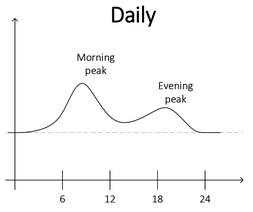
Geothermal Heat on the Scale

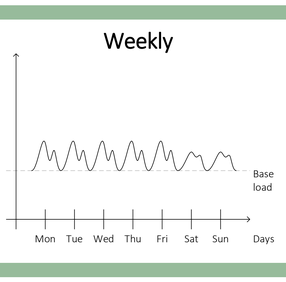
We are transitioning away from fossil fuels for district heating – however, we have to understand the intrinsic properties to the new fuels to fully understand how to design a robust district heating system with security-of-supply and cost-efficient production in mind.

Profile



District heating experience two peak situations during normal days – a pronounced peak in the morning and a lesser peak (but longer in duration) during evening.

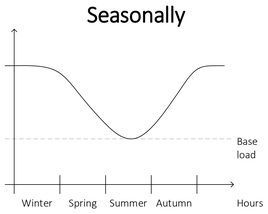
To cope with these peaks district heating companies utilise storage systems such as buffer tanks built-in to the distribution system and accumulation tanks, and they – depending on their energy mix – throttle production.



Weekly variations are on a minor scale – and come weekend the peaks becomes less distinct.

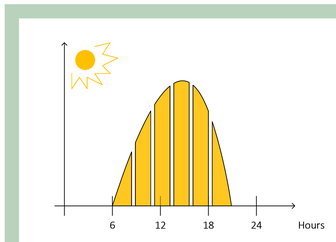
The load profile for a district heating system is dependent on size, and there are significant differences between small systems supplying less the 400 consumers, and system supplying +500,000 consumers.

Hence, there is a continued development of district heating technology in DK.



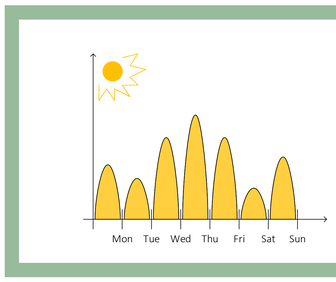
Seasonal variation dependents on the location, and number of consumers – however, there is always a requirement for a base load to sustain comfort levels and ordinary living standard such as the hot bath in the morning.

Sun

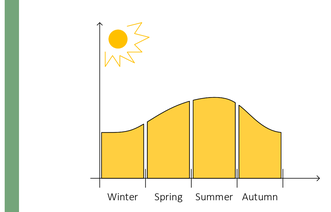


Sun peaks at midday, but also have a varying daily production profile due to cloud cover. Sun (thermal) can be stored, but requires a rapid charge storage technology to accommodate for the high influx.

District heating companies has a rule-of-thump which dictates that ~20% of the capacity can be covered by solar collectors.

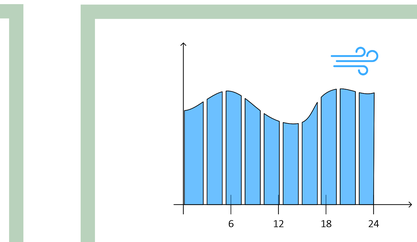


Solar collectors works ideally in supply situations, where they can be placed relatively closely to the distributions, however, they take up significant areas of land, which otherwise could be developed for residential, commercial or industrial use.



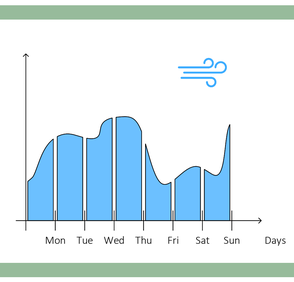
Seasonal variations means that sun has to work in conjugation with other renewable sources.

Wind

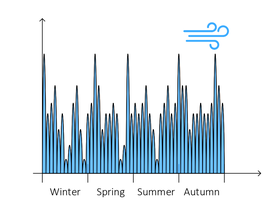


Wind fluctuates across the day, however, to add wind into the energy mix for district heating requires the use of heat pumps, electrical boilers and generally systems, which can adjust to the purchase conditions on the spot marked for electricity.

Storage options to defer the time of use from the time of purchase can be wind more flexible components for district heating.

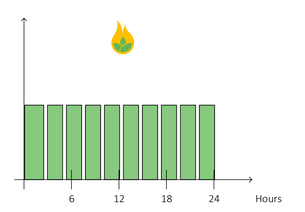


Wind has an even greater fluctuation across a week, and wind has a significant impact on the landscape profile. With advances in offshore wind this source of energy is gaining an important footing in the marked, and with an increasing electrification of our supply systems wind will grow in importance in the coming years.



Seasonal average of wind can be used as an indicator – however, wind still periods occur across the year.

Biomass



Biomass incineration is stable, can be (somewhat) throttled and forecast. However, biomass is a 'x-over' technology towards a 'Fuel-free heating'.

Biomass displays most of the required properties from a good district heating fuel, however, with significant concerns about its environmental profile, biomass is poised to lift the requirements from heavy transport and flights to become greener.

Criteria for developing geothermal heating projects

Organisation and management of geothermal heat project has to be conducted in a safe and cost-efficient manner, and with delegation of task to suppliers, who posses specialist knowledge and know-how.

