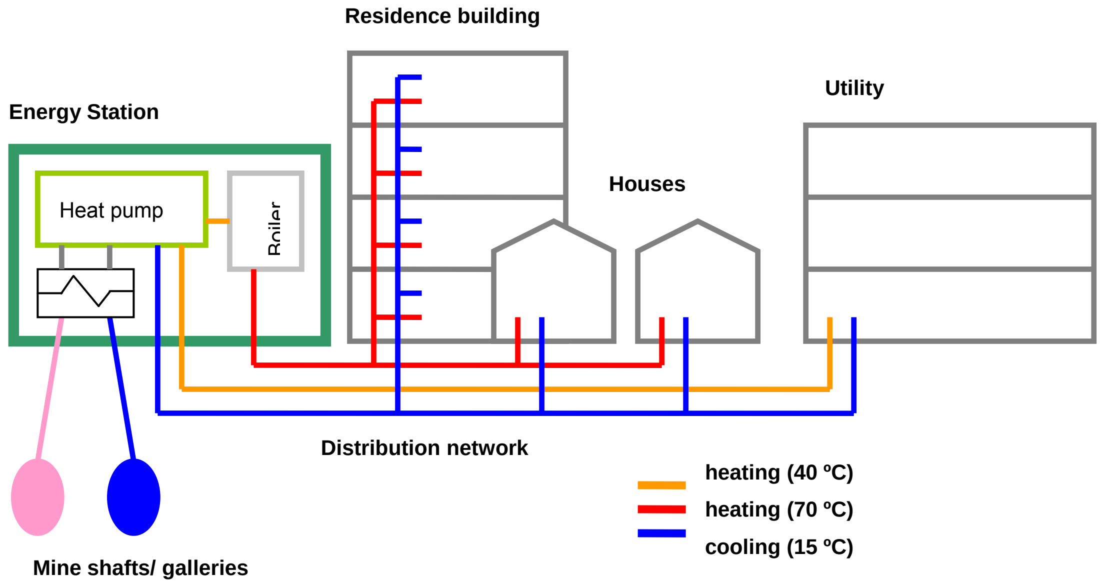
Figure 1: Schedule of minewater energy system with half fabricate minewater

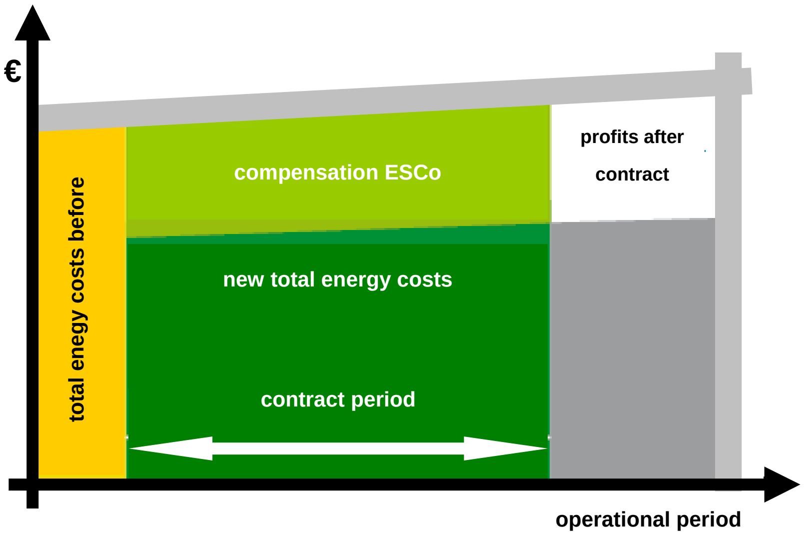


A typical organisation form of an Energy Company is a Energy Service Company (ESCo). An ESCo has a Energy Performance Contract (EPC) with the owner or user of a building. The EPC is a agreement on the total costs of energy, the contract period and delivery guarantees. The total costs of energy content:

- maintenance, repair and depreciation costs;
- standing fee for electricity and/ or gas;
- energy costs for the use of fossil fuel (e.g. electricity, gas, oil).

The ESCo invests in energy saving measures and the renewable energy system that cause a lower energy bill. The difference between the total energy costs before and after the energy saving measures are used to finance the energy saving installation. After the contract period the owner of the building takes over the renewable energy system. From then the user has directly the benefits of the lower energy bill. The ESCo model is especially suitable for (high-level) renovation, with significant reduction in energy consumption.

Figure 2: Schedule of the Energy Performance Contract with an ESCo



Because of the big spreading in energy use for heating and cooling buildings and the DHW use in houses, it is hard to get an agreement on the total energy costs. In case of a Minewater project it is often better to charge users for the heat and cold they actually use from the network. It also supports energy efficient behaviour. It is important for the social support that the consumers pay according to the principle of business-as-usual. In most cases a MEC is in between an EC and an ESCo.

For single tenant industry and office buildings an agreement on the total costs of energy can be a good solution to convince stakeholders to connect the renewable energy system.

3. Important stakeholders

In the whole process of developing a district heating network with use of geothermal energy of the minewater there are different stakeholders to deal with. All the stake holders have different incentives. Working together in a team and transparency are the only way to make an MEC to a success. The most important stakeholders are:

- minewater Energy Company (MEC);
- minewater Production Company (MPC);
- local authorities;
- the (intended) owners of the buildings;
- development Manager;
- consumers.

In the direct area of the mines there must be sufficient need for heating and cooling and the (intended) owners of the buildings must be willing to connect to the network. When a new area is going to be developed, there must be the guarantee that most of the buildings that are planned also get build. Summarized it is very important that both the MPC, the MEC as the (indented) owners and consumers have an (economical) advantage of the system.

