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Guide on Project Management

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Contents

INTRODUCTION

One of the most important issues in design of geothermal systems is the management of the project, which comprises planning, organization, motivation and the engagement of controlling resources. This document provides basic information on management tasks, which have to be accomplished for a particular geothermal system. Without those, the risk of technical or the potential economic failure is too high, therefore the proposed steps in this document are highly recommended for future GEODH systems.

The starting point of management is usually based on feasibility study and the preliminary design of the system. In geothermal district heating/cooling systems, these two activities must not consider only the geothermal system, but should represent broader analyses, related to the development of the specific area and its characteristics. It is namely well known that the geothermal heat should be brought to the lowest possible enthalpy before the reinjection. This means, that planning of the geothermal source and its utilization must consider a multipurpose use of energy. This further depends on potential customers and related demand, as well as the future development of certain surrounding area. In this document, some basic aspects of the multipurpose use of the geothermal heat are presented. This is supported with the list of different potential technologies, which may be successfully applied in such systems.

1. Multipurpose utilization of geothermal energy

Geothermal resources with temperature above >100°C can be used for the generation of electric energy. Geothermal sources, which represent temperature levels above 85°C (for large systems), can be successfully utilized for the production of cooling energy, by application of sorption technologies. On the other hand, geothermal heat can be applied at different temperature levels, depending on the particular application. Considering different combinations of energy products generation we can differentiate between the following: geothermal power plants (heat transfer to the environment needed), geothermal cogeneration (combined production of electric energy and heat, which is used), geothermal trigeneration (polygeneration or combined generation of electric, heating and cooling energy) and geothermal cooling/heating systems (geothermal energy is used for cooling and/or heating). When the geothermal temperature levels are not adequate for the desired conversion technologies it is reasonable to combine geothermal energy sources with additional sources that are based on consumption of gas, biomass and in some cases also solar energy.

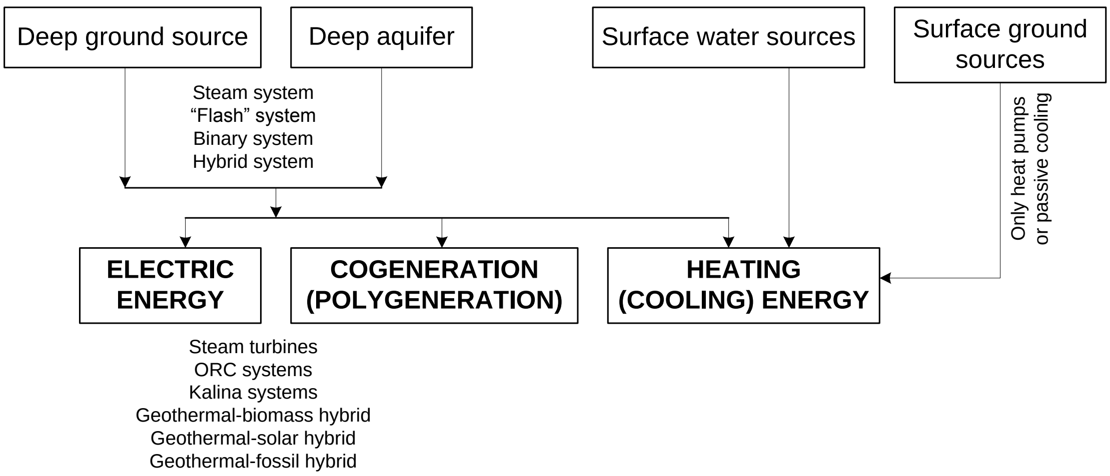


Figure 1: Geothermal energy sources and their potential utilization

For a good utilization of geothermal energy its whole potential has to be used. This means that the state of a reinjected thermal flow has to be close to the reference state of the environment. With high temperature (deep) sources, avoiding high thermodynamic irreversibility and energy loss, the former is only possible through multipurpose utilization of geothermal energy. Firstly, if possible, the geothermal energy needs to be converted as much as possible into electric energy (i.e. pure exergy) and in the next stages to meet some other local energy needs, as in examples in Figure 2.

