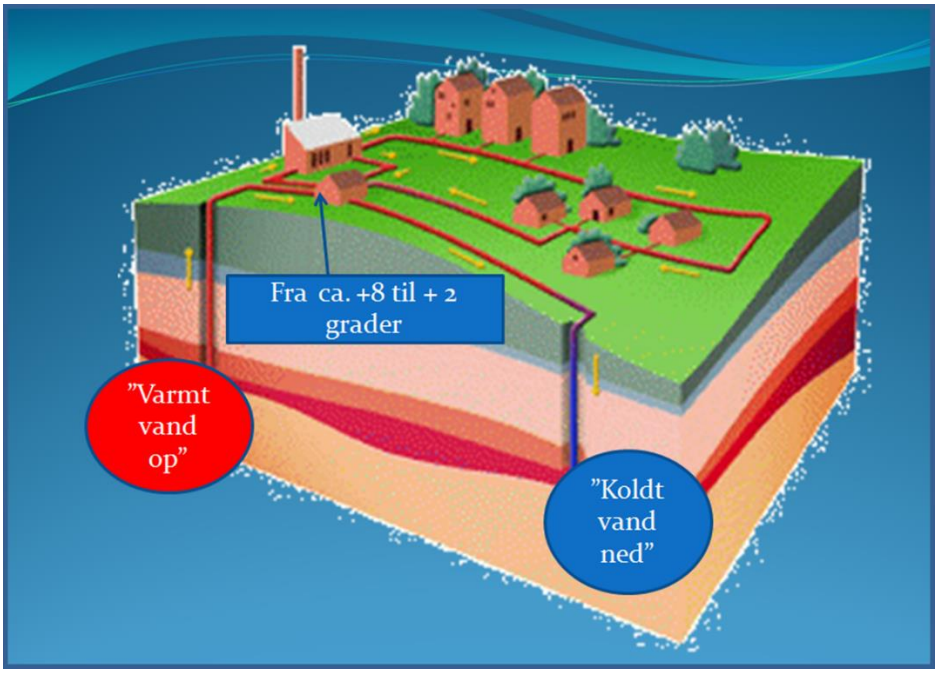
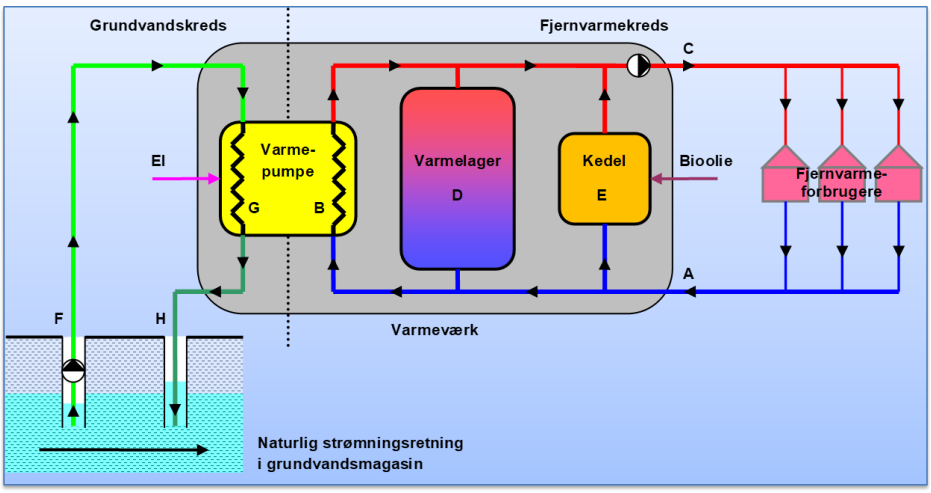
Final report

Optimization of Ground Water Heat Pump





1. Project details

Project title	Optimering af grundvandsvarmpumpesystem
Project identification (program abbrev. and file)	64013-0119
Name of the programme which has funded the project	EUDP-13-I
Project managing company/institution (name and address)	PlanEnergi Jyllandsgade 1 9520 Skørping
Project partners	**PlanEnergi** Jyllandsgade 1 9520 Skørping, CVR 74038212 Contact: Jens Birch Jensen, jbj@planenergi.dk **Præstø Fjernvarme** Værkstedsvej 3 4720 Præstø, CVR 6724 7817 Contact: kontor@praestoe-fjernvarme.dk Formand Morten Kristensen **Geo** Maglebjergvej 1, 2800 Kgs. Lyngby, CVR 7978 1812 Contact: Lars Hjortshøj Jacobsen **Orbicon** Jens Juulsvej 16 8260 Viby J., CVR 2126 5543 Contact: Anders Edsen, edsn@orbicon.dk
CVR (central business register)	74038212
Date for submission	December 2018