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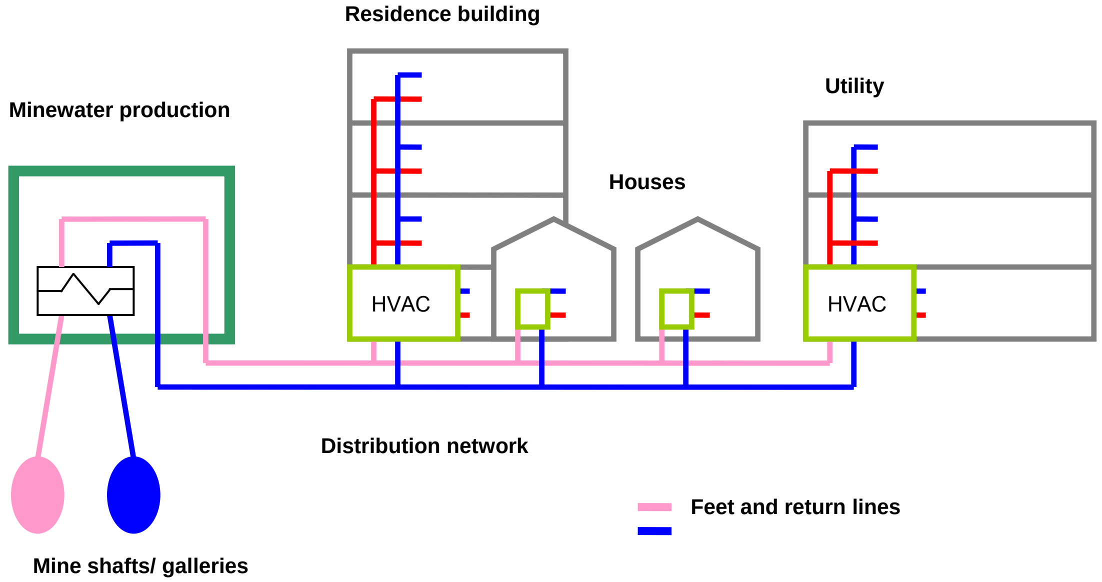
Minewater Energy Company (MEC)
The MEC finances, maintains and operates the energy station and the distribution network. The core business of the MEC is to supply heat and cold to consumers.

Minewater Production Company (MPC)
The MPC delivers the water from the mines to the energy station of the MEC. The MPC is responsible for the temperature conditions of the minewater and must guarantee the delivery. It maintains and operates the pump system in the mines. The MEC pays for the heat and cold they use out of the mines, a connection fee to connect and/or a annual standing fee. It is also possible that the MPC directly delivers the water of the mines to buildings, with their own HVAC system to upgrade the half-fabricate. The MPC can be the same company as the MEC, the owner of the mines or the local municipality.

Figure 3: Schedule of minewater production system (half fabricate)



Local authority
Local authorities can have their benefits developing a district heating network with use of the geothermal energy out of minewater. It reduces the carbon footprint and can improve self-image, health, employment and economy, thereby helping to restore local pride and heritage. The municipality can give direction in (re)developing potential areas and can be the initiator of a minewater project. It also can share in the MPC and/or MEC in a public-private partnership (PPP).

The (indented) building owners
Investors, social housing corporations and private owners are crucial to the success of a minewater project. The owners pay a connection fee for a connection to the district heating and cooling network. They are willing to pay a fee because they do not have to invest in a central heating and cooling installation (e.g. gas boiler and/ or condensing cooling unit). They also do not have the maintenance and repair costs, so therefore the MEC can normally also charge an annual standing fee.

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To connect on the network, the building has to be good insulated and have a low temperature heating distribution system (lowex). It is very important that the MEC is transparent in all the costs they charge. It is also possible that the building owners directly buy the minewater energy from the MPC. With their own HVAC system, for example a heat pump, they upgrade the half-fabricate ready to be used for heating and cooling.

Development Manager

The Development Manager has an important rule in getting al the different stakeholders in the same direction and acquire new customers for expansion of the system. In every stage of the project the manager must asses the different incentives. The manager and his advisors must be compatible to solve the split-incentives and show the benefits for all stakeholders. Transparency and cooperation are the only key to success.

Consumers

The consumers pay the MEC for the heat and cold they use. It is important for the social support that the consumers pay according to the principle of business-as-usual. That means the same energy rates as consumers using heathers (and coolers) on fossil fuels, for example a central gas heather. The MEC can also charge an annual standing fee. For example the same standing fee that consumers pay if they are connected to a gas network.

4. Minewater temperature

The type of product that can be delivered to consumers is very important for the business case. Using minewater (geothermal energy) as renewable energy resource one can think of:

- heating (> 40 ºC);
- cooling (< 15 ºC);
- water heating (> 70 ºC);
- electricity (>> 100 ºC).

Common temperatures in mines are about 16 to 18°C at 250 meters and around 30°C at 700 meters underground. Heated up by the surrounding rock, minewater can function as a source of low valued energy for the heating and cooling of buildings. Shallow water up to 15°C is usable for the cooling of lowex buildings, while deep water of at least 40°C is usable for (direct) heating lowex buildings. Between these limits, extra processing is necessary to get the suitable supply temperatures for cooling and heating. Common solutions for this post processing are heat pumps or solar energy.

A clear distinction should be made between direct heating and cooling buildings by minewater on the one hand, and minewater as a thermal half fabricate which needs post processing on the other hand.
Direct heating (and cooling) is strongly preferred because of the high energy savings, the clear structure of costs, low investments and less dependency on fossil fuel prices. To balance potential fluctuations of minewater temperature and flow, post processing by heat pumps is an option.

Of big importance is to know if the minewater energy is 'inexhaustible' or must be regenerated in case of long term use For example by reinjection minewater of proper temperatures. This can be a risk for the operation period of the system, but this risk can be minimized by geological research and reservoir modelling.