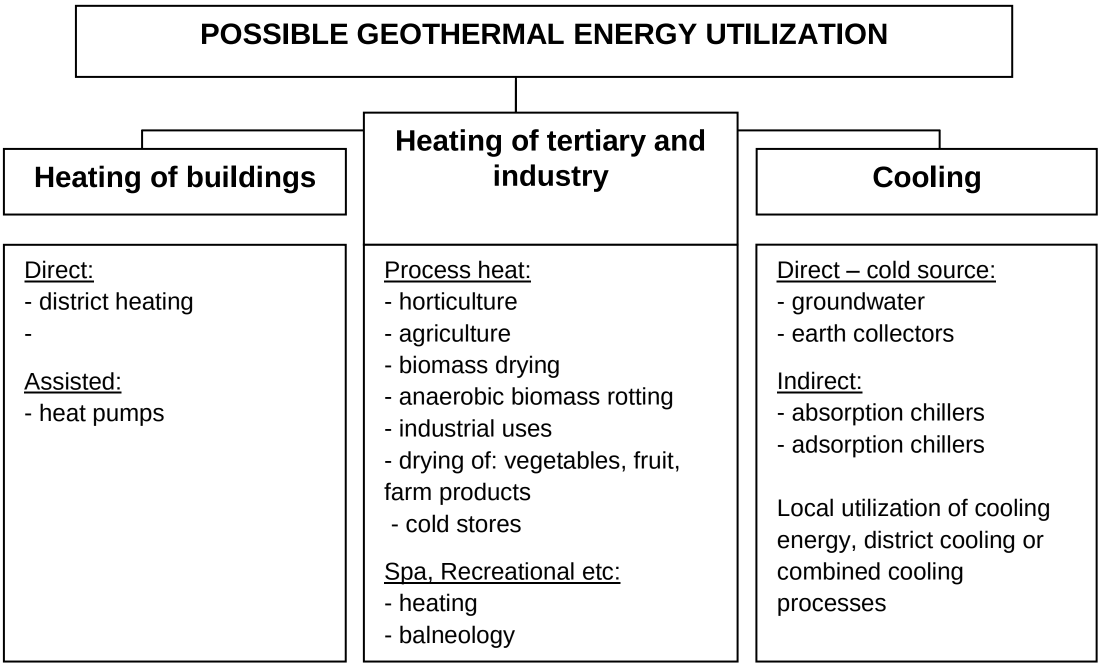


Figure 2: Different ways of using geothermal energy with low thermodynamic potential

1.1. Polygeneration technologies

In polygeneration energy conversion system the input energy is converted, in addition to electric energy, also to other energy products (heating, cooling energy). There are two main options of utilizing geothermal energy, and are mainly depended on its temperature levels. When geothermal energy is extracted in the form of high temperature steam (at least ~180 °C) it can be directly expanded in steam turbines. However when the parameters of extracted energy are lower the binary cycle system can be installed. There the heat from moderately hot geothermal water (above 100°C) is transferred using heat exchanger to a fluid with a much lower boiling point than water. This causes it to vaporize and the vapour drives the turbines which produce mechanical energy to drive the electric energy generators. The most often used binary system is the Organic Rankine cycle system and there is also the possibility to use the Kalina cycle power system.

The main advantage of polygeneration systems is the utilization of high quality sources to produce electric energy and the utilization of lower quality energy for heating and/or cooling energy production. Doing so the match between quality of energy demand and energy supply is better met [4].

1.1.1. Steam turbines

A steam turbine produces mechanical energy by expansion of high temperature and pressure steam. They are differentiated on the basis of the exiting steam pressure. The pressure after the turbine is higher than the atmospheric pressure in back pressure turbines and lower in condensing turbines. It is possible to extract steam from the turbine before the final expansion in both cases. This means that it is possible to supply process steam of different parameters for the following utilization.

1.1.2. Binary cycle systems

Organic Rankine cycle (ORC) is a technology whose operation is very similar to conventional turbo-compressor refrigerators. The fundamental difference is that the ORC system has an opposite direction working fluid flow. Organic working fluids are used in the ORC systems. Compared to conventional Rankine processes (steam turbines) the ORC system is used for lower temperature sources and are ideal for geothermal energy sources below 180 °C. The evaporation and condensation take place at constant temperatures. When selecting the working fluid the source and the required heating/cooling temperature levels have to be considered. The geothermal source temperature levels where ORC systems can be installed are in the interval between 80-350 °C. However when this temperature is below 120 °C the electric efficiency of ORC systems is lower compared to Kalina systems.

As a working fluid in the Kalina systems at least two different working fluids are used (usually water and ammonia). The share of the components is changing with the intention of reducing the thermodynamic irreversibility and increasing the electric efficiencies. There are only a few practical applications of Kalina systems. The main reasons for this are [2]:

- scarce experiences in operation,
- toxic working fluid,
- special construction standards due to ammonia,
- more expensive than ORC,
- larger heat exchangers as with ORC systems are needed.

1.2. Heating and cooling

In a combined heat & power production systems an overall efficiency of over 80 % can be achieved. However this value is of a hypothetical nature and is based on a prerequisite that all of the heat is always used. When it is used for space heating this condition is only fulfilled in the heating season and it is not possible to avoid transferring some excess heat to the environment in the summer months. This problem can be largely improved by using the heat in the summer months to generate cooling energy in a sorption process.

In addition electric energy consumption for cooling via compressor technologies in the EU is increasing. It is a result of improved working and living conditions as well as climate changes. As a result in most parts of the world the peak electric energy consumption has shifted from winter to summer period. This problem can also be reduced by using heat to meet the cooling needs.

Table 1 is showing different technical parameters of the main sorption technologies for cooling energy production. We can see that the minimum temperature levels of supplied energy are around 75 °C. However the COP is dropping by decreasing the temperature levels and therefore an optimization study of these temperatures is needed in the design stage of the system.

