Lake-water based district heating network in Weggis (Switzerland)

Country: Switzerland

Name of city/municipality: Weggis / Canton Lucerne

Title of case study: Lake-water based district heating network in Weggis

Year and duration of the renovation: Phase I: 2016-2020

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Link(s) to further project related information/publications, etc.: http://www.korporation-weggis.ch/waermeverbund.html (only in German)

Schematic figure or aerial overview

Since 2010 the Corporation Weggis has been operating a district heating network with wood chips as energy source in the Weiher district (marked in black in Figure 1). The plant generates almost 3 MW of thermal energy that supplies the Weiher industrial area and part of the village including various commercial enterprises, private properties and hotels. The generation capacity of this heating system has been exhausted by the connection of many properties. The need to supply other properties in the municipality of Weggis with ecological thermal energy continues to be high, which created the opportunity to exploit the energy potential of nearby Lake Lucerne.

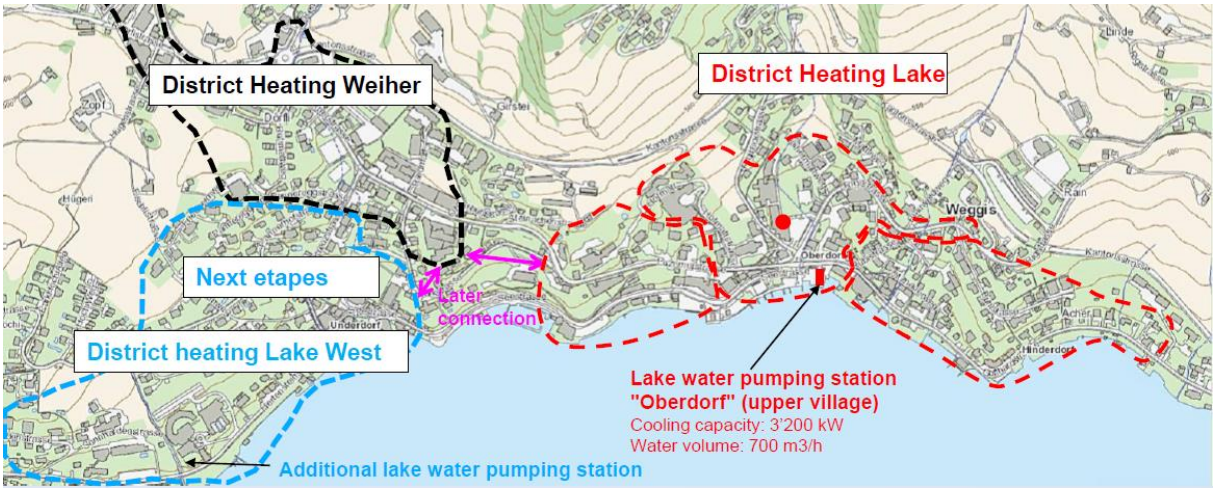

Figure 1. Schematic view of the different stages of the district heating networks in Weggis (Source: Corporation Weggis).

To extend the offer of the district heating, a district heating network sourced with lake water was built in Weggis (District Heating Lake, marked in red in Figure 1). This project was initially staged in order to allow it to be adapted to the needs of the community and local conditions and to limit the financial risks. An additional network on the west side of Weggis is planned for a later stage.

A schematic view of the buildings connected and of the existing pipeline network in April 2020 is shown in Figure 2.