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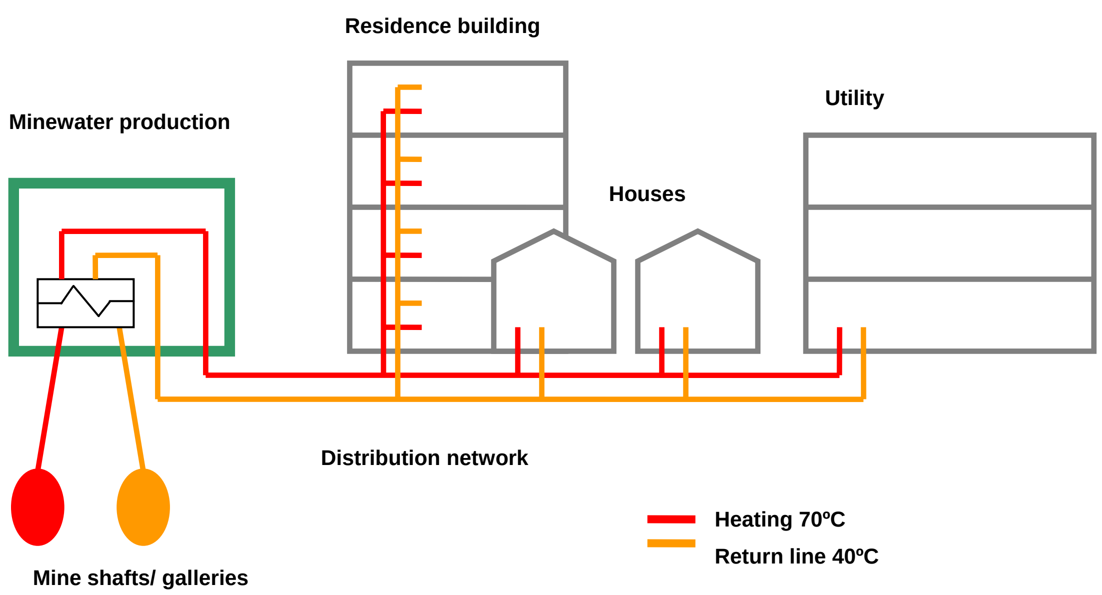
Figure 4: Schedule of minewater energy system with direct heating buildings



A typical organisation form of an Energy Company is an Energy Service Company (ESCo). An ESCo has an Energy Performance Contract (EPC) with the owner or user of a building. The EPC is an agreement on the total costs of energy, the contract period and delivery guarantees. The total costs of energy content:

There are three main temperatures of geothermal energy:

Low temperature

Geothermal energy with the temperature less then 15ºC (in fact ground water) can be used directly for cooling. The disadvantage of direct cooling is the sensitivity for fluctuations of water temperature. For heating buildings, the water temperature need to be upgraded with a heat pump to 40ºC under the condition that the buildings are lowex. For DHW the temperature needs to be upgraded to higher temperature, for example with a gas boiler.

Mid temperature

Geothermal energy with a temperature of at least 40ºC can be used directly for heating buildings under the condition that the buildings are lowex. For DHW the water temperature need to be upgraded to higher temperature, for example with a gas boiler. The water temperature is to high for efficient cooling. For water conditions in between low and mid temperature a head pump can also downgrade the temperature to 12ºC for cooling.

High temperature

Geothermal energy with a temperature of 70ºC and more can be used directly for heating all types of buildings and deliver DHW. The disadvantage of direct heating is the sensitivity for fluctuations of the water temperature. If the water temperature is high enough to produce steam (around 120ºC), it is also possible to generate electricity and cold.

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When there is a geological report of the temperature of the minewater, there must to be buildings or industry in the direct area of the mines for distribution. If there is a match, there is a potential business case for using the minewater.

5. Financial aspects

Before starting a minewater project it is important to know if it is economically feasible. So the cashflow must be calculated. The most important input for the cashflow is:

- operational period, for example 30 years (must relate to the technical life span of the system);
- total cost of investment;
- maintenance and operational costs;
- revenues from energy delivery, standing fees and installation fees.

5.1 Investment

The total costs of investment can be divided in three main parts:

- minewater installation;
- energy station;
- distribution network.

Minewater installation

Considering the type of minewater application, there are different situations possible:

- minewater is already available, for example by pumping to dehydrate operational mines;
- minewater should be extracted from closed mines, in that case drilling of wells is necessary;
- minewater can be extracted from (still open) shafts of closed mines.
- minewater energy is inexhaustible or regeneration is needed

If new wells have to be drilled in various locations to access the underground mine shafts, the total investment depends on:

- number of drillings;
- drilling depths;
- failure costs.

Energy station

In the energy station the half- fabricate minewater will be upgraded. The minewater network is usually connected to the energy station by heat exchangers. The type of installation depends on the minewater temperature and the energy demand of the buildings. With low temperature minewater a heat pump is the most efficient installation. If there is a need for DHW, a boiler on fossil fuel is needed to reach high temperatures. For an efficient working installation there must be a control and monitoring system. For the distribution there is a pump system in the energy station. The total investment depends on:

- minewater temperature;
- energy loses in the distribution network;
- energy demand for heating, DHW and cooling.

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A renewable alternative for a heater on fossil fuel can be a biofuel heater on discarded frying oil, biogas or wood pellets. In some cases a Combined Heat & Power (CHP) installation can be used to reach high temperatures for heated water and producing electricity at the same time.

Distribution network

From the mines to the energy station there are feed and return lines for the minewater. Depending on the temperature of the minewater the pipes have to be insulated. From the energy station, the heat is distributed to buildings via a network of insulated pipes. Whether the pipelines for cold water transport must be insulated depends on several parameters and should be examined on forehand. District heating systems also consists of feed and return lines. Usually the pipes are installed underground. The distribution network is a big part of the total investment. To reduce the investment it is important to:

- minimize the distance between the mines and the buildings;
- optimise the density of occupation and building types;
- maximize the percentage of building that connect the network.