Single-effect LiBr/H_2O absorption chillers can apply low pressure (usually saturated) steam or hot water as the heat source which is used in the generator. The coefficient of performance of single-effect absorption systems is low. In the case that the heat source represent higher energy value, the single-effect device with one generator will not be sufficient for evaporation of refrigerant (water in Li-Br/H_2O). The double-effect chiller uses two condensers and two generators. This enables more refrigerant to boil. In this case, the higher temperature generator uses the external source. The refrigerant vapor flows from the high temperature generator to the condensator. This is connected to the low temperature generator. Therefore the condensator of the first stage is cooled by the generator of the lower stage, similar as this is the case in cascade refrigeration systems. The single-effect, double lift absorption chiller applies two generators, with intermediate heat exchangers, what enables use of hot water with lower temperature levels (e.g. 85°C). In the Table 1, approximate costs, occupancy of the space of the absorption chiller and weights are given.

Table 1: Sorption technologies [3]

Technology	**Absorption**				**Adsorption**
Type	**LiBr/H_2O**			**H_2O/NH_3**	**H_2O/Silica gel**
	single effect	**double effect**	**single effect, double lift**		
Heat source	hot water, steam <2 bar	steam 6-8 bar	district heat	hot water, steam <2 bar	hot water, sun
Inlet temperature [°C]	85-110	135-200	80-100	100-180	75-90
Cooling capacity [kW]	35-12,000	200-6,000	600-6,000	100-10,000	15-500
Coefficient of performance (COP)	0.6-0.8	0.9-1.3	0.4-0.75	0.25-0.6	0.5-0.7
Installation price [€/kWh]	1,200-200	/	>400	1,250-400	1,500-350
Space	(1.8) 15-96 m^3	17-56 m^3	25-168 m^3	>50 m^3	12-70 m^3
Weight	(0.6) 5-41 t	10-30 t	15-60	>11 t	5-25 t
Application	Air-conditioning	Air-conditioning & industrial	Air-conditioning & district cooling	Retailing, industry	Air-conditioning
Market penetration	high	high	small	small	small
Number of manufacturers	>8	>5	1	>2	2

Figure 4 is showing the possibilities of geothermal energy utilization for heating and cooling purposes as the second part of the multipurpose geothermal energy utilization.

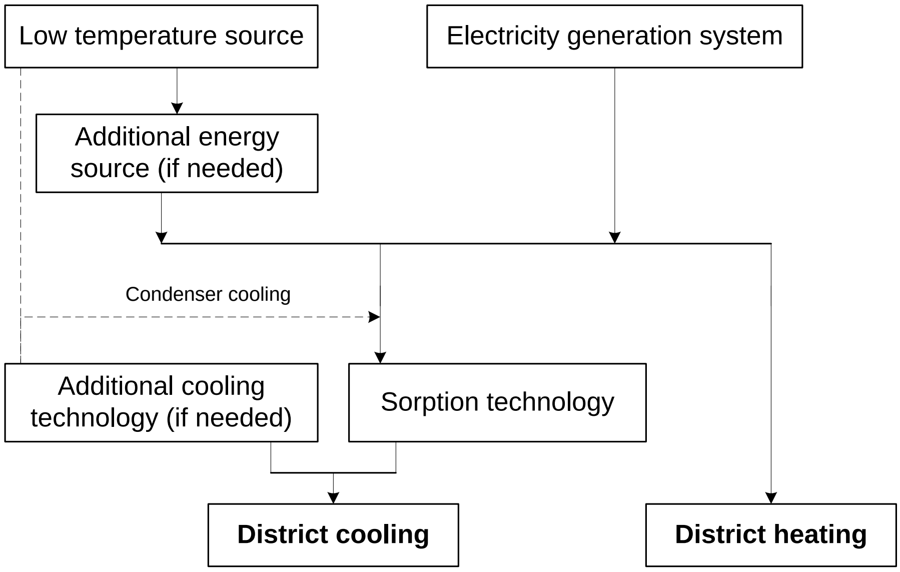


Figure 3: Utilization of geothermal energy for district heating and cooling in an efficient manner

The heat from a low temperature energy source or condensing heat from a geothermal electricity generation system is used for heating purposes (in a district heating system in our example) and for cooling energy generation (district cooling) in a sorption system. If the low temperature energy source is not adequate to supply the required heat of appropriate parameters an additional energy source can be installed. It is often the praxis to supply the base load cooling energy from a sorption cooling system and the rest from a conventional compressor cooling system. The reason for this is relative high investment cost of sorption systems.

1.3. Example of the multipurpose use of geothermal energy

Good urban planning of geothermal district energy system includes the use of heat in a multipurpose system, by utilizing the most of the geothermal potential. Therefore it is very important that urban planners, municipalities, policy makers as well as the investors perform a comprehensive analysis on possibilities not only to use the geothermal energy at different temperature sources, but also to expand the possibilities of its use with regard to new business opportunities.

The district heating pipeline can cover a large variety of different industrial needs. Furthermore, it enables use of hot water to drive sorption chillers. The return temperature of such pipeline is in many cases sufficient to be applied as the secondary supply pipeline (Fig. 4).

New types of low temperature district heating systems will certainly apply low temperatures of supply and return. This is also in accordance with use of different renewable energy source and waste heat.