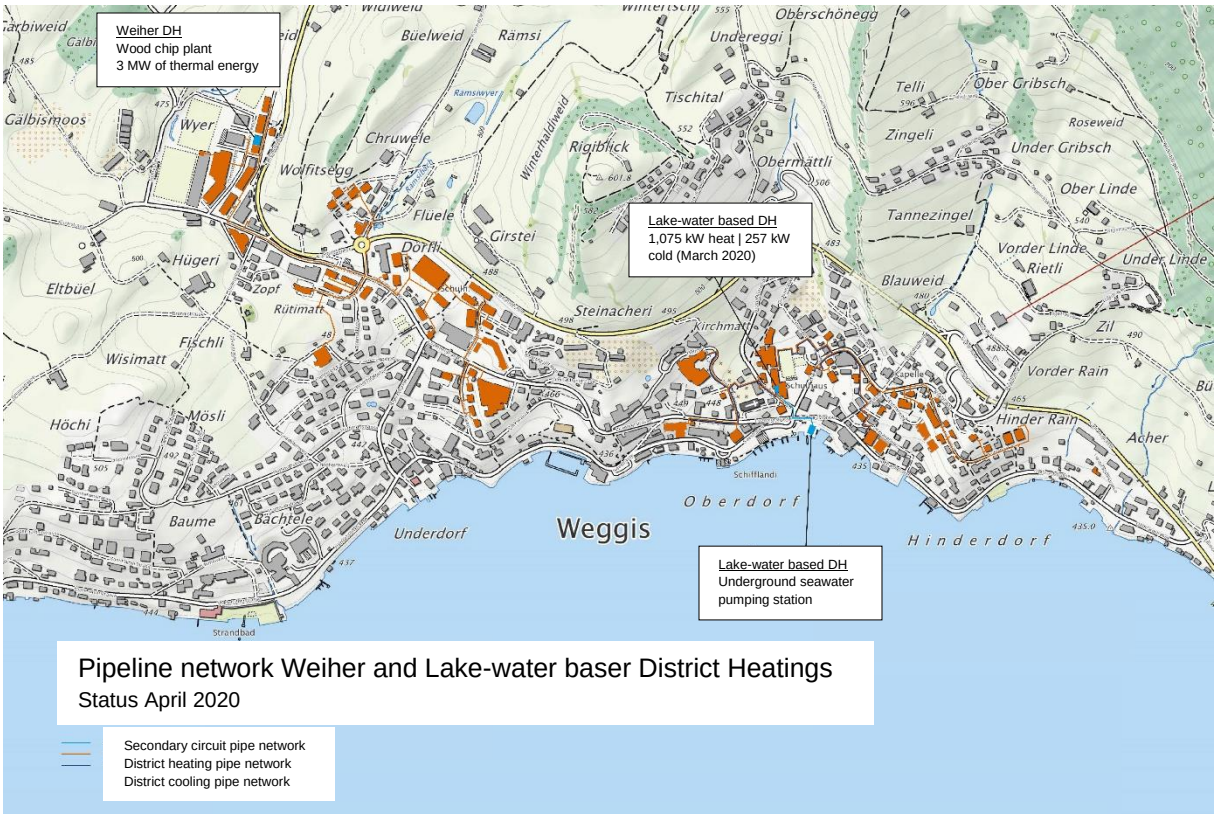

Figure 2. Schematic view of the buildings connected in April 2020 and of the existing pipeline network (Source: Corporation Weggis).

The information for this success story was gathered through participation in an open day event on site on 13 April 2019, an interview carried out with Mr. Lottenbach, the president of the Corporation Weggis, which owns the district heating system, on 14 June 2019, further contacts with the Corporation as follow-up, and information provided through documents and the website about the district heating system.

Introduction and description of the situation before the renovation

In the municipality of Weggis, before the creation of the new district heating plant, the sources for heat generation in the buildings were as follows:

- Oil: 68%
- Electricity: 13.8%
- Wood: 9.3%
- Heat pumps (electric): 4.7%
- District heating: 1.7%
- Gas: 0.2%
- Others: 0.3%

As the heating capacity of the first district heating system in the Weiher district was reached and the requests for new connections from village residents continued to be still high, the idea of creating a new district heating network originated. A private resident wanted to build a lake water based heat pump for his property, and the municipality extended this idea to create a new district heating network from which a substantial part of the population could benefit.

In the following text, reference is only made to the new district heating system, and not the previously available wood district heating system, unless specified differently.

The construction of the lake water heating district network in Weggis started in 2016. First parts of the district heating systemcame into operation in 2017.

The district heating network provides heat mainly to residential buildings and single family houses, but it provides heat also to all school buildings of the village, a hotel and a bank. In spring 2019, the buidlings connected corresponded to the equivalent of 150 residential units. To some tertiary buildings the system also provides energy for cooling. Only 5% of the connected buildings are new buildings.

In March 2020, the district heating system provided 1’075 kW of heating power and 257 kW of cooling power.

Additional distribution lines are planned, but it will take 10 years to complete the district heating.