At customer level the heat network is usually connected to the residences by heat exchangers. The water used in the district heating system is not mixed with the water of the central heating system in the buildings. Every consumer gets his own heat exchangers and heat meter.

5.2 Maintenance and operational costs

During the exploitation period of the system there are maintenance and operational cost:

- fossil fuel costs for heat pumps, distribution pumps and boilers;
- annual maintenance costs;
- repair costs;
- replacement costs;
- management and billing costs.

The fossil fuel costs for heat pumps, distribution pumps and heaters depend on:

- the coefficient of performance of the installation;
- the distance from energy station to the buildings;
- the quality of insulation of the pipes;
- the temperature of the transported heath, the higher the temperature the higher the losses.

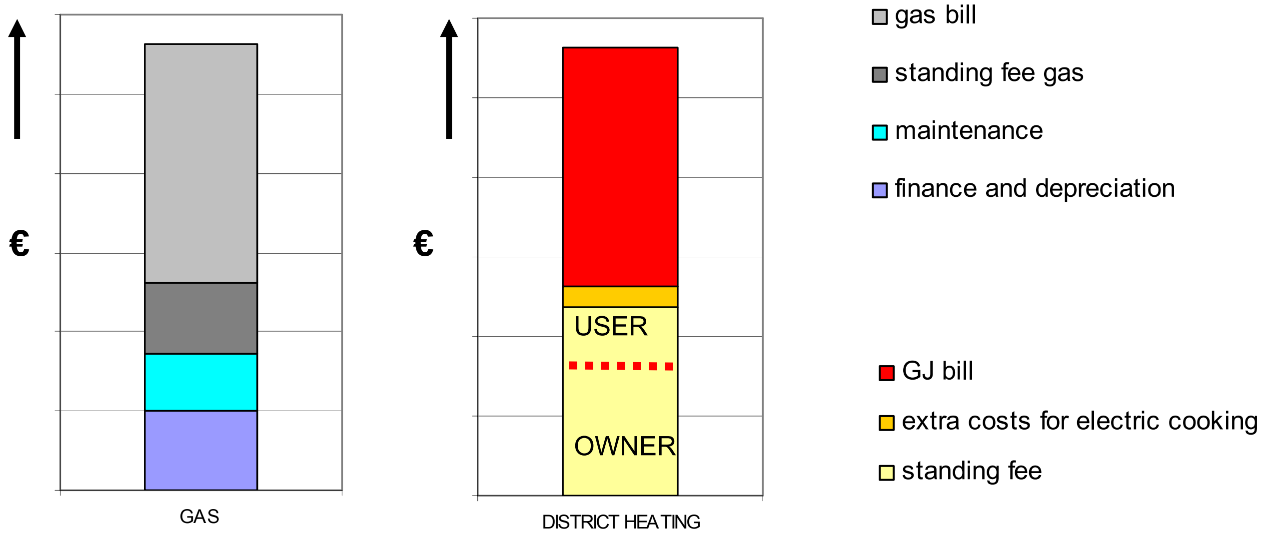
The heat losses in the distribution network and pump energy for the distribution network are very important for the operational costs and the total coefficient of performance of the minewater energy system.

5.3 Revenues from energy delivery, standing fees and installation fees

A new building that connects to a DH&C needs a contractual agreement and a connection fee. The fee can depend on the power supply of the building and the products that will be delivered (space heating, DHW and/ or cooling). The connection fee is negotiable between intended owners, development managers and the MEC.

If connected the owner of the building pays the MEC an annual standing fee because they do not have the maintenance, repair and replacement costs of a ‘traditional’ heating and air conditioning installation. The users of the building (consumer) pay the MEC for the heat and cold they use from the network. The MEC can also charge an annual standing fee. For example the same standing fee that consumers pay if they are connected to a gas network.

Figure 5: Example of a calculation of the standing fee for one connection for a district heating network compared with a gas boiler situation



In figure 5 there is an example of a business as usual calculation of the standing fee if connected to a district heating network, compared to a gas boiler situation. In this example no cooling is delivered. The finance and deprecation cost of the gas boiler are also calculated in the standing fee. So in this case these costs should not be calculated in the connection fee. For a unit of heat (GJ/ kWh) the consumers pays the same amount as the gas bill when using a gas boiler.

6. Urban planning aspects

When starting a minewater energy system, do not underestimate the urban planning aspects.

Existing area development

Existing buildings are often bad insulated. That is why a mid temperature distribution network is not suitable for existing buildings. The solution is to insulate all buildings and make a lowex distribution system. The reconstruction of a building to a lowex building is expensive. Most of the existing areas have more then one owner, so it is very hard to get everyone in the same direction. In a multifamily house, an association of owners is often an important precondition for success.

A high temperature distribution network is more suitable for an existing area. In that case you still need to open the streets to fit in the distribution network. All the different owners must also be willing to connect the network. In most cases they already have central heating (and cooling) so it must be economical attractive to join. Lower energy rates and attractive connection fees can persuade owners.

New area development

In most of the European countries there are laws and regulations that determine good insulated buildings. When planning an area, all the buildings will be good insulated and windows have double glazing. Good insulated buildings reducing there need for heat, while the core business of an Minewater Energy Company is to supply heat (and cold) to consumers. These interests are conflicting when starting a MEC.

The passive house technology that results in ultra-low energy buildings, with very thick insulation and triple glazing, require little energy for space heating. This concept is getting more and more popular in some European countries, especially in Germany, Austria, Swiss and Scandinavia. For the economical success of a MEC there has to be found a optimum between reducing energy need and delivering enough heat to have a return on investment.

For the investment of the district network it is important to minimize the distance between the mines and the buildings and to optimise the density of occupation and building types.