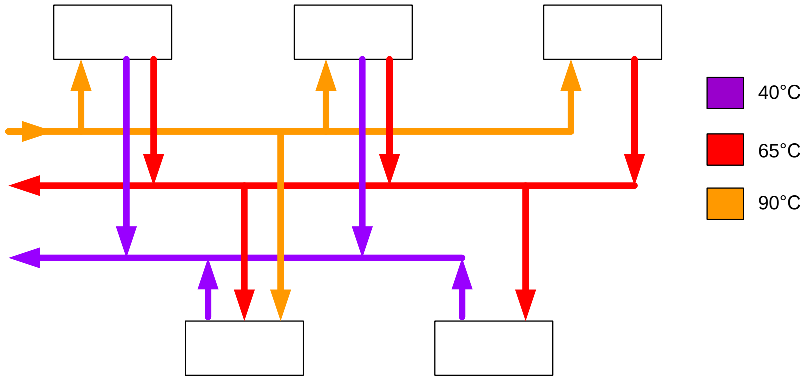


Figure 4: An example of an advanced district heating system (note that there exists a variety of combinations as well as multiple pipelines for different supply and return temperatures)

Figures 5 and 6 show the so called Lindal diagrams, which represent different temperature levels as potentials for the use of geothermal energy.

Figure 7 shows an example of the multipurpose geothermal district heating and cooling systems (without power generation) in an urban area. As it is shown in the Figure 7, a well operating multipurpose system would demand the installation of the additional pipelines (depending of course on the particular needs and required parameters).

Because consumers in an area supplied by district heat require different temperatures for different means, a problem occurs, when designing an advanced district heating system. If the supply temperature is low it is not sufficient for the high temperature needs. On the other hand if the temperature is high, lower network efficiency is achieved and there are negative impacts on the prior stages of energy utilization in a multipurpose system. This problem can be tackled by installing several supply pipes (normally two), each to meet a specific demanded temperature level. In state of the art systems the increased costs of such a design are controlled by installing twin pipes or triple pipes [5, 6], as shown in Figure 8.

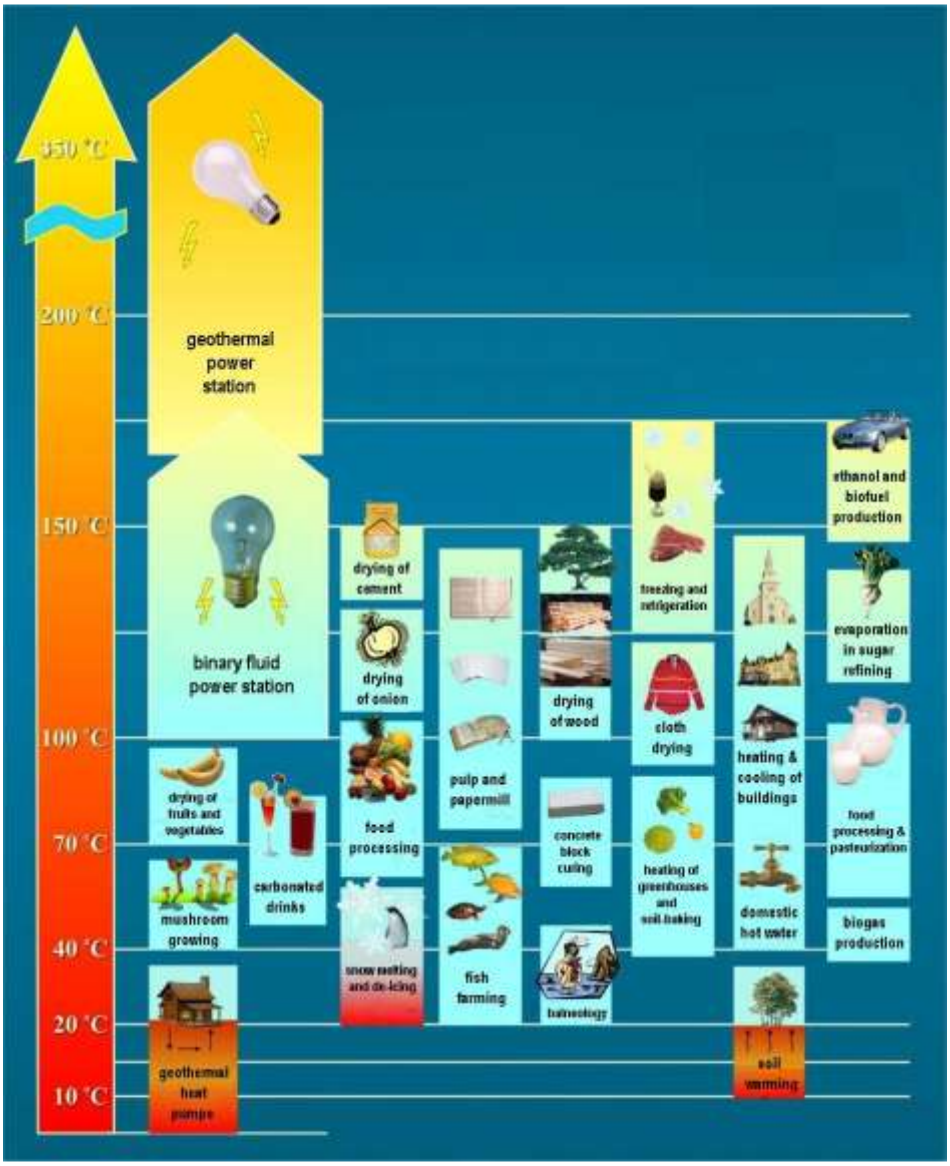
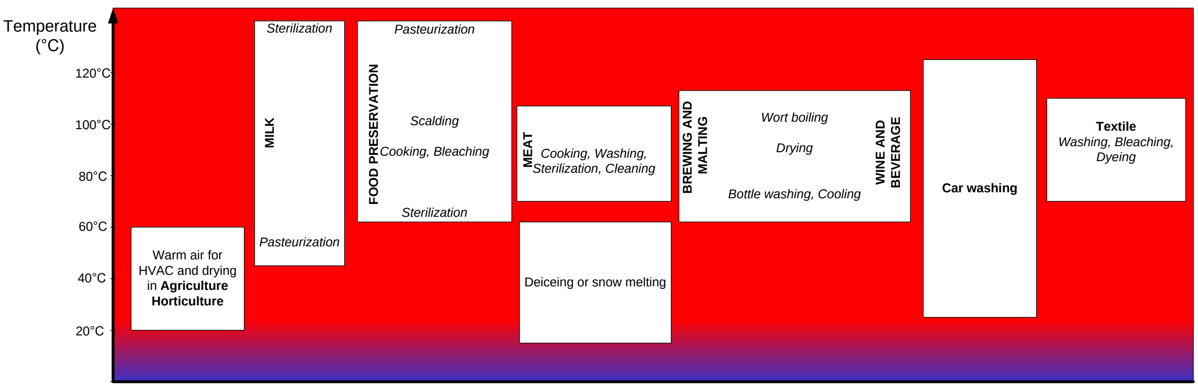