Description of the renovation goal

The goal of the creation of a new district heating system was to respond to the request of the residents to have a district heating network that produces heat from renewable sources.

The project includes different stages until completion with an installed power of 5.6 MW. At this moment, the heat capacity is 1 MW (however, the total installed capacity at the end of the first stage will be 2 MW). The next extension of the network (stage 2) could allow increasing the heat capacity by 2 MW additionally and the extension towards one of the village's hotel (stage 3) could allow to increase the heat capacity by 1.6 MW additionally.

In 2017, the heating network was put into operation. The first properties to be supplied with thermal energy were the school facilities and adjacent properties. The connection of further 40 properties was carried out in 2018. The further expansion in the following years is foreseen due to the interest of the residents and businesses of the municipality of Weggis.

The project can be adapted to the connection requirements and the further development of the municipality of Weggis; the information collected here refers to the first phase.

Some buildings have been renovated during the process, but there is not any coordinated initiative for the renovation of the buildings. However, the Corporation recommends to the owners to perform renovation works before connecting to the district network. In that case, building owners benefit from lower connection fees since these depend on the needed heating power. If they insulate the envelope afterwards, the energy costs will be reduced, but the connection fees have already been paid. For the Corporation it remains profitable to connect buildings with a lower heating need since in such a case they are able to provide service to other buildings (without having to increase the installed power) and, therefore, they profit from more connection fees and they can amortize the installation in a shorter period of time.

The costs for the project in the first expansion phase amount to approximately CHF 6 million[1]. This includes the lake water pumping station with the lake water collection system, the heating plant with the heat pumps in the Weggis school building and the long-distance distribution networks. In the further stages of expansion, there won't be any further costs related the lake water connection and the pumping station. The Corporation finances the installation and recovers the investment through the connection fees.

The Foundation for Climate Protection and Carbon Offset KliK supports the project with CHF 100 per ton of CO_2 reduced. There was no financial support from the canton of Lucerne due to measures to reduce expenditure of the canton. Apart from the support by KliK, the financing of the district heating will have to be covered by the fees of the connected properties and the operation of the heating system.

[1] https://www.local-energy.swiss/arbeitsbereich/projektdatenbank/projekt/Projekte/2018/projektportraet-weggis-seewasser.html#/

Description of the renovation concept

The lake based heating network consists of a lake water intake with a related pumping station, a heating plant with heat pumps (at the moment there is only one heat generation unit), a distribution network consisting of district heating and cooling pipes and the decentralized transfer substations.

The lake water intake is built as an underground structure. The pumps suck in the lake water at temperatures between 6-8 °C below a depth of 25 m and deliver it filtered through an approximately 100 m long extraction pipe to the separation heat exchangers in the lake water pumping station. The heat exchangers transfer the heat from the lake water to an intermediate circuit filled with frost-proof propylene glycol. The COP of the heat pump in the heating plant is 4.

The lake water, cooled to around 2-4 °C, is returned to Lake Lucerne via a return pipe below the vegetation line at a depth of approx. 36 m.

