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OPTIONS FOR ENERGY CASCADING AND HEAT DEMAND MANAGEMENT AT BALMATT

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Summary

Energy cascading strategies can maximize the energetic efficiency of geothermal systems. Energy cascading corresponds to a stepped use of heat in function of the temperature; subsequent energy demanding processes are fed by with excess energy from a previous step.

The current study defines the options for energy cascading regarding the Balmatt geothermal plant. These options are based on an inventory of heat demand in the vicinity of the plant. The area around the Balmatt geothermal plant comprises several (large) heat consumers that could satisfy their heating needs through a heating network, fed by the geothermal plant. The heating demand of these consumers differs regarding temperature level and annual consumption. Based on the location of the potential heat consumers, three options for energy cascading are proposed. These options are identified by using rough data and estimations on the heating demands.

To evaluate the technical feasibility of energy cascading, each option should be investigated more into detail. Therefore, heat and temperature profiles of the different consumers are needed.

CHAPTER 1: Introduction

Energy cascading strategies can maximize the energetic efficiency of geothermal systems, taking into account both the utilization of the source, internal energy consumption of the geothermal plant and energy losses. Cascading results in lower injection temperature and hence better utilization of the geothermal source. However, when evaluating options to lower the injection temperature, one also has to take reservoir specific processes into account, i.e.:

- Precipitation of dissolved substances from the brine which can lead to clogging of the Installations, wells and porosity;
- Thermal stress within the subsurface;
- Thermal breakthrough.

These effects are not evaluated in the current report. The first step is to define possible cascading schemes based on the demand from nearby heat consumers. The current report gives an overview of the heat demand in the vicinity of the Balmatt geothermal plant that already is or can be connected to a district heating grid. Based on the inventory, energy cascading options are defined.

CHAPTER 2: Potential heat consumers

This section gives an overview of heat consumers in the vicinity of the Balmatt geothermal plant. The selection of these heat consumers is based on the following criteria:

- Because the investment cost of a heat network is significant, a lower threshold of 5.000 MWh heat consumption per year for potential connections is taken into account.
- For the same reason, the geographical focus is limited to about 6 km radius.
- Only B2B ('business-to-business') heat consumers and residential areas with collective heating are targeted.

This selection is based on the complex steps that must be followed for the development of a district heating network. In the first step it will be the large (B2B) heat consumers that should secure technically and financially the back-bone of the district heating network. Afterwards in the second phase the back-bone can be extended by the smaller (mostly B2C 'house holds') heat consumers. In general, the extension of a district heating network will be very organic.

Information about the (potential) heat consumers is collected through polls, questionnaires, surveys and face-to-face interviews. Data regarding individual heat consumers are generalized by using data ranges instead of detailed numerical data, for reasons of confidentiality.

A short description of the potential heat consumers is given, including some technical details, if available. For each consumer, relevant data on heat consumption is listed:

- The annual and peak heat demand, based on historical energy data and/or estimations. Only a range is reported, expressing a lower and upper value between which the annual and peak heat demand are situated.
- The working temperature, indicated as high or low. The classification low/high cannot be defined unambiguously because we only have details about the operating temperatures for a few consumers. However, this is important for energy cascading. That is why we have assessed the working temperature qualitatively. Low/high is often an estimation based on the technical installations, age of the building and others. For example, if a condensing gas boiler is used, we consider this as low temperature system; a non-condensing boiler on the other hand will be high temperature. High temperature heat consumers are to be connected to the supply side of the heating grid, while low temperature heat consumers could possibly be located at the return side of the heating grid.
- Distance to the geothermal plant, straight measured.
- Type of heat consumer.

Molse Bouwmaatschappij

Molse Bouwmaatschappij wants to realize a high-quality supply of affordable housing in a livable living environment in the municipalities of Mol and Balen. In the village of Mol-Donk, Molse Bouwmaatschappij has developed a site together with the municipality in which a primary school, a church and a very outdated parish hall with adjoining café have been converted into 46 social dwellings and a meeting house. In preparation for the connection with the geothermal power plant (GEO@VITO), Molse Bouwmaatschappij has already connected all homes via an internal heat network fed by a central gas-fired boiler.