Figure 5: An illustrative example of using geothermal energy at different temperatures (http://geotermia.lapunk.hu/tarhely/geotermia/dokumentumok/lindal_angol_ok.jpg)



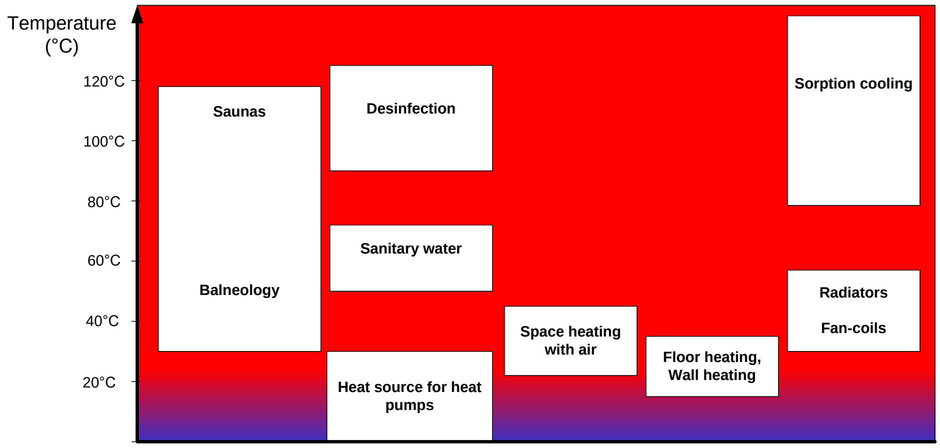


Figure 6: The Lindal diagram for use of geothermal heat without the electricity production