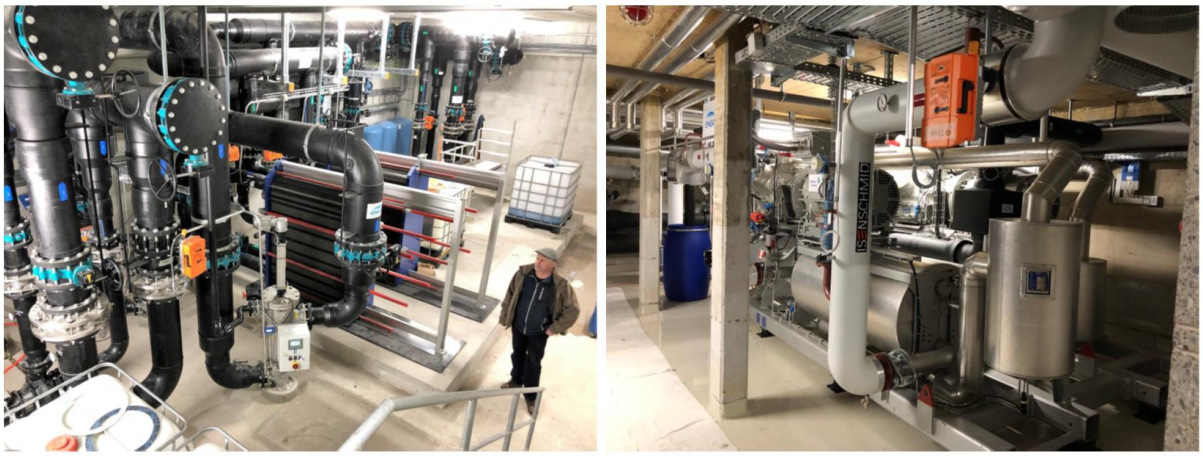

Figure 3. Left: 1 MW Heat pump; Right: Lake water pumping station. (*Source: Corporation Weggis).*

In summer, the district cooling circuit can also be used for cooling, with a cooling capacity of 3’200 kW and a water volume of 700 m^3/h. The heating plant for the first phase is built in the Sigristhofstatt school building. The Corporation owns the heat generation unit and operates the plant. The heat network will have a pipe network of approx. 3’500 m in the final stage. Public buildings such as schools, parish buildings and the local retirement home will be amongst the buildings supplied with the district heating. However, the majority of district heating and cooling customers are private and commercial properties and hotels.

The underground lake water pumping station is visible from the surface through an access hatch. The hydraulic components of the pumping station essentially consist of the circulation pumps, heat exchangers, valves and piping distribution as well as the electrical components. The two lake water pipes (extraction and return) are connected into the lake water pumping station.

The distribution networks can be extended over almost the entire municipal area, provided that the technical, ecological and economic necessity arises. The heat generation unit

consists of an ammonia heat pump, which uses the temperature level of the lake water and raises it to appropriate temperatures for space heating and domestic hot water heating. In the transfer substations for district heating and district cooling, which are located in the respective properties, the heat/cooling energy is transferred to the in-house distribution network.

All the distribution pipes and the energy consumption of all components are monitored and the system can be controlled remotely.

Project Fact Box (I)

General information

Parameter	unit	before renovation	after renovation
Urban scale of area:	m²	-	-
Population in the area:	-	4'369	4'369
Number of buildings in the area	-	ca. 2'800 dwellings	150 equivalent housing units (Spring 2019)
Heated floor area of all buildings	m²	-	ca. 20,000
Building mix in the area:			
Single family homes (SFH)	% of heated floor area of all buildings	n/a - not available	n/a
Multi-family homes (MFH) - up to three stories and/or 8 flats		n/a	n/a
Apartment blocks (AB) - more than 8 flats		n/a	n/a
Schools		n/a	n/a
Office buildings		n/a	n/a
Production hall, industrial building		n/a	n/a
other (please specify)		n/a	n/a
Consumer mix in the area:			
Small consumers: SFH + MFH – < 80 MWh/a	in % of annual heat demand	n/a	n/a
Medium consumers: AB, schools, etc. – 80-800 MWh/a		n/a	n/a
Large consumers: industrial consumers, hospitals, etc. > 800 MWh/a		n/a	n/a
Property situation of buildings:			
private	% of heated floor area	n/a	n/a
public		n/a	n/a
Property situation of energy supply system (district heating):			
private	% of heated floor area	n/a	n/a
public		n/a	n/a

Project Fact Box (II)

Specific information on energy demand and supply:

Parameter	unit	before renovation	after renovation
heating demand (calculated)	kWh/m²a	n/a - not available	n/a
domestic hot water demand (calculated)	kWh/m²a	n/a	n/a
cooling demand (calculated)	kWh/m²a	n/a	n/a
electricity demand (calculated)	kWh/m²a	n/a	n/a
heating consumption (measured)	kWh/m²a	n/a	n/a
domestic hot water consumption (calculated)	kWh/m²a	n/a	n/a
cooling consumption (measured)	kWh/m²a	n/a	n/a
electricity consumption (measured)	kWh/m²a	n/a	n/a
(Thermal) energy supply technologies:			
decentralized oil or gas boilers	% of heated floor area	70%	0%
decentralized biomass boilers		10%	0%
decentralized heat pumps		5%	0%
decentralized electrical heaters		15%	0%
centralized (district heating)			100%
other *(please specify)*			
renewable energy generation on-site:			
solar thermal collector area	m²		
photovoltaics	kWp		
other (please specify)	kW		