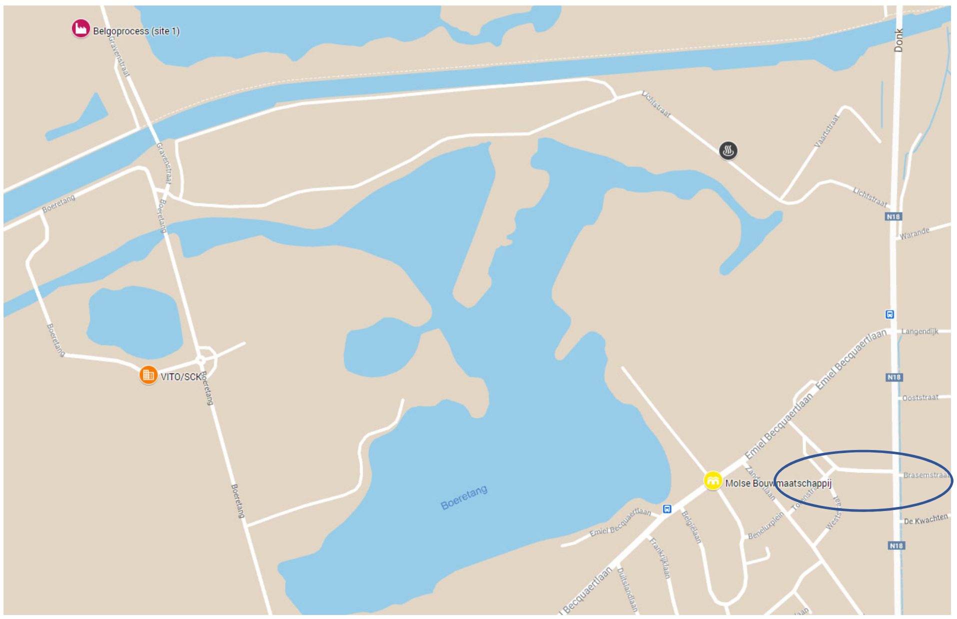

Figure 1: Location Mol-Donk

Data on the heat consumption:

Molse Bouwmaatschappij	
Heat demand, yearly	< 1 GWh
Heat demand, peak	< 1 MW
Working temperature	low
Distance to Balmatt	0,7 km
Heat consumer type	residential

JRC-site Geel

JRC-site Geel is one of the six scientific sites of the European Commission's Joint Research Centre (JRC). Heat is produced in a central boiler house. The heat is transported towards the buildings through an internal district heating grid. The internal district heating grid consist of 3 closed circuits. Two of the circuits serve IRMM buildings and one circuit leads towards the biology department of VITO. The central boiler house contains 3 non-condensing gas boilers.

Figure 2: JRC-site Geel[1]

Data on the heat consumption:

JRC-site Geel	
Heat demand, yearly	5-10 GWh
Heat demand, peak	1-5 MW
Working temperature	high
Distance to Balmatt	5,7 km
Heat consumer type	offices, labs

[1] https://visitors-centre.jrc.ec.europa.eu/en/media/photos/jrc-geel-belgium

European School Mol

This school complex comprises a primary school, secondary school and a nursery school, as well as gymnasium and swimming pool, canteen, dormitories etc. A few years ago, they replaced all non-condensing gas boilers by condensing gas boilers except the boilers for the swimming pool (25mx10m). The boiler house of the swimming pool contains 3 non-condensing gas boilers and 1 light-fuel boiler.

Figure 3 European School Mol[2]

Data on the heat consumption:

European School Mol	
Heat demand, yearly	1-5 GWh
Heat demand, peak	1-5 MW
Working temperature	high/low
Distance to Balmatt	5,3 km
Heat consumer type	school, swimming pool

[2] https://www.groepvanroey.be/nl/referentieprojecten/europese-school-mol

Belgoproces (Site 1)

Belgoprocess (site 1) has an internal steam network (maximum pressure 12 bar, operating pressure 7 bar) which is fed by 2 steam boilers. More than 95% of the steam production is used for space heating, the rest is used for liquid transport (radioactive materials) using steam jets. In the future, space heating could potentially be converted from steam to hot water.

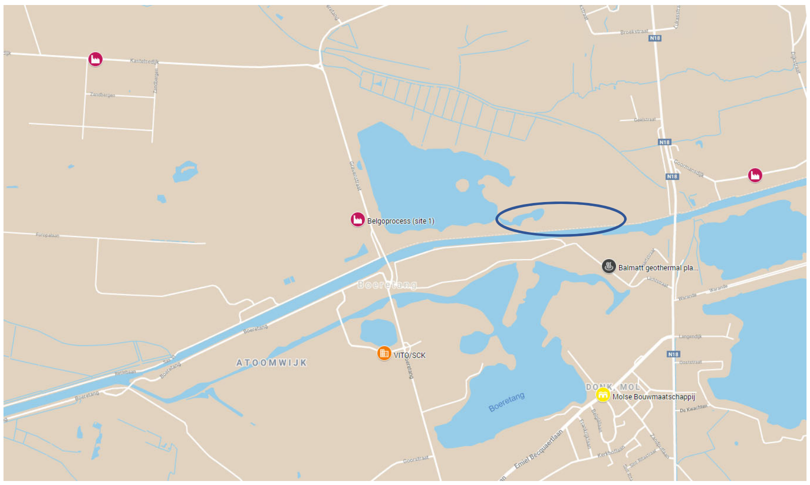

Figure 4: Location Belgoproces (Site 1)

Data on the heat consumption:

Belgoproces (Site 1)	
Heat demand, yearly	15-20 GWh
Heat demand, peak	5-10 MW
Working temperature	high
Distance to Balmatt	1,7 km
Heat consumer type	industrial

Industrial site 'Goormansdijk'

This industrial area contains several SME's that mainly need space heating. Only one company uses heat to dry minerals on site:

- Bandencentrale Wuyts
- Clevr/Belcotec
- Cleantrans/Detraco
- Marcel Cars
- Deckx algemene onderneming
- Deckx Services
- Deckx elektromechanica
- Tielen groep
- Peeters ramen en deuren
- Elektroplan
- Plastiekbouw peeters
- Adesco
- Innotec