Image 2: Scale model of the new compact area development Heerlerheide, Heerlen the Netherlands

Fitting the underground network

District heating systems consists of feed and return lines. When distributing heating, cooling and DWH there are three feeding lines and at least one return line. When distributing heating, the pipes must be good insulated. The primary network are big pipelines, the secondary network in the individual streets are smaller. Under the street are more cables and lines like rain water drainage, electricity cables and sewerage. In the urban design all the underground networks have to fit under the streets. All the cables and lines have to be accessible for maintenance and replacement without damaging each other. In an existing situation the fitting of the network is even more complex.

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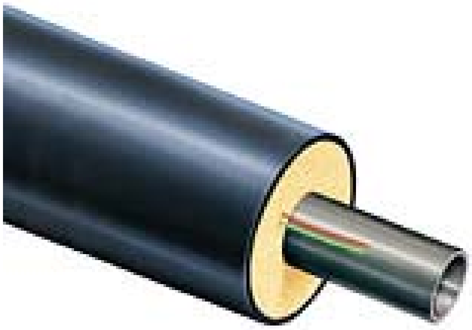
Phasing of construction
The phasing and planning of the construction is very important for the MEC. The biggest part of the investment in minewater production, energy stations and distribution network is at the start of the construction of the minewater energy system. If there is a long term urban planning it has a negative influence on the cash flow of the MEC. Long term planning can be a risk for the MEC because of a possible economical recession.

Image 3: Underground distribution network with insulated pipes



7. Legal aspects

When starting a minewater energy system, there are a lot of legal aspects to deal with. Although they can be different in all European countries the principles are comparable.

Maximum energy rates
In a lot of countries the Competition Authority legislates the protection of consumers against paying a to high energy rate if they are connected to a district heating network. It is important to check if the calculated energy rates of the MEC are conform the national legislation. Also standing fees and connection fees can be restricted by law. If there are no laws for protection the advice is to charge consumers according to the principle of business-as-usual, because of possible (European) regulation in future. The European Competition Authority is very active and has priority on the European agenda, so this can restricts tariff structures also.

Energy performance index
The performance of a renewable energy system is better than a conventional installation. For example a gas heater. Every country in Europe has energy restrictions for new buildings. With better heating and cooling performances buildings easier pass the restriction and easier reach a good energy label or a sustainable label like BREEAM or LEED. An independent performance statement with the coefficient of performance of the total renewable energy system is important for the decision of investors to connect the building to the network.

The European Commission has a proposal for a common European procedure for the Energy Performance of Buildings, the so called EPBD (Energy Performance of Buildings Directive).

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Government and European subsidy and finance
Innovative renewable energy sources can have a financial gap because of the high investments. It has risks to deal with, like unknown performances and changing of urban planning. Always check the options for governmental and European subsidy and finance. Also fiscal programmes or tax reduction for renewable energy sources can benefit the financial prognosis.

Agreements
Before starting with the tender and the construction of the minewater energy system there must be contracts with agreements between the MEC and other stakeholders to reduce risks. Important agreements are:

MPC
- multiple users of the minewater energy or monopoly for the MEC;
- price agreement of connection fee, standing fee and minewater energy price;
- quality and temperature of the minewater;
- delivery guarantees and terms.

Local authorities
- connection obligation in case of future developments or free choice;
- connection obligation in case of lot sales or free choice;
- building guarantees.

Real estate investors, building owners and consumers
- building guarantees;
- connection obligation or free choice;
- price agreement of connection fee, standing fee and energy price;
- transfer provision for future owners to ensure long term market;
- delivery guarantees and terms;
- energy performance contracts (EPC);
- technical building requirements for lowex buildings.

These agreements are very important for the economical risks of the MEC. The most important for return on investment are the number of square meters building area connected to the network. Without connections there are no revenues. So there must be a guarantee of buildings with connection obligation. Also there must be a guarantee that the buildings get build. The biggest part of the investment in minewater production, energy stations and distribution network is at the start of the construction of the minewater energy system. What for example if the minewater energy system is completed and 50% of the buildings are cancelled because of a economical crisis or the bankruptcy of a real estate investor?

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Outsourcing / DBMFO contract

When a local authority, the owner of the mines and/ or a real estate investor wants to start a MEC a good opportunity is outsourcing. There are different types of contracts. One of most common contract is a Design, Build, Finance, Maintain and Operate (DBFMO) contract. With a DBFMO contract the MEC is responsible for the whole energy system, from the design phase to the operational phase. Depending of the investment volume count on the schedule of a European tender. This is very important for the planning when developing new areas with a minewater energy system. Contractors can be installers, energy companies or a local energy corporation. Before starting a tender it is important to know:

- the main technical aspects, like the coefficient of performance;
- delivery guarantees and terms;
- building guarantees and connection obligation;
- price of connection fee, standing fee and energy price;
- technical building requirements;
- the economic feasibility and cashflow.

8. Economic feasibility and cash flow model

Before starting a minewater project one of the most important financial parameters is the internal rate of return (IRR). The IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. It is also called the rate of return (ROR). The term internal refers to the fact that its calculation does not incorporate external factors (e.g. the interest rate or inflation).

If the IRR is greater than the cost of capital, the project is economically feasible. If the IRR is less than the cost of capital, reject the project.

To calculate the IRR the cashflow must be calculated. In figure 1 there is an example of a cashflow model of a minewater energy project. The most important input for the cashflow is:

- operational period, for example 30 years;
- total cost of investment;
- maintenance and operational costs;
- revenues from energy delivery, standing fees and connection fees.