Financial issues:

Parameter	unit	before renovation	after renovation
total investment costs of the renovation	CHF	-	
- building envelope renovation costs	CHF	-	-
- heating/cooling supply costs	CHF	-	CHF 10-15 Mio. at the end of the project (power installed 5.6 MW). Phase I: CHF 5'66 Mio. (2 MW).
- renewable energy production costs	CHF	-	-
LCC available	yes/no	-	No

Description of the technical highlight(s) and innovative approach(es)

As technical highlights, it can be said that the intake and return of the lake water is done at a depth of 25 and 36.5 meters respectively through 110 and 55 meters PE-HD pipes. The temperature of the water is 8 °C at the intake and 4 °C when it returns to the lake.

The heat exchanger is located in the pumping station whereas the heat pump is located in the central heating plant, which is located at the school facilities and heats up the water up to 70 °C. A delivery substation that consists of a heat exchanger, a heat counter, a heat water storage tank and a control and adjustment panel is built in each of the connected buildings.

The use of a big ammonia heat pump of 1 MW heating capacity with reaches a higher efficiency than the use of small heat pumps in each building could be considered as an additional innovation. This occurs, however, at the cost that the water in the distribution system has to be heated to relatively high temperature levels in order to be able to fulfill heating requirements of all buildings. Ammonia has zero ozone depletion potential and is not a greenhouse gas.

Decision and design process

General/organizational issues:

The project was initiated due to fact that the demand from the population to be connected to the existing district heating network was large while the existing network could not accommodate new connections since the full heat capacity was already reached, and the Corporation decided accordingly to initiate a new district heating network.

The community and its citizens ultimately benefit from a modern, sustainable infrastructure.
As early as 2017, the heating network was able to start provisional operation after the completion of the first distribution networks, the construction work in the heating plant generation unit in the Sigristhofstatt school building and the lake water pumping station. In the 2017/2018 heating period, first contractually binding heat deliveries were fulfilled.

Stakeholders involved

The main stakeholder involved in the project is the municipal Corporation that acts as a policy actor and, at the same time, as investor.

In Weggis, various public tasks are divided between the corporate community and the municipality. The idea for the heat connection came from the private sector and the Corporation Weggis was able to materialize it to a district heating project. Therefore, Corporation Weggis played an important role in this project. The general planning of the project was taken over by the engineering company ENGIE Services AG. Numerous companies in the perimeter of the municipality of Weggis are involved in the implementation of the heating network and thus a large part of the economic benefit remains in the region.

Residents interested in a connection to the lake can contact the Corporation.

Stakeholders' role and motivation

Main stakeholder	**Specify which organization(s) was (were) involved**	**Role (decision maker, influencer, technical advisor, delivery)**	**Driver/motivation**
Policy actors (municipality department, government body, innovation agency, etc.)	Municipal corporation	Decision maker	First of all, ecological motivation. To provide a central heating system based on renewable heat sources (lake water) to the inhabitants of the municipality that were asking for it.
Users/investors (individual owner, housing association, building managers, asset manager, project developer)	Municipal corporation	Decision maker	The same as above.
District-related actors (Community/occupants organizations, etc.)	Active residents	Influencer	The wish of having a reliable and sustainable heat source for the dwellings / buildings.
Energy network solution suppliers (Distributor system operator, energy supply company, energy agency, ESCO, renewable energy companies)	ENGIE	Technical advisor	To build a reliable and efficient district heating network.
Renovation solution suppliers (Planning and construction parties, urban planners, architects, design team general contractors, products suppliers, ESCO, contractor, energy monitoring, facility manager, installation provider, one-stop-shop, etc.)	-	-	-
Other intermediaries (public bodies, trade organizations, NGO's, consultancies, research institutes)	Foundation for Climate Protection and Carbon Offset KliK	Financial	Support financially interventions that reduce CO_2 emissions, to offset a part of carbon emissions triggered by the use of fossil motor fuels of Swiss mineral oil companies.