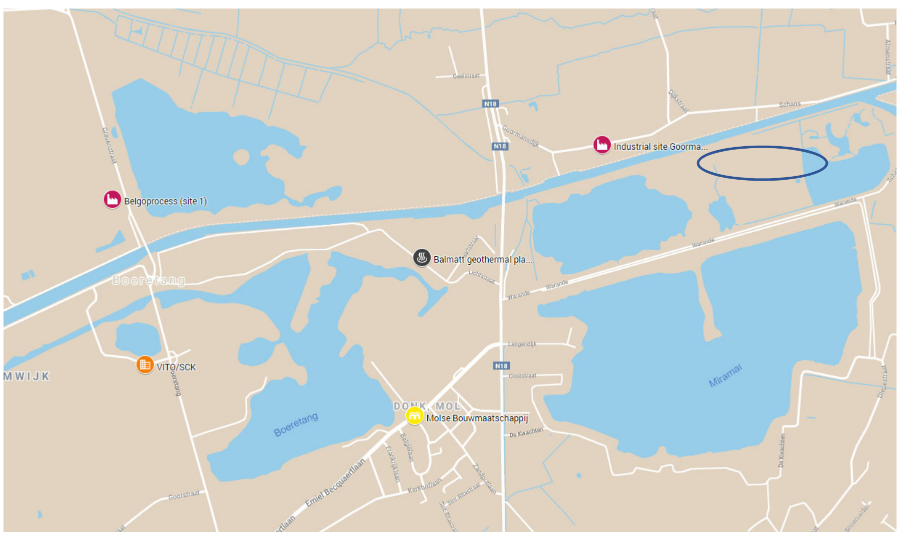

Figure 5: Location industrial site 'Goormansdijk'

Data on the heat consumption:

Industrial site 'Goormansdijk'	
Heat demand, yearly	1-5 GWh
Heat demand, peak	< 1 MW
Working temperature	high
Distance to Balmatt	1,4 km
Heat consumer type	industrial

Industrial site 'Kastelse dijk'

This industrial area contains several SME's that solely need space heating:

- Alu service
- Hout Feyen
- Bedrijvencomplex 'Smet'
- Offinie Printing
- OMG
- TC Design
- Unidoor

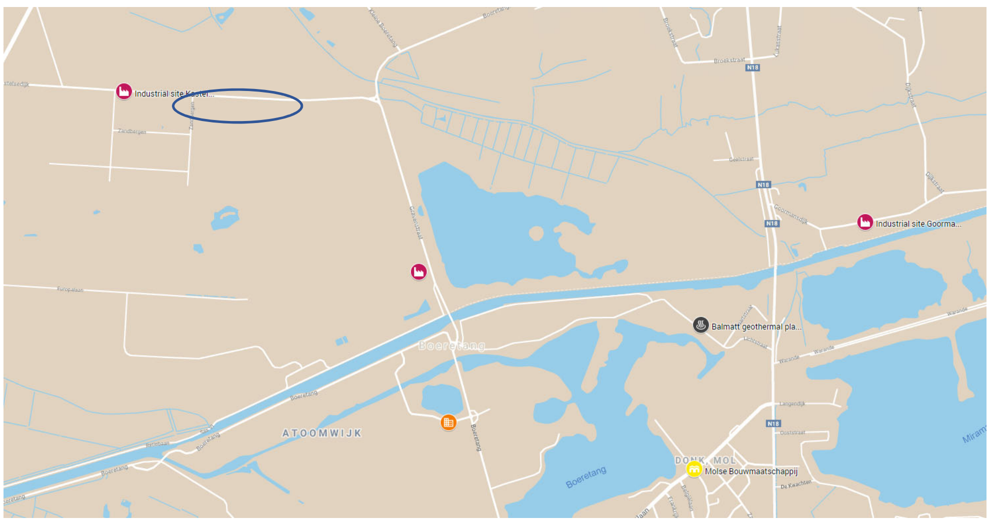

Figure 6: Location industrial site 'Kastelse dijk'

Data on the heat consumption:

Industrial site 'Kastelse dijk'	
Heat demand, yearly	< 1 GWh
Heat demand, peak	< 1 MW
Working temperature	high
Distance to Balmatt	3,3 km
Heat consumer type	industrial

De Ark

De Ark is a social construction company and rents out approximately 2.600 homes in the regions of Arendonk, Baarle- Hertog, Balen, Beerse, Dessel, Hoogstraten, Kasterlee, Lille, Merksplas, Mol, Oud-Turnhout, Ravels, Retie, Rijkevorsel, Turnhout and Vosselaar. In 2019/2020, Fluvius installed a district heating network in the residential zone Brasel in Dessel. In anticipation of the energy from GEO@VITO the network is currently fed by a gas-fired boiler. A total of 164 residential units will be connected to the heat network.