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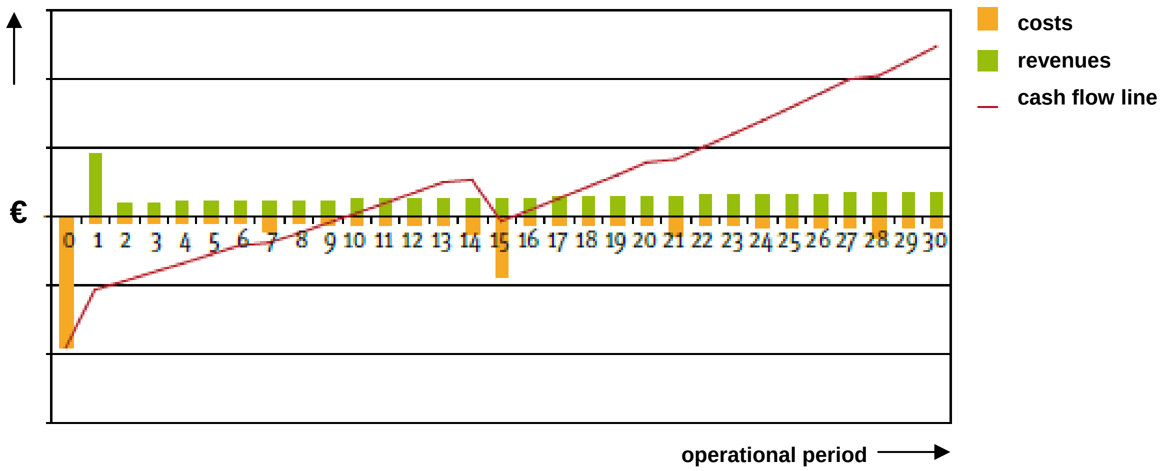
Figure 6: Cash flow model minewater energy project (example)



The cash flow model shows:

- the total cost of investments at the start of the project;
- the installation fee when the buildings connect the system in the first year;
- the yearly maintenance and operational costs;
- big repair and replacement costs after 15 years;
- the yearly revenues from energy delivery and standing fees;
- the operational period of 30 years;
- the return on investment in 9-10 years.

With a cash flow model there can be made sensitivity analyses. What happens with the IRR if:

- less buildings get connected than provided;
- building schedules are delayed;
- energy prices will increase;
- energy delivery will decrease because of better insulated buildings;
- the coefficient of performance of the minewater system differs form the calculated value;
- price of installation fees and/ or standing fees is lower because of negotiation;
- the total cost of investment changes because of a alternative installation or subsidy.

With the sensitivity analyses the risks of the project can be estimated and a good business plan can be made. A specific note on risk management and mitigation is available within Reming-lowex.

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9. Conclusions and recommendations

A Minewater Energy Company (MEC) distributes heating (and cooling) by way of a district heating network to buildings. The business model and financial forecast for minewater as a commercial energy source is of particular importance.

A clear distinction should be made between direct heating and cooling buildings by minewater on the one hand, and minewater as a thermal half fabricate which needs post processing on the other hand. Direct heating (and cooling) is strongly preferred because of the high energy savings, the clear structure of costs, low investments and less dependency on fossil fuel prices. To balance potential fluctuations of minewater temperature and flow, post processing by heat pumps is an option.

In the whole process of developing a district heating network with use of geothermal energy of the minewater there are different stakeholders to deal with. Al the stake holders have different incentives. Working together in a team and transparency are the only way to make a Minewater Energy Company (MEC) to a success. The most important stakeholders are:

- minewater Energy Company (MEC);
- minewater Production Company (MPC);
- local authorities;
- the (intended) owners of the buildings;
- development Manager;
- consumers.

A public-private partnership (PPP) or outsourcing (DBFMO contract) can be a good construction starting a MEC. Before starting with the tender and the construction of the minewater energy system there must be at least a letter of intent, but preferably contracts with agreements between the MPC, the MEC and other stakeholders to reduce risks. Important agreements are:

MPC
- multiple users of the minewater energy or monopoly for the MEC;
- price agreement of connection fee, standing fee and minewater energy price;
- quality and temperature of the minewater;
- delivery guarantees and terms.

Local authorities
- connection obligation in case of future developments or free choice;
- connection obligation in case of lot sales or free choice;
- building guarantees.

Real estate investors, building owners and consumers
- building guarantees;
- connection obligation or free choice;
- price agreement of installation fee, standing fee and energy price;
- transfer provision for future owners to ensure long term market;
- delivery guarantees and terms;

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- energy performance contracts (EPC);
- technical building requirements for lowex buildings.

These agreements are very important for the economical risks of the MEC. The most important for return on investment are enough connections of buildings to the network. Without connections there are no revenues.

A cash flow model is a good instrument to investigate the economical feasibility in an early stage of the project and to calculate the internal rate of return (IRR). With a cash flow model there can be made sensitivity analyses. With the sensitivity analyses the risks of the project can be estimated and a good business plan can be made. Most important parameters are:
- the total cost of investment;
- price of connection fees, standing fees and energy price for heating and cooling;
- building guarantees and connection obligations;
- building schedules;
- the increase of (fossil) energy prices;
- legislation on the tariff structure for end-users;
- type of buildings and energy demand (e.g. quality of insulation);
- the coefficient of performance of the minewater system;
- the temperature and quality of the minewater after long term exploitation.

The heat losses in the distribution network and pump energy for the distribution network are very important for the operational costs and the total coefficient of performance of the minewater energy system.

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Annex I: Case studies

Case 1: Heerlen, the Netherlands

Recently the town of Heerlen in the south eastern part of the Netherlands repurposed an old abandoned coal mine into a source of geothermal energy for heat and cold storage. The system went online in 2008 and provides the new developed area Heerlerheide and the main office of the CBS in Heerlen town of heating in the winter and cooling in the summer. A Public-Private Partnership (PPP) between the local authority and a local social housing corporation during the pilot phase was crucial and made this project possible.