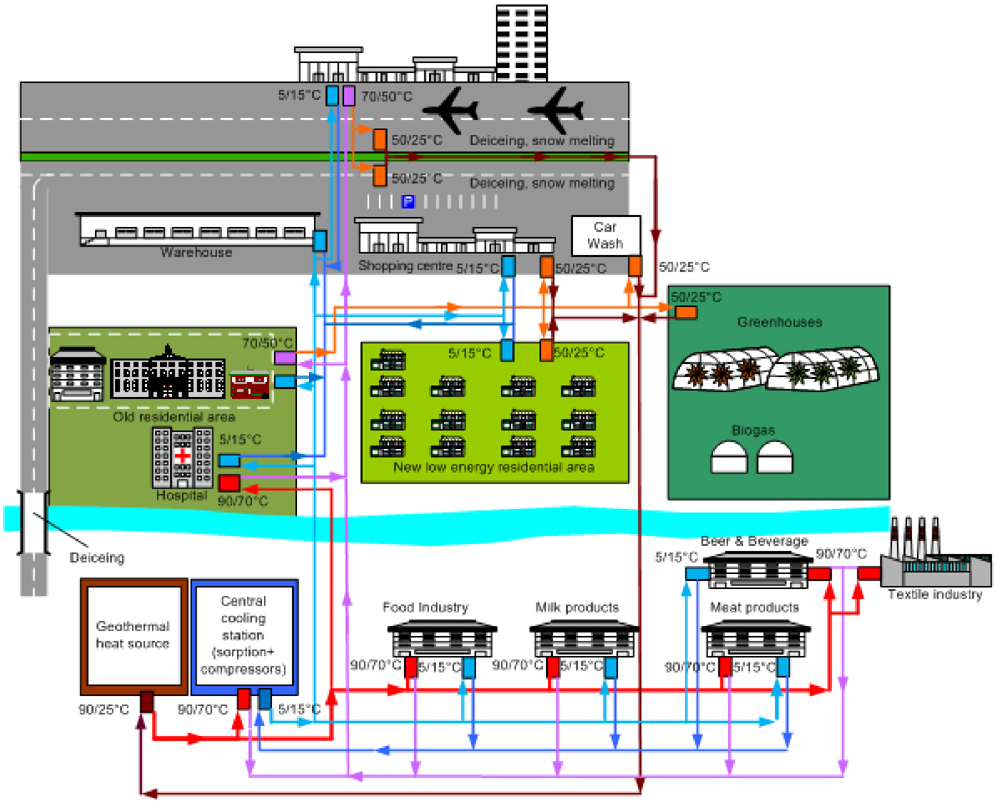


Figure 7: An example of the multipurpose geothermal district heating/cooling system

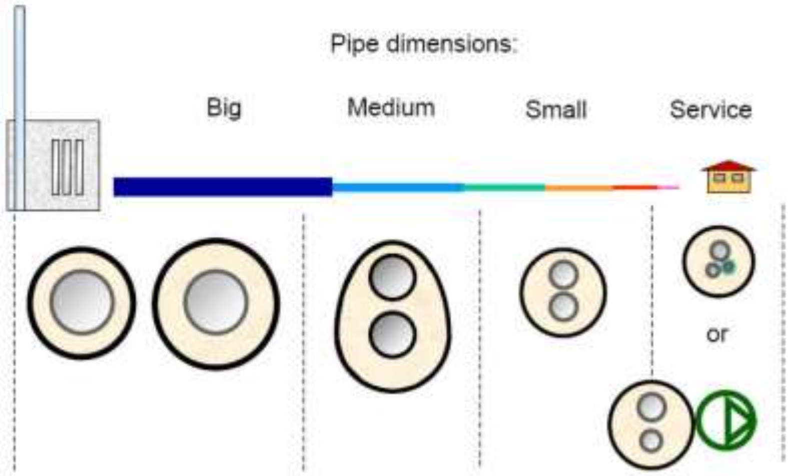


Figure 8: Possible pipe designs from single pipes to triple pipes and twin pipes with a booster pump at the customer [5]

1.4. References

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2. Project Management

2.1. Introduction – definition of project management

According to the definition of Project Management Institute (the world's largest not-for-profit membership association for the project management), project management is the process and activity of planning, organizing, motivating, and controlling resources to achieve specific goals [1]. A project is a set of organized activities in the limited time leading up to the specified goals. The activity is a task needed to be done in a given time with a defined beginning and ending.

GeoDH projects in this report are the projects, implemented according to the business models, described in WP4.2.

Project management is defined at the start of the project, which is subject to interest and arrangements between Key Partners. The owner of a project is a key partner, whose interest is to implement business model. It can be DH Utility, Public authority or ESCO Company.

But still there are key activities that are common and must be carried out regardless of who is the owner of a project. These activities will be presented (Fig. 9).

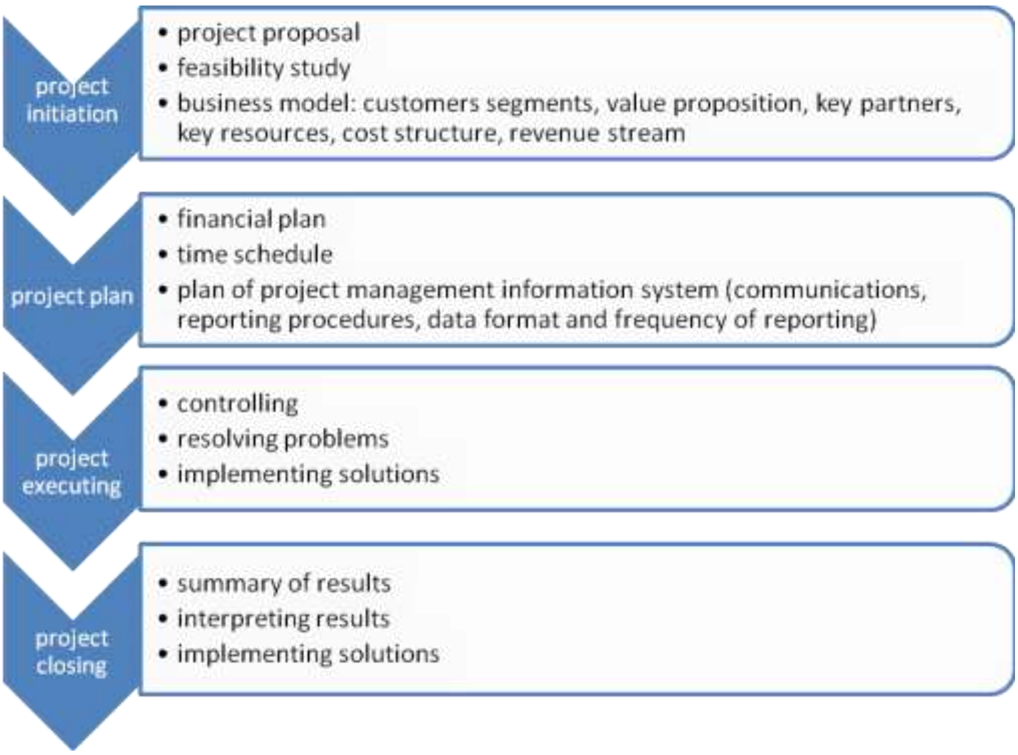

Figure 9: Project management process

2.2. Duties and responsibilities of participants in the project

Because of legal framework and obligations which must be met in the GEODH project implementation GeoDH must be represented in the project team knowledge in the following areas:

- Regulatory framework for GeoDH – production, distribution and heat supply; environmental regulation; public procurement, public-private partnerships and concessions.
- Economics: an understanding of factors that affect the success of the project in economic terms – there must be a general knowledge of the economics of investments
- Technical part: domain knowledge of geothermal systems, district heating systems and heat installations.

Even in the case of smaller projects, the project team members have to be familiar with all of these fields, however, certain procedures can be simplified. Of course, if the owner of a project is smaller local community, the project may also be managed by an outside consultant or contractor. Experience in such projects show that in the local community there has to be at least one key person who has an interest in the project, that the project is successful.

2.3. Management of the Project

The aim of the project manager is to implement the project within the planned time and the estimated costs, and also with the appropriate quality. In the case of poor quality, adjustment that require additional time and cost (sometimes even after project completion) are necessary.

Basic tasks and responsibilities of project management to achieve these objectives are:

- Planning,
- Organizing,
- Staffing,
- Controlling,
- Directing (Intructing, Guiding).

2.4. Planning

Project plan is crucial in all the projects, including GeoDH projects. Key activities must be defined to achieve the goals and for each of them, time and cost components have to be defined and also quality that has to be achieved (Fig. 10). These are the quantitative components.

Figure 10: Quantitative planning components

For planning of each component there are several options and tools of project management. Therefore at this point these are not considered.

For projects GeoDH it is necessary to take into account the specific requirements related to the characteristics GeoDH: as in a time schedule the specific deadlines, for example: the heating season, the season of cooling, industrial process...

In addition to quantitative plans other aspects of planning are also important: organizing the project, management, control and communication in the project.

2.5. Organizing the Project

Organizing projects depends of the owner of the project. The most common the implementation of project is organized in the project office (PMO- project management office), which operates according to certain rules. Depending on the position in the hierarchy of the organization or local community there are three levels of PMO mentioned:

- administrative control office for one project;
- project office, that primarily coordinate work of people (common sources) in a large number of projects;
- Strategic project office, which is close to the top management as an advisory body for organizing, managing, monitoring projects and also for enforcement of project work in the organization.

At different levels, the PMO has different functions depending on this as well as various employees. The PMO may be otherwise employed project administrator (manager PMO), project managers and coordinators, project information system administrator, analyst and administrator projects [3].

This is also in the case that the project is implemented by concessionaire or private partner.

Small local communities and the contractors for small-scale projects usually simplify the process, but therefore, often the quality of project management is poor and consequently also the goal cannot be achieved.

2.6. Staffing

As it was already mentioned, in the project team for implementing GeoDH projects there has to be members with different knowledge or the outsourcing of activities connected with some of the fields should be done. (i.e. regulatory frameworks for GeoDH, economics of investments, technical knowledge on geothermal systems, DH systems and heat installations)

2.7. Controlling

The process of controlling includes monitoring of performance (scope, time, quality, costs, risks, and supply), comparison with the plan, identifying anomalies and planning and implementation of corrective actions / measures to ensure that the project will be carried out in the framework of set goals. We have to draw attention to the difference between the control and supervision. The manager, whose function is (also) controlling, shall monitor the implementation and act in case of deviations, while the supervisor (usually monthly) gets a full report and typically does not intervene. Only advising to him/her or recommendation for a replacement of a manager, if he/she does not manage a project can be done.

The process of controlling means permanent comparison between planned and actual situation (costs achieved, implemented activities in time schedule). It has to be regularly! The sooner deviations are detected, smaller are they and easier to solve. It is very important that the team members are involved in control and that they provide the right information and not to conceal problems and deviations.

2.8. Project management information system

Reporting to project owner and other stakeholders of the project is an upgrade of the controlling. They have to be regularly informed about the progress of the project. The frequency of reporting depends on the individual participants and type of project.

Plan of project management information system should therefore determine who will receive the information, how often and in what way (medium).

Communications management is the formal or informal process of conducting or supervising the exchange of information either upward, downward, laterally or diagonally. There appears to be a direct correlation between the project manager’s ability to manage the communications process and project performance [4].

2.9. Milestones

Start of the project: from broader perspective, this is already the decision on whether to carry out a feasibility study. This study normally providessome guidelines for implementation. In a narrow sense, it represents a basis for decision on the implementation of the project.

Milestones: must be specified in the plans mentioned in the previous paragraphs. They can be divided into three groups: financial, time and technical milestones.

Completion of the project: in a narrow sense this can be the putting system in the operation, in a broader sense, depending on obligatories of contractual partners; this is the conclusion of the life-cycle of vital components of the system, the end of the contractual period of the concession relationship or the end of the energy supply contract.