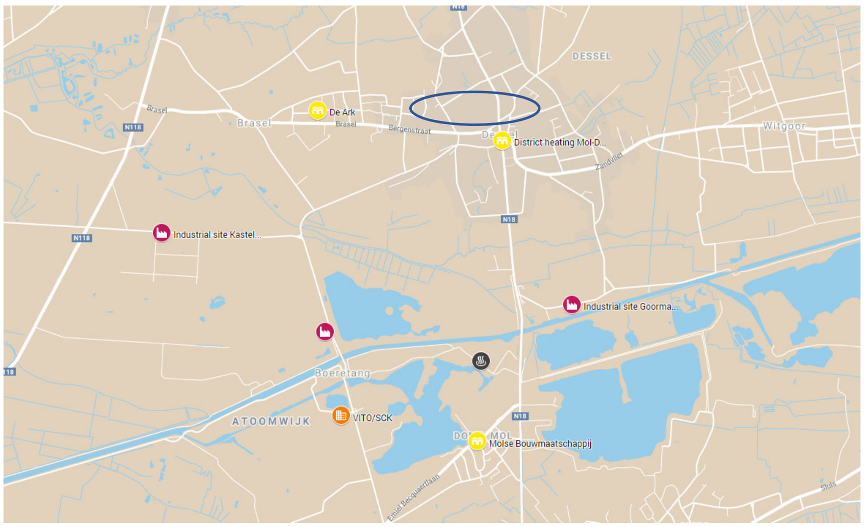

Figure 7: Location 'De Ark'

Data on the heat consumption:

De Ark	
Heat demand, yearly	1-5 GWh
Heat demand, peak	1-5 MW
Working temperature	low
Distance to Balmatt	2,0 km
Heat consumer type	residential

Sun Parcs

Sun Parcs 'Kempense meren' is a leisure parc located in Mol near the biggest land-locked lake. The heated area can be divided into three parts.

- The reception and technical unit only have a heat demand for space heating. Both buildings use a gas-fired boiler, connected to a convectors delivery system.
- The main building includes a swimming pool, a hotel and a shopping arcade and amusement centre. This is the biggest heat demand due to the presence of a subtropical swimming pool. There are 3 boilers in the main building that produce water at approximately 85 ° C. This water is sent through the building in a main circuit. The return temperature is around 75°C. The water of the swimming pool is heated to 30°C and remains at 28°C during the night.
- There are 600 holiday homes on the domain. The houses have limited insulation and all have a combi boiler. The houses are always (occupied or unoccupied) kept at a minimum temperature of 12°C. The boilers were all replaced about 5 years ago. The houses are all equipped with convectors on the 80/60 regime, but they are switching to radiators, because of comfort issues.

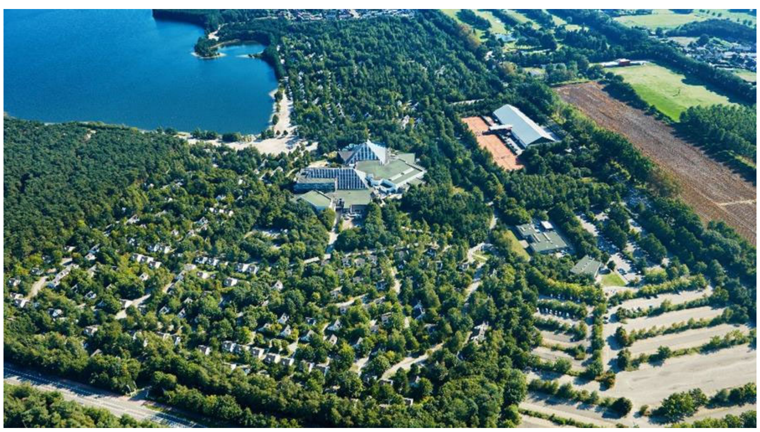

Figure 8: Sun Parcs Kempense meren[3]

Data on the heat consumption:

Sun Parcs	
Heat demand, yearly	5-10 GWh
Heat demand, peak	15-20 MW
Working temperature	high
Distance to Balmatt	6,0 km
Heat consumer type	leisure parc

[3] https://toerisme.gemeentemol.be/aanbod/288/vakantiepark-sunparks-kempense-meren

Mol city centre

The city centre of Mol comprises about 8 relatively large heat consumers, all tertiary buildings like a hospital, schools etc:

- Hospital Mol
- Gemeenschapsinstelling De Markt
- Gemeenschapsinstelling De Hutten
- Campus Het Spoor
- Campus Rozenberg
- Campus St-Lutgardis
- Campus TISP
- Campus SJB

Data on the heat consumption:

Mol city centre	
Heat demand, yearly	10-15 GWh
Heat demand, peak	15-20 MW
Working temperature	high
Distance to Balmatt	4,1 km
Heat consumer type	hospitals, schools and other

Industrial site 'Hofstede'

The industrial area ‘Hofstede’ comprises three SME’s that mainly need space heating:

- Lidwina a social workplace that employs persons with mental or physical disabilities;
- VDL KTI, a member of VDL Groep, specializes in design and production of equipment for the oil, gas, and petrochemical industries since 1971;
- Eriks, a specialized industrial service provider.

Data on the heat consumption:

Industrial site 'Hofstede'	
Heat demand, yearly	1-5 GWh
Heat demand, peak	1-5 MW
Working temperature	high
Distance to Balmatt	3,8 km
Heat consumer type	industrial

Balmatt building

The Balmatt building will be a newly established building located on the same grounds as the geothermal power plant for VITO employees. Currently, 13.800 m² are foreseen for workplaces, meeting rooms, auditory, entrance, restaurant etcetera (office area) and 4.700 m² are foreseen for laboratories. A heat demand of 70 kWh(th)/m²/year is assumed for the office area while the tenfold is foreseen for the laboratories. These numbers are based on Dutch reference numbers for office buildings. The resulting heat demand is about 3.030 MWh/year. The connection capacity that is foreseen for the office area equals 40 W/m² and the tenfold is foreseen for the laboratories. A low temperature heat delivery system will be foreseen in the building.