In the Netherlands, coal was one of the main sources of energy from the turn of the century up until around 1959, when large amounts of cheap natural gas were discovered in the north. The coal industry lost market share and mine after mine was closed down – in the city of Heerlen, for instance, the last coal mine was closed in 1974 and the underground system of galleries, panels and shafts were flooded with water.

The minewater project in Heerlen makes use of an abandoned site, essentially coalfield, and uses the naturally occurring geothermal heat to warm the water that has flooded the underground mines. Five new wells were drilled in various locations around town to access the underground mine shafts. Each well is 700 meters deep and can pump out nearly 80 cubic meters of water per hour. The minewater temperature at the bottom of the well is about 30ºC and gradually cools to 28ºC at the surface. The temperature of the minewater is in between low and mid temperature.

The Minewater Production Company (MPC) brings the minewater to a energy station of the Minewater Energy Company (MEC). In the station a heat pump extracts the heat out of the minewater in order to supply energy for heating the buildings in the direct area. Meanwhile the minewater is pumped back down 450 meters to be reheated. In the summer, to provide cooling, water will be pumped from a much shallower depth of 250 meters, where it is not so warm. The heat pump cools down the water temperature so it can be used for cooling the connected buildings.

The area supplied by the Minewater is a new development area and includes a supermarket and a brand new cultural centre and library. All buildings are placed in a very compact area – ideal for energy distribution – and are situated between two warm wells. Most of them are residential buildings, in total 170 apartments. For DHW, every residential building has his own gas heater to upgrade the heat from the energy station from 45ºC to 70ºC.

The MPC delivers the minewater to the CBS heath quarter office (21.000 m^2) al the location Stadspark Oranje Nassau in Heerlen city, without using the energy station of the MEC. The CBS has his own heat pump system to upgrade the minewater temperatures.

Image 1: Heerlerheide: Cultural centre with integrated energy station and minewater project information centre

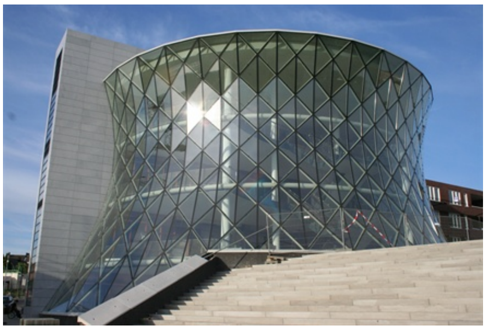


Image 2: CBS heath quarter office Stadspark Oranje Nassau Heerlen

Special in this project is that the main investors, the local social housing corporation Weller, is also the owner of the MEC ('Weller Energie BV'). Weller had during the pilot phase a close collaboration with the municipality of Heerlen, who is owner of the MPC ('Corio Energy NV'). This was important for the realization phase of the project. This construction makes lower internal interest rates and profits from selling energy not as core business possible.

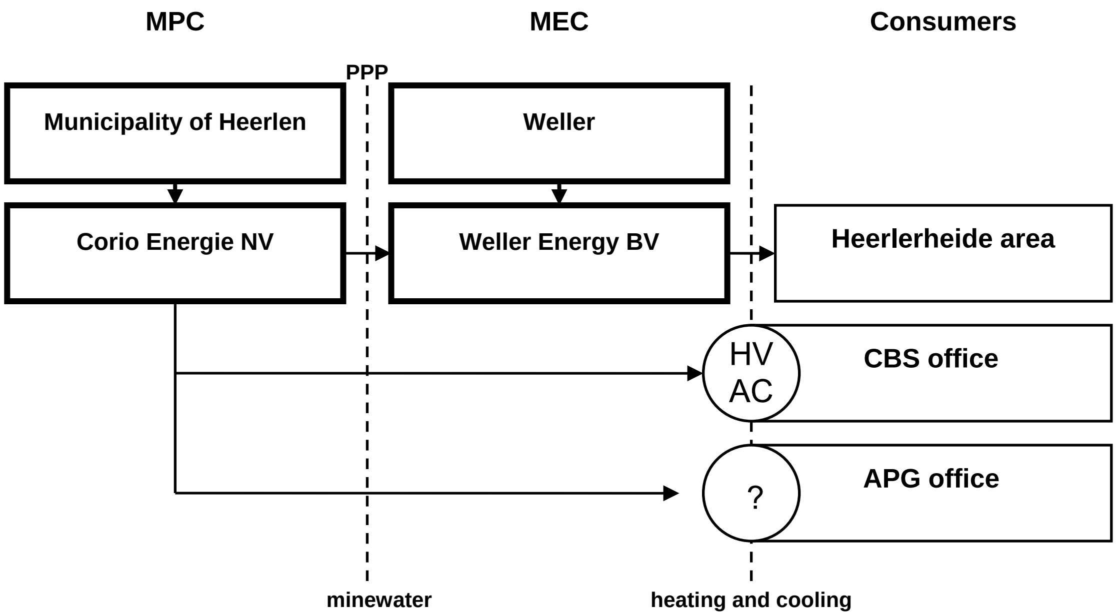
Around 70% of the residences are rent in the social sector. The commercial residences are sold to private owners and a investor. A residential building (elderly home) in the same area owned by an investor company decided not to connect the system. The connection guarantee of 170 houses, a supermarket and the culture centre was enough for Weller to start the project.

For the municipality of Heerlen the development of Heerlerheide area and some office developments in the town of Heerlen were enough guarantees to continue the project from a pilot to a commercial phase. The only office that is actually connected is the CBS in 2009. Some other office developments are still under negotiation to connect to the MPC.

Another office, the APG head quarter is an existing office building that is renovated. The building is insulated and lowex (climate ceilings), so the building is suitable for connection. The necessary pipeline to the south of Heerlen is already constructed

This case illustrates that agreements on building guarantees and connection obligations at the start of the project are essential for the economical feasibility.