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2. Short description of project objective and results

English:
The objective of the project is

- optimization of the ground water part (drillings, pipes, storage, water treatment, reinjection) in relation to a new heat production system for Præstø Fjernvarme
- setting up models for the water streaming in the subsurface layers
- standardization of the ground water part

Unfortunately, due to unexpected results of test drilling, the project has not been realized. In connection with the completion of preparatory work, test drilling, installation of simulation models, etc. However, many experiences have been obtained and results that have been and can be used in other projects. These experiences relate to:

- costs for test drilling and analysis
- ground water source modelling
- the emphasis of water analysis (water chemistry)
- hydrology and hydrogeology

Dansk:
Formålet med projektet er

- optimering af grundvandsdelen (boringer, rørføring, lager, vandbehandling, re-injicering) i forbindelse med et nyt varmeforsyningssystem til Præstø Fjernvarme baseret på et grundvandsvarmepumpeanlæg
- opstilling af modeller for vandstrømning i grundvandsmagasiner
- standardisering af grundvandsanlægget

På grund af uventede resultater af prøveboringer med mere er projektet desværre ikke blevet realiseret. I forbindelse med gennemførelse af forarbejder, prøveboringer, opstilling af simuleringsmodeller mv. er der dog indhentet mange erfaringer og resultater, der er blevet og fremadrettet kan anvendes i andre grundvandsprojekter. De indsamlede erfaringer relateres til:

- omkostninger til testboringer og analyser
- grundvandsmodelleringer
- vandkemi
- hydrologi og hydrogeologi

3. Executive summary

The objectives of the Project were:

- optimization of the ground water part (drillings, pipes, storage, water treatment, reinjection) in relation to a new heat production system for Præstø Fjernvarme
- setting up models for the water streaming in the subsurface layers
- standardization of the ground water part

Since the implementation of the plant never was initiated the objectives of optimization and/or standardisation of plant components and installation was not achieved.

During the project we have seen very complicated hydrological and geohydrologic issues that have been the basis for discussions and improvements of the understanding of these systems and the modelling of the hydrogeology.

4. Project objectives

Before Project Start-up two preliminary test-drillings had been made and the results of these drillings was very positive for development of a heat pump system with ground water as heating source. The principal system is shown in figure 1:

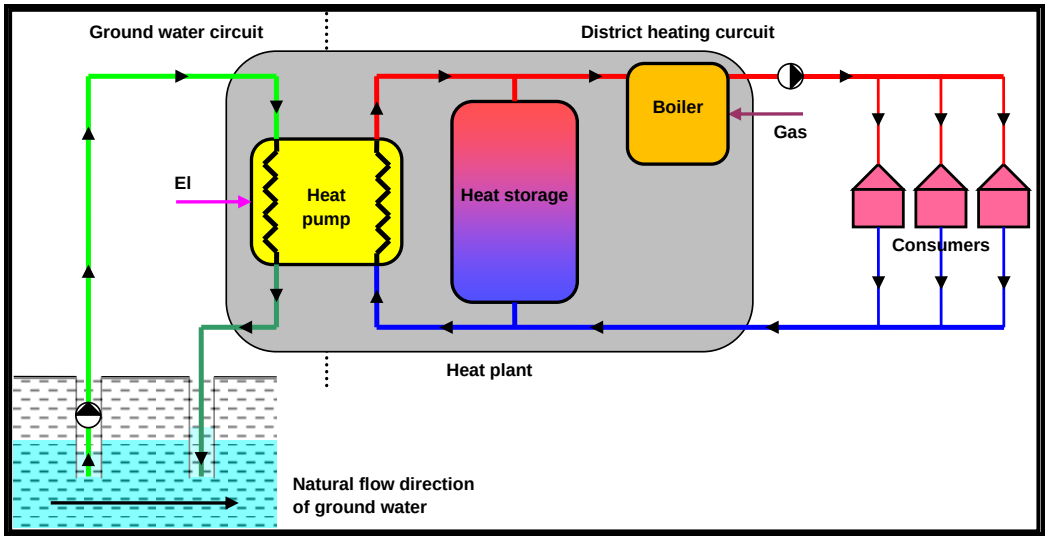

Figure 1: Principle system design for a ground water heat pump system

The first two test drillings were made in 2009-11 as DGU 226.1240 and 226.1242. The performance test of the 2 100-meter drillings showed relatively high flow rates of water production. It was estimated that the production range would possible be approx. 65 m3/h. By the performance results, 4 production drillings and 4 re-injections drilling would be suitable for the heat pump project for Præstø Fjernvarme.