Design approach:

The design targets of the intervention were to achieve a secure heat supply that is renewable. Ecology was the driving factor followed by the economy. The Corporation considers that ten years ago, the order of priority would have been different, but nowadays the ecology is a priority over the economy.

To obtain the construction permission is a long process, which includes among others planning how to protect the flora and fauna of the nature conservation area, the permission of the municipality as well as the regional and national government.

The main challenges in the design phase were the high time effort that such a process requires and the need that all or at least a majority of the people who are part of the Corporation agree with the project and the vision of a CO_2-neutral Weggis.

Technical issues:

The main challenge was related to the rapid development of the project from the decision to build a new district heating network to the approval from the authorities and to the various planning phases, which required the flexibility and ability to innovate of all those involved in the project. Challenging is in particular that different project phases overlap, some of them are still in the conception phase while other sub-projects are already completed which makes it difficult to coordinate.

Financing issues:

The Corporation Weggis, which is legally a public entity and is subject to the law of the municipality, finances the project. The investment is recovered by the user connection fees and the sale of heating energy.

The Corporation is taking part in a subsidies program financed by the Foundation for Climate Protection and Carbon Offset KliK. This foundation supports financially interventions that reduce CO_2 emissions, in order to offset a part of carbon emissions triggered by the use of fossil motor fuels of Swiss mineral oil companies. This program supports operators of district heating networks that use energy sources from renewable sources, which replace fossil fuel based heating systems, and reimburses the operator annually an amount of CHF 100 per reduced ton of CO_2 for a certain time period. By the end of 2020, the amount expected to be given to the Corporation Weggis will be CHF 255’000 (approximately 5% of the construction costs).

To assess the profitability of the intervention, Corporation Weggis performed calculations considering that only 50 % of the power capacity will be used. Based on this, the project was considered economically feasible.

Building owners connected to the district heating system benefit from the fact that they do not need to perform any revision of their own heating system at home, e.g. boiler or chimney.

Management issues:

The main challenge regarding project management is the long period of time that such an intervention requires.

Policy framework conditions:

There are some regulations that were an obstacle to the process; for example, building owners that substitute their fossil fuel based heating system by a connection to a district heating network receive subsidies from the regional government; however, the Corporation does not receive any money.

Residents started this initiative; the Corporation was the policy actor who was implementing it.

Lessons learned/interesting findings

The following success factors can be highlighted:

- The intervention was initiated due to the wish of the population and, therefore, acceptance among the population was high.
- The network operator is a public institution and therefore considered trustworthy by potential clients of the district heating network.
- The municipality has supported the project. Almost all public buildings are connected to the network as well. Consensual communication between the network operator of the Weggis Corporation and the municipality of Weggis has led to beneficial acceptance by the population.
- The lake based heating network is characterized by the integration of sustainable, locally available energy resources. The environmental benefits of using such energy are key for having a high acceptance in the population.
- Synergy effects between the renovation of municipal supply lines, road rehabilitation and the heating network reduce the overall costs for all parties involved.
- The energy potential of the lake is large and provides an efficient energy supply; this potential can best be accessed through a district heating network, individual buildings could not access this energy resource.
- The existence of the network has encouraged building owners to switch to renewable energies.
- The Corporation, as a large energy actor with an interest to make their renewable energy based heating system a success, is a strong driver for encouraging people to switch to renewable energies.
- The possibility for expanding the network, in combination with connection fees that provides revenues for each new building connected, makes energy efficiency measures on the building envelopes also attractive for the district heating network operator, as this allows connecting more buildings without increasing the overall capacity of the system.

As major bottlenecks, it can be said that the rapid development of the project from the decision to build, to the approvals from the authorities and to the different planning phases requires flexibility and innovative ability of all those involved in the project. Additionally, different project phases overlap, some are still in the conception phase, while other sub-projects are already completed.

As major lesson learned, the project shows that it is necessary that the communication with the local authorities and the population is carried out continuously throughout the entire process, from planning to system operation, and that it is continuously adapted to the requirements in order to eliminate prejudices in advance. The project was actively communicated through presentations, published articles in the local media, open days, and events for schools. This is considered to have been an important factor for ensuring the success of the project. Information is considered to be key to convince the population of the benefits of such a system and to attract thereby interests of building owners to participate in a common solution.