Figure 9: Balmatt building[4]

Data on the heat consumption:

Balmatt building	
Heat demand, yearly	1-5 GWh
Heat demand, peak	1-5 MW
Working temperature	low
Distance to Balmatt	0,2 km
Heat consumer type	offices, labs

[4] Technical evaluation of the Balmatt geothermal project

VITO/SCK

VITO and SCK are two research institutes located at a distance of 1,8 km of the geothermal power plant. Their buildings (office buildings + laboratories) are interconnected with a local heating grid in which Belgoprocess is also coupled. Heat could be injected in the local heating grid. The temperature regime of the heating grid has a seasonal dependency and varies between 95°C/80°C at -10°C ambient air temperature and 65°C/60°C at 20°C ambient air temperature.

Figure 10: Location VITO/SCK

Data on the heat consumption:

VITO/SCK	
Heat demand, yearly	> 20 GWh
Heat demand, peak	10-15 MW
Working temperature	high/low
Distance to Balmatt	1,8 km
Heat consumer type	offices, labs

District heating Mol-Dessel

A potential district heating grid covering Mol-Dessel could contain 1000 new dwellings, coupled to this grid. Based on the restrictions for new buildings, the heat demand for these 1000 residential dwellings is estimated at about 15.000 MWh/year. It is assumed that it will be a low temperature district heating grid.

Figure 11: District heating Mol-Dessel[5]

Data on the heat consumption:

District heating Mol-Dessel	
Heat demand, yearly	10-15 GWh
Heat demand, peak	5-10 MW
Working temperature	low
Distance to Balmatt	1-3 km
Heat consumer type	residential

[5] https://www.dessel.be/warmtenetdessel

Overview of heat consumers

This map gives an overview of the heat consumers and their location relative to the geothermal plant.

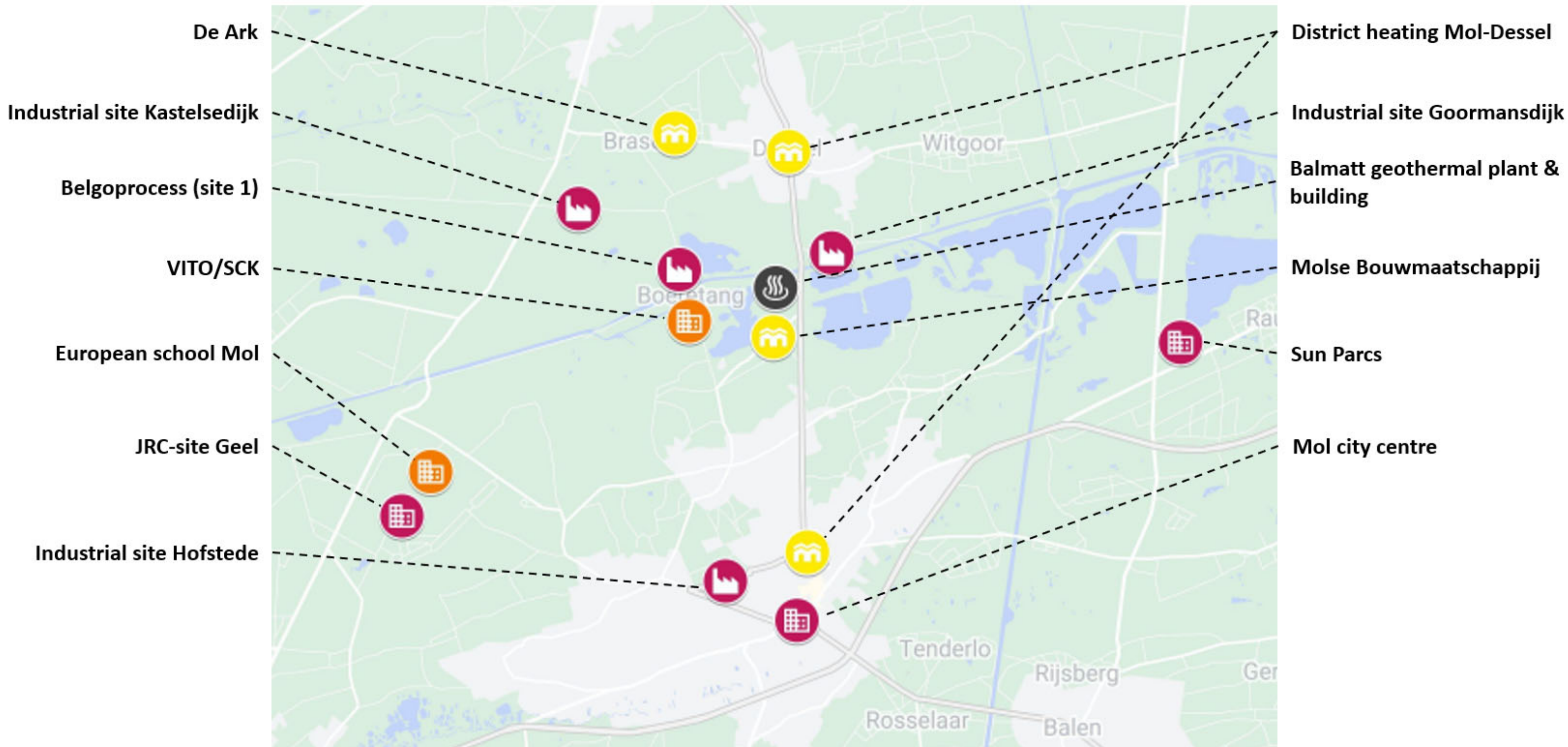

Figure 12: Overview of heat consumers.