For this project a feasibility study showed that a heat pump project based on the design data shown in table 1 and the investments as shown in table 2 would have a pay-back time of 7 years or a 2 mio. DKK/year saving after capital costs.

Forudsætninger:	Enhed	Antal
Varmt vands-akkumuleringstank	m^3	1.000
Varme-effekt	MW	4
Antal driftstimer på varmepumpe	timer/år	8.760
COP-varm (COP betyder Coefficient Of Performance eller på dansk nyttevirkningsgraden.)	-	3
Effekt fra grundvand	MW	3,5
Afkøling af grundvand	grader celcius	7
Grundvandsflow pr. 2 boringer	m^3/ time	65
Grundvandsflow i alt for 2 x 4 boringer	m^3/ time	260
Antal grundvandsboringer	stk.	8
El-effekt	MW	2

Table 1: Design data for heat pump project

Investeringer i tekniske anlæg og bygninger:		Kr.
Varmt vands-akkumuleringstank	Mio.kr	1,0
Grundvandsboringer (6 nye + pumper mv. i de 2 eksisterende boringer	Mio.kr	7,2
Elektrisk varmepumpe	Mio.kr	6,0
Biooliekedel	Mio.kr	5,0
Bygning	Mio.kr	4,0
Rådgivning, projektering, tilsyn	Mio.kr	1,5
Diverse	Mio.kr	2,0
Investeringsoverslag I alt:	Mio.kr	26,7

Table 2: Investment in heat Pump Project 4 MW.

Based on this information the project objective was to establish a ground water source for a district heating heat pump. The presumptions were to establish 4 production drilling and 4 re-injection drilling at an area northwest of Præstø and in a distance of a few hundred meters from the existing district heating network of Præstø Fjernvarme. The drillings were expected to be positioned as shown in figure 2.

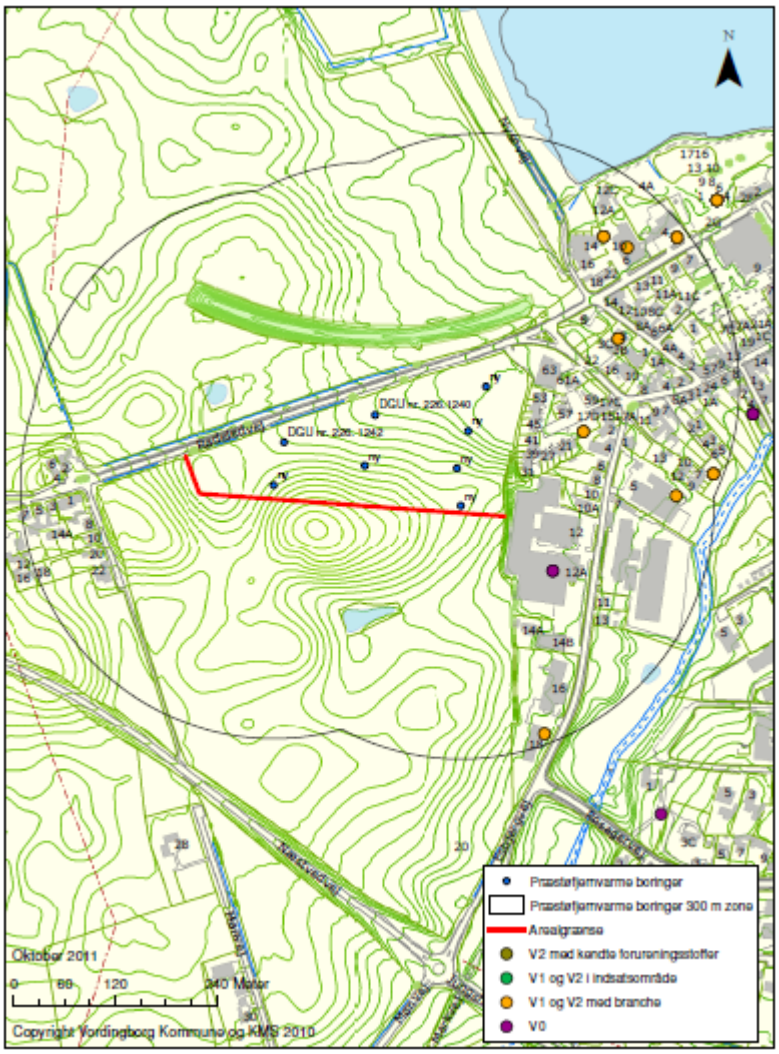

Figure 2: Initial project for 2x4 drillings.