2.10. Definition of activities in accordance with GeoDH Business Model

2.10.1 Start of the project: feasibility study - the definition of the boundary conditions for the feasibility study must be done.

In ***Customer Segment*** potential of heat customers and heat consume has to be determined and the need for an energy source for the local DH utility must be checked.

Determination of potential heat customers, heat consumption

- Preliminary contracts for connecting to the DH system have to be concluded
- Analysis of intentions for connection to the system has to be done.

It is necessary to take into account:

- The importance of accuracy of data on heat consumption and the required capacity of potential customers
- The interest of potential customers (is there any legal obligation to connect to the system)
- Determination of prices for energy consumption before all the parameters are known

It is very important that at this stage we check the data on the actual use - the quantity and temperature level, since in the calculation of the economics of the project need to be considered real income, which will later be realized from the energy supply. Therefore, such determination is required in order to provide realistic data and not theoretical estimations. In particular, it is necessary to check larger and more sensitive consumers like industry and services sector and their long-term strategy. It is necessary to check their interest and price sensitivity.

Local DH utility with a need for renewable suitable heat supply - determination of an energy source.

Key Activities for the definition of the boundary conditions for the feasibility study are:

- General requirements and definitions of the most important concepts must be identified.

It is necessary to obtain all key information affecting the economics of the project. For example:

  - consumption density,
  - power density,
  - specific cost of DH system,
  - heat loss in DH System
  - use of primary energy
- Technical solutions

Technical solution must be prepared to ensure adequate quality information on technical standards required. For GeoDH the possibility of multipurpose utilization of geothermal energy should be considered, according to Chapter 1.

- Management and maintenance costs

For a realistic economics assessment is necessary to properly evaluate all system costs that will occur in the life-time of the system, or in the case of the concession model or energy contracting model, the contract period. It is necessary to provide estimates for:

    - Maintenance costs (OPEX and CAPEX),
    - Energy management costs,
    - The costs for legal services, taxes,
    - Insurance costs,
    - The costs of energy supply (billing, accounting…),
    - Other expenses (for example media communications, reports ...).

- Proposal of the Business Model

Already in the feasibility study options shall be proposed which the subscriber may choose. The possibilities of cooperation between key partners for models of concessions or energy contracting should be described.

- Establishing the financing of the project - according to the Business Model

After the decision for the Business Model and implementation according to the feasibility study, the pre-construction phase begins.

2.10.2 Pre-construction phase

Key activities before the construction of GEODH system are:

- Tenders for contractor (s)

In the case when the GeoDH system will be implemented according to the energy contracting model or concession, at this stage key partner should select the contractor - ESCO Company. In the tender all the conditions that were set in the feasibility study should be defined.

In the case event when the GeoDH system will be implemented by one of the key partners (local community or DH utility), it is necessary to do all of the following phases prior to construction first and then make the selection of contractors for the construction of all components of the system.

- Preliminary design of GeoDH system
- Preparation of relevant acts, which are required according to the Business model and legal regulations
    - Tariff system, price calculation and price list
    - Conditions for the connection to the system (technical and financial)
    - System operating instructions
    - Contracts with customers

Owner of a project has to prepare these acts (either a key partner or an ESCO Company). They should be implemented or certified according to Regulatory framework by authorized authorities.

2.10.3 Building phase

Key activities of the implementation of GEODH system are:

- Permits and planning process
- Final design for GeoDH system
- Construction phase
- Putting into operation, commissioning

2.10.4 Operation phase

- Energy supply
- Management and maintenance in life or contract period.

During operation, the key activity is the energy supply, according to contracts (with customers, suppliers and other service providers).

But also all the other appropriate services have to be carried out to operate the system (billing, accounting, insurance ...)

If all stages up to here were performed correctly, both Revenue stream and Cost Structure are within the limits as have been predicted and thus also the Value Proposition (long term stabile, secure energy supply).

Key activities for the whole process are summarized in Annex 1.

2.11. References

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APPENDIX 1: KEY ACITIVITIES FOR IMPLEMENTATION OF GEODH SYSTEM

I **Feasibility study**
1 Determination of potential heat customers, heat consume
1a Preliminary contracts for connecting to the DH system have to be concluded
1b Analysis of intentions for connection to the system has to be done.
2 Determination of energy source
3 Identifying general requirements and definitions of the most important concepts
4 Preparation of technical solutions
5 Estimation of management and maintenance costs for the system in life period or in contract period
6 Proposal of the Business Model
7 Establishing the financing of the project

II Pre-construction phase
Key activities before the construction of GEODH system
1 Tenders for contractor(s)
2 Preliminary design of GeoDH system
3 Preparation of relevant acts, which are required according to the Business model and legal regulations
3a Tariff system, price calculation and price list
3b Conditions for the connection to the system (technical and financial)
3c System operating instructions
3d Contracts with customers

III Building phase
Key activities of the implementation of GEODH system
1 Permits and planning process
2 Final design for GeoDH system
3 Construction phase
4 Putting into operation, commissioning

IV Operating phase
1 Energy supply
2 Management and maintenance in life or contract period.