All together these consumers represent a yearly heat demand of 109,1 GWh. The peak heat load is about 73 MW. Note that this peak is calculated with a simultaneity of 100%. In other words, all heat consumers experience their individual peak at the same moment in time.

CHAPTER 3: Energy cascading

High system temperatures in district heating networks lead to fairly substantial heat distribution losses and reduce the potential of renewable sources of energy and of waste heat from industry, as well as the efficiency of conventional production facilities. The temperatures in district heating networks are determined by different aspects:

- The (maximum) heat demand and temperature(range) requirements of the consumers;
- The working temperature of the production facilities;
- The temperature drop caused by consumers, due to heat delivery;
- The amount of heat transported through the network.

Some heat consumers require a high supply temperature in order to satisfy their heat demand. For other heat consumers a lower supply temperature is sufficient. Whether a high or low supply temperature is needed depends on several aspects: design and management of the heating system, temperature setpoints in the building, seasonal effects, etc.

In case both high and low temperature heat consumers are to be connected to one common heating grid, energy cascading can be considered. Energy cascading is about balancing the temperature levels of heat production, distribution and consumption. Energy cascading corresponds to a stepped use of heat in function of the temperature; subsequent energy demanding processes are fed by with excess energy from a previous step. This means that low temperature heat consumers are supplied through the return line of a high-temperature district heating network, which further reduces the return temperature of this network. A lower return temperature:

- Results in lower heat losses in the system;
- Improves the efficiency of heat production;
- And enables the use of low temperature heat sources.

Therefore, the concept of energy cascading could be a solution for the transition from high to low temperature district heating networks, as it combines both high and low temperature heat consumers.

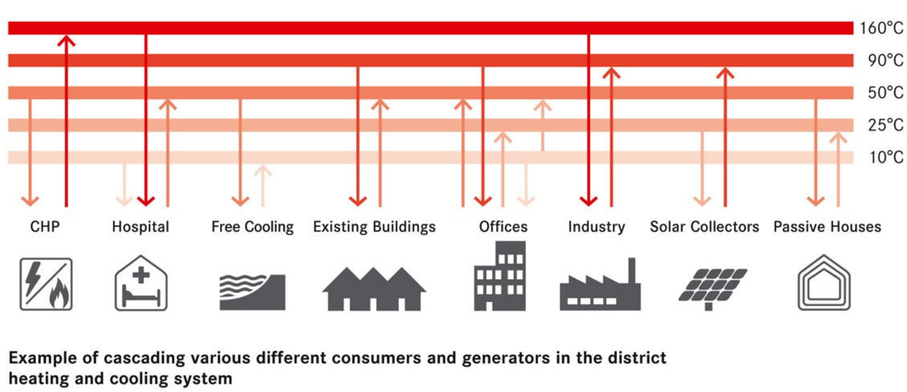

Figure 13: Energy cascading concept6

[6] https://www.energy-innovation-austria.at/wp-content/uploads/2015/04/eia_01_15_E_FIN.pdf

In this section we investigate the possibilities of energy cascading related to the potential heat consumers in the vicinity of the Balmatt geothermal plant, identified in the previous chapter. The basic idea is that high temperature heat consumers could their heat from the supply side of the heating network, which is at high temperature. On the other hand, consumers that are suitable for low temperature heating could receive heat from the return side of the heating network, which is at lower temperature. Therefore, we do the following steps:

- Identify heat consumers at low temperature.
- Look for high temperature heat consumers that are located close to these low temperature heat consumers. Together these low and high temperature heat consumers could form an energy cascade.
- For each option for energy cascading, we check if the heat consumption (ranges) within the energy cascade match with each other. The low temperature heat at the return side of the heating grid must meet the heat demand of the low temperature consumer.

The following figure shows which of the potential heat consumers is considered to be a low temperature heat consumer. Considering the location of these low temperature heat consumers, we identify three possible options for energy cascading. These are discussed further in this chapter.