During the project different partners have introduced suggested analysis results showing positive result for the ground water as source for a heat pump.

The first conclusion was that the proposed position of the drillings would introduce a relatively high risk of a thermal short-cut between production and re-injection drillings. Therefor a new position of the drillings was suggested as shown in figure 3.

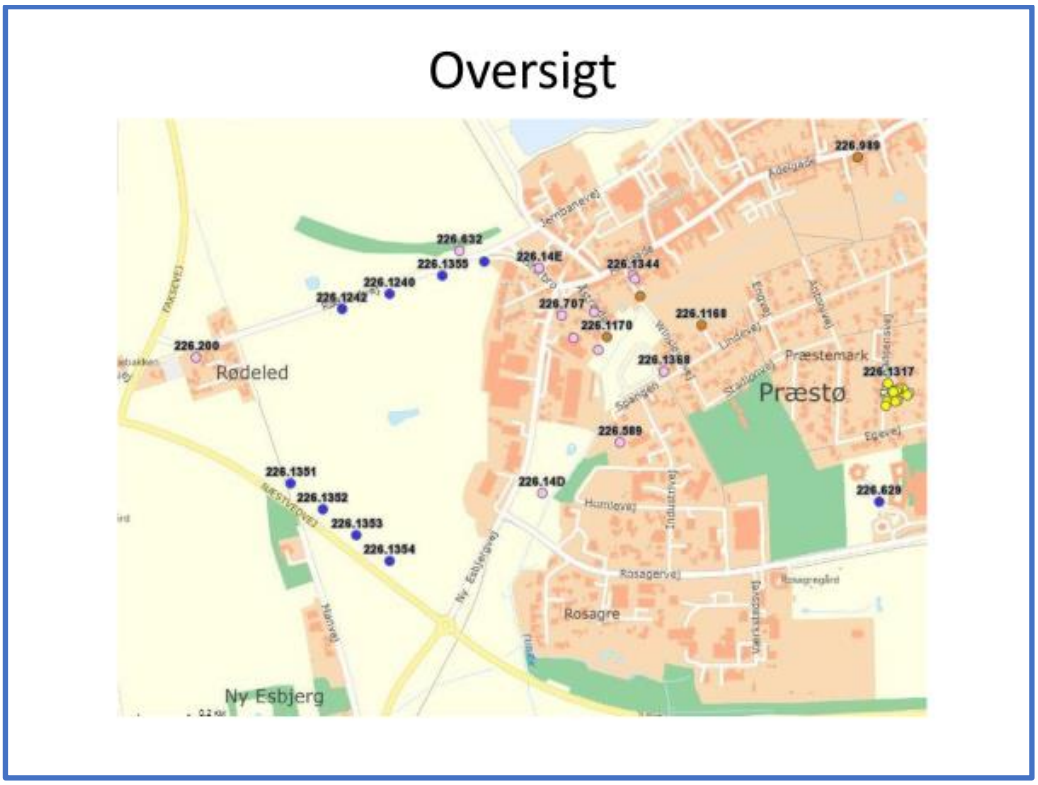

Figure 3. Proposed alternative position of drillings (blue dots, 226.1351-56).