Figure 1: Stakeholders minewater project Heerlen, the Netherlands



Case 2: Cherno More, Bulgaria

Cherno More mine is located in the south eastern part of Bulgaria, northwest of Burgas city. The mine consists of three coalfields which were abandoned between 1972 - 1988 after more than 50 years of exploitation.

A potential consumer of the minewater is a private furniture factory located near a existing vertical shaft where the water can be extracted. At the bottom of the vertical shaft the water temperature is 15 °C. The furniture factory ABV & sons is heated by a incinerator, residual waste of the furniture production is used as fuel. Because of environmental issues this heating system needs to be replaced. The furniture factory has a total floor area 935 m^2, including some small office rooms. The factory is already insulated. The building is heated by plate and tube heaters and air heaters, but these are not used because of the dust spreading. At the moment there is no cooling available, however there is a cooling requirement. Ventilation takes place by natural ventilation.

With a heat exchanger a heat pump can be connected to the mine shaft. From the schaft to the heat pump in the factory a non insulated feed and return pipeline has to be constructed. For the cold period a fossil fuel peak boiler can be installed. The minewater of 15°C is directly useful for cooling. For the lowex distribution of the heat and cold in the factory cotton ventilation pipes can be used. There is calculated that the energy bill will decrease with 67% comparable with the installation of a fossil fuel boiler.

After a economical feasibility assessment with a cash flow model and sensitivity analyses the owner of the factory can decide to make the investment in the heat pump installation. Another option is to find an Exploitation Company to finance, maintain and operate the installation.

Because there is a single tenant user an ESCo can be a good opportunity. Because of the small scale of the building it can be that the business case is not interesting for an Exploitation Company.

Image 3: Furniture factory ABV & sons Cherno More, Bulgaria

Case 3: Czeladź, Poland

Czeladź is one of the oldest towns in the Upper Silesian Coal Basin as well as in Poland. The town is located in the central part of the region, in the Silesian Conurbation near its capital Katowice. The Saturn coal mines are still in use. To dehydrate the mines there is a underground pumping station, where minewater is pumped out of the mine. From the shaft there is a pipeline to the river to discharge the water.

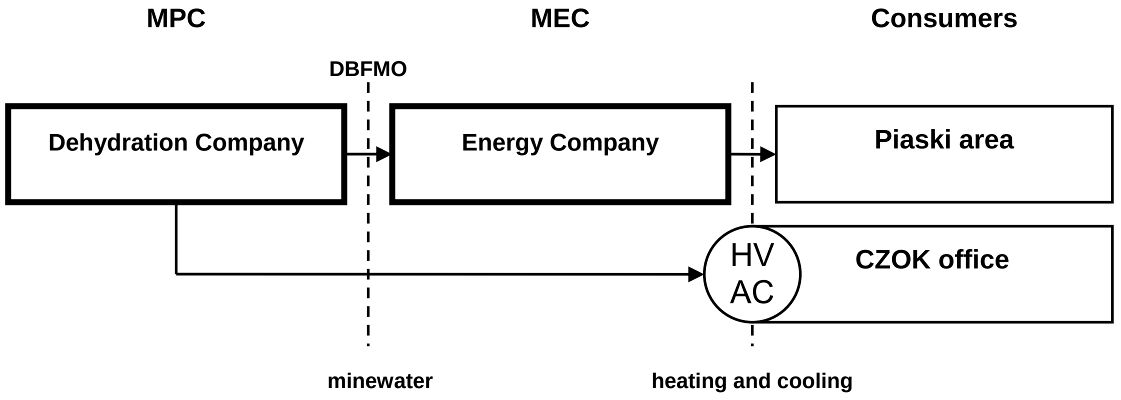
There are two possible sites where the minewater can be used for heating and cooling: the new Piaski area which is planned in the south-eastern part of Czeladź as well as the office modernization of the Central Plant of the Dehydration Company, the CZOK office. These two locations are situated close to the pipeline.

The Saturn minewater pipeline is located near the Piaski area, where extended real estate development is planned. It is a district of around 300 residential apartments, some commercial and cultural buildings and a school. The new area development is comparable with the business case in Heerlerheide, the Netherlands. The big advantage at this spot is that there is no investment necessary in a Minewater Production Company (MPC), because minewater of 12°C to 14°C is available, as a result of the dehydration. This is perfectly usable for a heat pump system.

The most important stakeholders are the real estate investor and the Dehydration Company. At the moment the development is on hold. If the investor can give a building guarantee, the economical feasibility is high potential. After a economical feasibility assessment with a cash flow model and sensitivity analyses a tender of the Minewater Energy System can start.

A tender with a DBFMO contract is very suitable in this business case. Other option is to start a MEC with local stakeholders (e.g. the Dehydration Company and a investor).

Figure 2: Stakeholders minewater project Czeladź, Poland



The second option is the existing CZOK office. A potential target group for minewater heating and cooling are commercial buildings, especially office buildings with a relatively high cool demand which can be fulfilled with minewater. The minewater of 12°C to 14°C is directly useful for lowex cooling.

The office building was built during Soviet time with a floor area of around 1900 m^2, divided over two floors and a poor energy efficiency. There is a plan for the modernisation of the office building includes also an improvement of the energy efficiency and thermal comfort. The owner first must get the building lowex (insulation, double glazing and low energy distribution system). Wit a heat exchanger a heat pump can be connected to the minewater pipeline. For the cold period a fossil fuel peak boiler can be installed. The minewater of 12°C to 14°C is directly useful for cooling.

The only stakeholder is the Dehydration Company itself, so that makes this case less complex. After an economical feasibility assessment with a cash flow model and sensitivity analyses the Dehydration Company can decide to make the investment in the heat pump installation and save on energy costs. Another option is to find a Exploitation Company to finance, maintain and operate the installation. Because there is a single tenant user an ESCo can be a good opportunity.

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