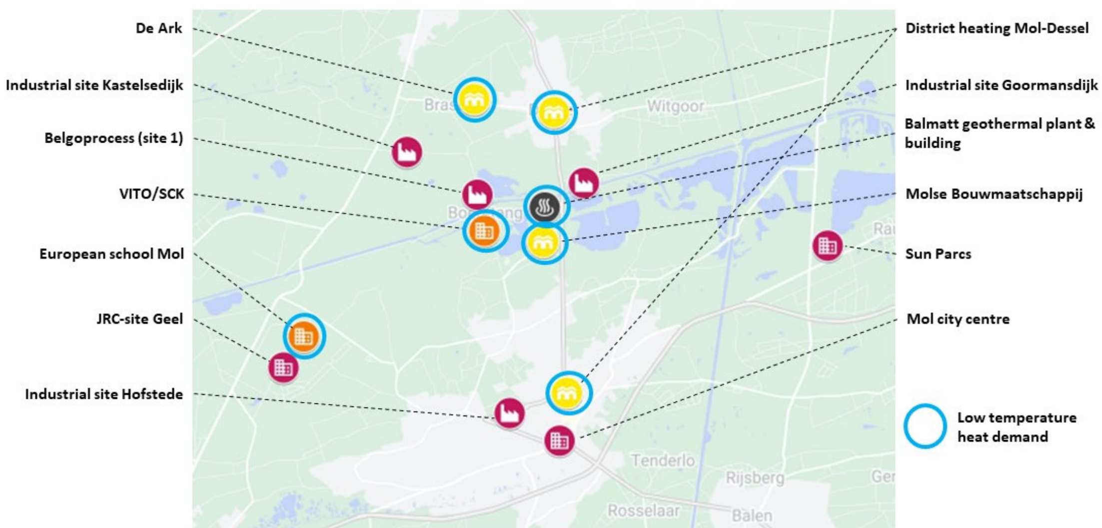

Figure 14: Low temperature heat consumers

Energy cascading, option ‘JRC’

The energy cascading option ‘JRC’ includes European school Mol and JRC-site Geel:

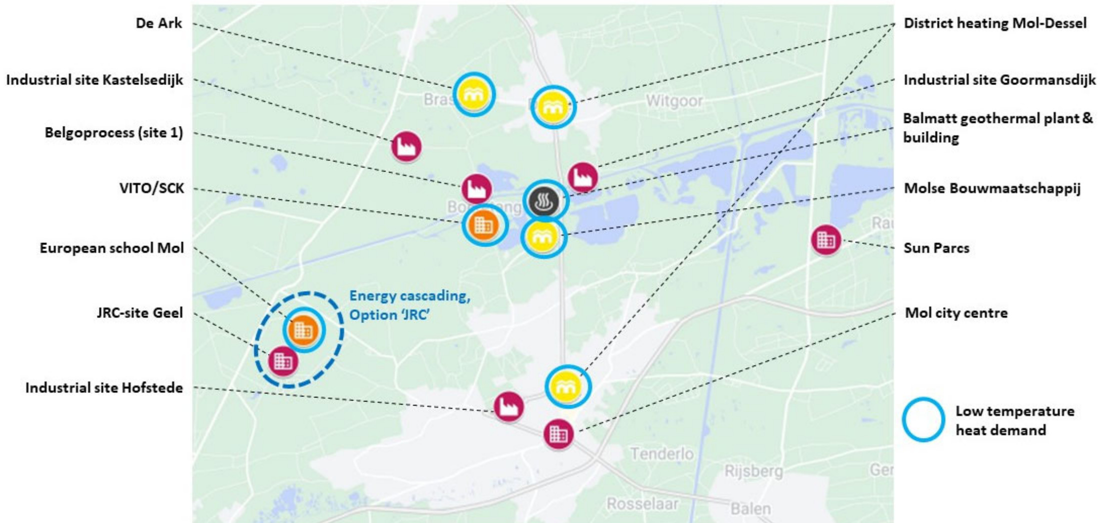

Figure 15: Energy cascading, option 'JRC'

European school Mol uses a combination of condensing and non-condensing gas boilers. We consider the heat from the condensing boilers as low temperature heat. The heat originating from the condensing boilers (used for the swimming pool) is considered to be high temperature heat. The overall heat consumption ranges between 1 to 5 GWh/yr.

JRC-site Geel is located nearby. Only non-condensing gas boilers are used, so we consider the heat demand the be at high temperature. The heat consumption ranges between 5 to 10 GWh/yr, so higher than for European school Mol. Therefore, energy cascading could be feasible here.

Energy cascading, option 'Mol'

The energy cascading option 'Mol' includes Mol city centre, district heating Mol-Dessel and the industrial site Hofstede.

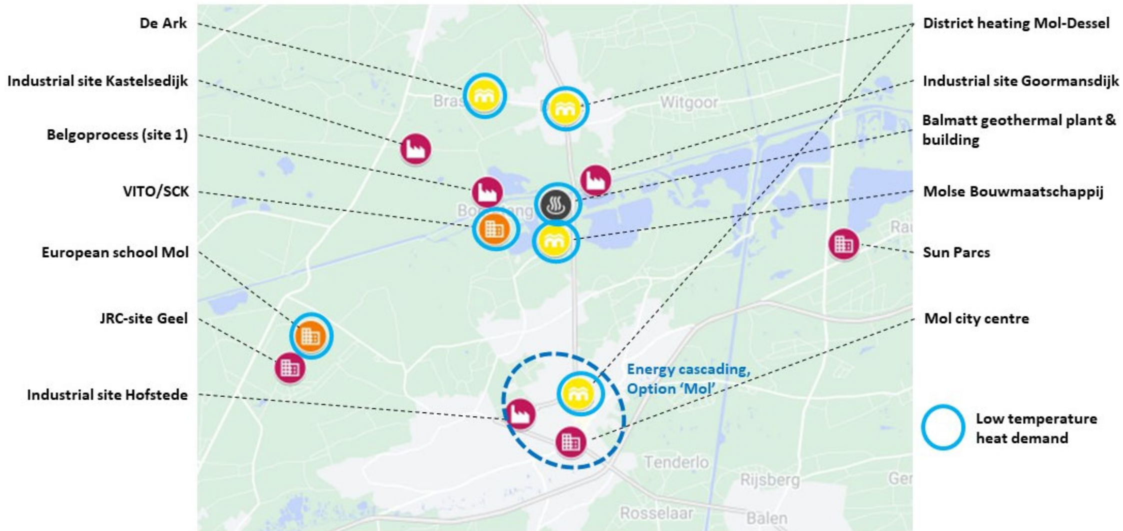

Figure 16: Energy cascading, option 'Mol'

The yearly heat demand of the district heating network Mol-Dessel ranges from 10 to 15 GWh. This is an estimation of the network as a whole. For the current cascading option however, we only consider the part of the network that is located in or close to the city centre of Mol. We estimate this part at 5 to 10 GWh/yr.