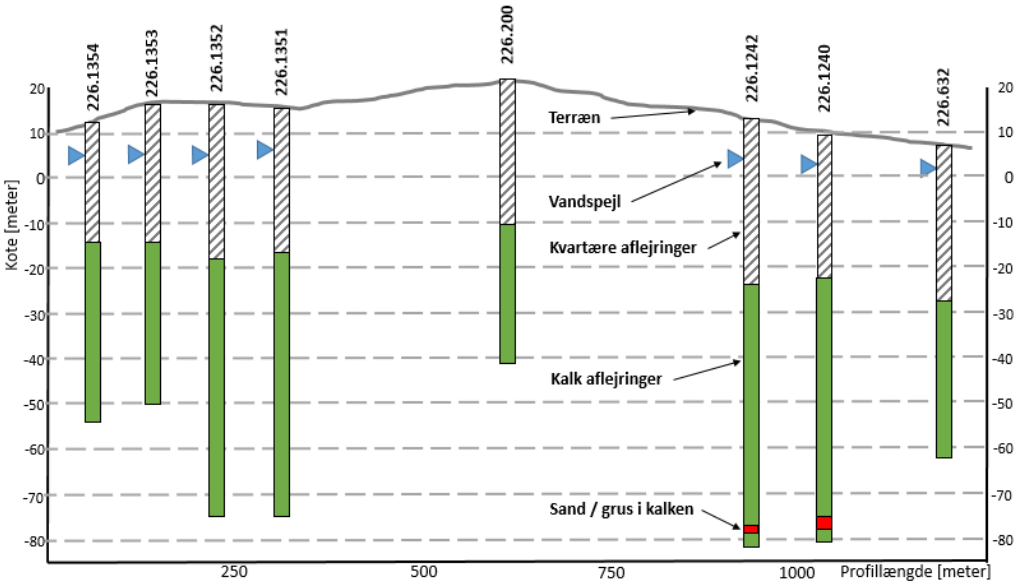

Figure 4: Profile of drillings in the area (the 6 test drillings and 2 old)

After performing all in all 6 test drillings and analysis of the pump test results it was concluded that the water source within the tested area would not be enough as source for a feasible ground water heat pump project. The capacity was too small, the capacity utilizing all 6 drillings as production drillings was only 150 m^3/h. The pump test results are shown in table 3.

	DGU 226.1351	DGU 226.1352	DGU 226.1353	DGU 226.1354	DGU 226.1240	DGU 226.1242	Sum m3
Ydelse m3/t	**12**	**13**	**21**	**13**	**42**	**51**	**152**
Egensænking	12,48	9,16	9,76	9,68	5,65	20,10	
Sænkning fra andre boringer	7,63	8,88	6,59	6,73	1,72	2,38	
Dybde til vandspejl (ro)	11,85	12,66	12,84	9,54	6,50	9,20	
Dybde til vandspejl (drift)	31,97	30,70	29,19	25,95	13,87	31,68	
Dybde til kalk	32,50	30,80	30,00	26,00	32,00	37,00	
Diff	0,53	0,10	0,81	0,05	18,13	5,32	

Table 3: Test results from 6 test drillings in Præstø

Therefor it would be necessary to either install a much smaller heat pump or further develop the project with a number of drilling in another position introducing further cost for investigations and implementation of the heat pump project.

Figure 5: Position of possible area for injection drillings

In 2018 after having made further feasibility studies of the Project the board of Præstø Fjernvarme decided that the risks of the project compared to alternatives were too big. The project was therefore closed, and the 6 test drillings were abandoned.

5. Project Results and dissemination of results

The project has shown the importance of accessing the project regarding analysing and testing of the possible ground water resources. Both theoretical analyses, modelling and actual test drillings are very expensive and have to be planned very carefully and utilising all existing information that can improved the quality of the analysis.

In this case it was shown that the hydrogeology of the area was not evident to understand and the result have been interpreted in different ways by different experts.

In the Handbook prepared by PlanEnergi some of the basic methods and traps to avoid is described.

5.1 Dissemination of results

PlanEnergi has based on the experiences from Præstø Fjernvarme Heat Pump Project and the other Danish ground water heat pump projects in Broager Kraftvarmeværk, Rye Kraftvarmeværk, Dronninglund Kraftvarmeværk and others prepared a guide book for similar projects intending using ground water as a heat source for a heat pump project.

The guide book (in Danish) will be available for download at PlanEnergis homepage www. Planenergi.dk.

There have been several articles in newspapers, Energy Journals as "Fjernvarmen" etc. describing the project.

PlanEnergi has for instance presented the project at:
Dansk Fjernvarmes ERFA-group
IDA Energiteknisk Group

6. Utilization of project results

Many of the experiences from the project have already been utilised in the work of other ground water projects.

Examples of plants are:

- Farstrup-Kølby Kraftvarmeværk – planning for a heat pump with ground water as heat source.
- Dronninglund Fjernvarme – planning for a heat pump with ground water as heat source in combination with an existing solar plant.
- Broager Fjernvarmeselskab – implemented a heat pump with ground water as heat source in combination with an existing solar plant.

7. Project conclusion and perspective

The implementation of heat pumps in the Danish energy system based on ground water as heatsource has a large potential as the ground water sources in Denmark are relatively good and as this source is very stable with a constant temperature also in winter when the operation of the heat pump is needed most.

Other low temperature heat sources for heat pumps are often best utilized in summer.

There are still many barriers for implementation of Ground Water Heat Pumps primarily due to high investigation cost before the preconditions for a feasibility study can be settled.

It is our hope that the results of this project as described in the Guide Book may help in the further improvement of the project management and analysis of the ground water sources to minimize the project development time and costs for coming projects.

27.12.2018
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