The heat demand of the large tertiary buildings at the city centre of Mol ranges from 10 to 15 GWh/yr. (These building are not connected to the heating network Mol-Dessel.) We don't have information on these buildings regarding their temperature regimes, but we consider that these buildings generally don't have recent heating installations and therefore require high temperature heat. If that is the case, the heat at the return side could match with the heat demand of the district heating network Mol-Dessel.

The industrial site Hofstede has a relatively small heat demand, so it would not fit in this energy cascade, unless the additional cost of connecting is limited.

Energy cascading, option 'Boeretang'

The energy cascading option 'Boeretang' includes several different heat consumers:

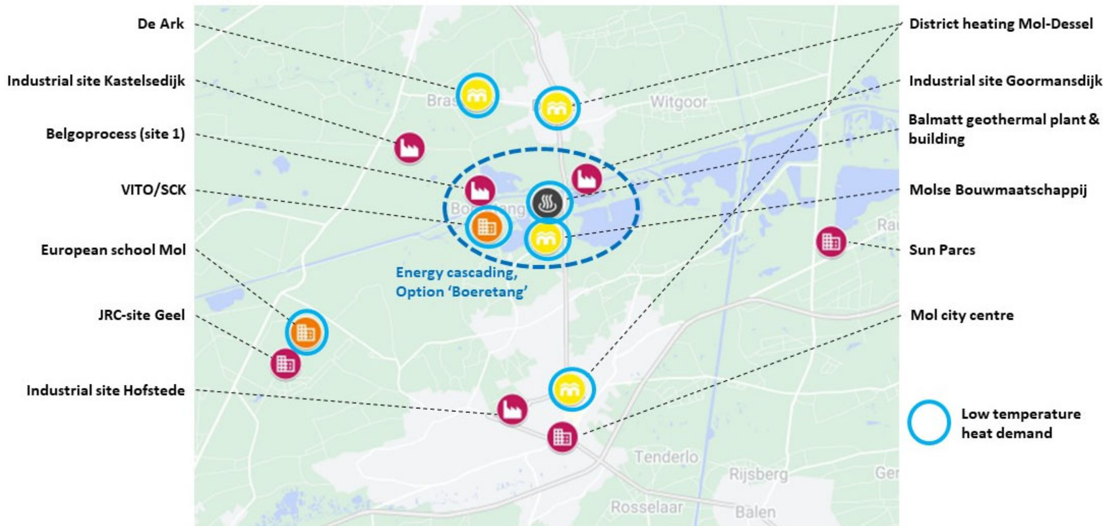

Figure 17: Energy cascading, option 'Boeretang'

Three heat consumers are suited for low temperature heating:

- Molse Bouwmaatschappij is a small local district heating network. Because it is recently built, we consider it to be designed for low temperature heating. The heating demand is very low: less than 1 GWh/yr.
- If the Balmatt building would be built in the future, it will be designed for low temperature heating. The heating demand would range from 1 to 5 GWh/yr.
- VITO/SCK currently utilizes a local heating network, powered by a set of gas boilers. This network temperature is high during the winter season, while a lower temperature is applied during the summer period. This means that high temperature heat is required during the winter, but during summer low temperature heat is sufficient.
  The heat demand of VITO/SCK is larger than 20 GWh/yr, in the range of 25-30 GWh/yr. Most of this heat is needed during winter time, so most heat requires a high temperature level.

There are two high temperature heat consumers located nearby:

- Belgoprocess (site 1) has a large heat consumption, ranging 15-20 GWh/yr.
- The industrial site Goormansdijk has a smaller heat demand, ranging 1-5 GWh/yr.

If VITO/SCK is excluded from this energy cascading option, we the heat at the return side of Belgoprocess and Goormansdijk should be sufficient to meet the need of the Balmatt building and Molse Bouwmaatschappij. Energy cascading including VITO/SCK is would only be possible during the summer season. The feasibility of including VITO/SCK depends on its heating need during summer and the availability of heat coming from Belgoprocess (site 1) at that same period. These aspects are not known at the moment.

CHAPTER 4: Conclusion and next steps

The area around the Balmatt geothermal plant comprises several (large) heat consumers that could satisfy their heating needs through a heating network, fed by the geothermal plant. The heating demand of these consumers differs regarding temperature level and annual consumption. Based on the location of the potential heat consumers, three options for energy cascading are proposed. These options are identified by using rough data and estimations on the heating demands.

To evaluate the technical feasibility of energy cascading, each option should be investigated more into detail. Therefore, heat and temperature profiles of the different consumers are needed.

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