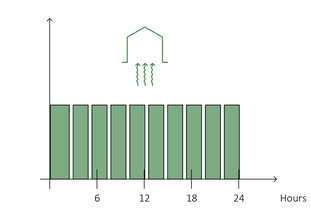
These suppliers and other stakeholders has to share a common goal, but also understand how value in geothermal is in the long-term commitment as oppose to commodities sold on the spot marked.

The stakeholders*, who will succeed in geothermal heat, understand the risks of geology and distribution, understand exploration and drilling and see marked barriers before they become a problem.

Geothermal heat has a markedly different valuation from e.g. fossil fuels, and for geothermal heat to be a successful source of energy must be put into a bigger context, where more then more project is developed successively.

* Could be a Public-Private partership

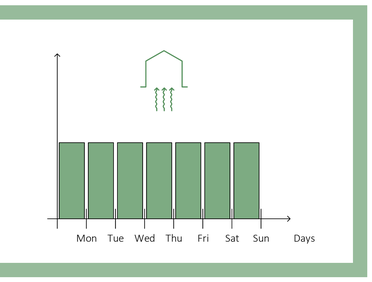
Geothermal



Geothermal has the same production properties as biomass, however, with a slightly less dynamic production profile.

Geothermal energy falls into three categories; low-enthalpy (DDU – Deep Direct-Use), high-enthalpy and EGS. Low-enthalpy geothermal is > 120°C, and works ideally in district heating systems as a base load fuel.

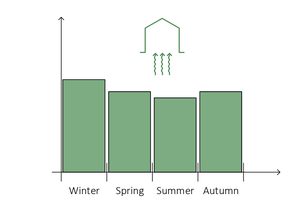
In, other words, geothermal heat is assurance of security-of-supply on an extended timescale.



Geothermal heat projects for district heating can be dived into two types;

- selecting deeper formations and selecting higher temperature for possible feed-in directly to the distribution system

- selecting more shallow formations and having higher flow rates, with addition of heat pumps, before distribution.



Geothermal heat can be produced to complement and supplement other renewable sources – however, none of them have the same properties with regards to security-of-supply.

Navigating between sources of energy is becoming distinctly harder as more sources of renewable energy reach maturity levels beyond that of demonstration.

However, looking at sources of energy for district heating the selection process becomes narrower;

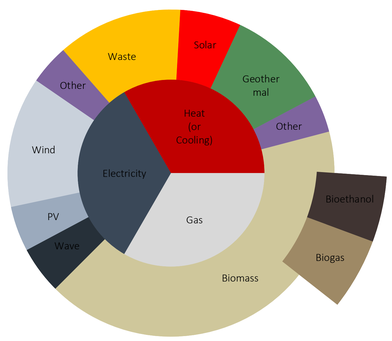
- Direct heat; Geothermal energy and Sun

- Indirect heat; Wind (electricity)

And there are two sources of energy which in the coming years will have a significant impact on the energy mix;

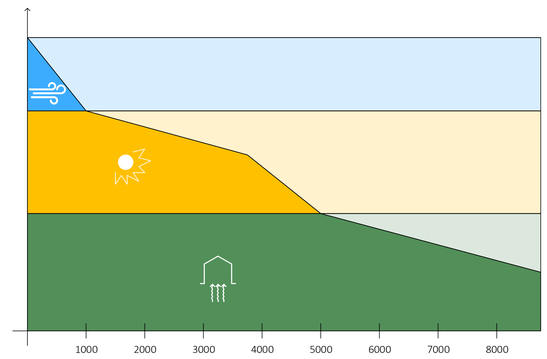
- Waste heat, collecting heat from industrial process for feed-in to the district heating system

- Waste incineration, burning of the residual part of waste after separation into reusable fractions



A combination of sources can be illustrated as on the right. There are multiple combinations and only after calculating the commercial and societal effects can a choice be made.

However, geothermal heat is an excellent choice for a stable, sustainable, long-term energy source. Geothermal energy supplement all of the other renewable energy sources, and looking at sources for 'fuel-free heating' geothermal energy is an evident choice for future production.



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Geothermal Heat on the Scale

We are transitioning away from fossil fuels for district heating – however, to develop geothermal projects we have to acquire knowledge.
A pre-feasibility study with milestone and decision points is a the way forward. Below are the recommended phases of mapping process

Project clarification

This is the prologue of the project, where the scene, actors and story is defined. The prologue describes what the journey has been to reach the conclusion 'what is we chose geothermal heat?'

The purpose of this stage is to understand the client's needs. The information requested will allow understanding of the predicted heat demand;

If the economics does not support geothermal development, help can be sourced our Danish Board of District Heating (DBDH) partners to recommend other options.

- What are the principle drivers for the project (e.g. resilience of supply, alleviation of fuel poverty, carbon reduction, life cycle assessment) and reporting requirements?
- What are the principal social considerations?
- What is the current size of the heat network in terms of dwellings and demand?
- What is the current expectation for expansion of the network?
- What are network heat demand growth forecasts?
- How do you currently plan to heat the network?
- How will the network be funded, is there an outline business model?

Milestone decision

Subsurface data

When assessing a drilling project, the availability of good quality subsurface data is crucial, consideration will be given to the following:

- What is the quality of the available seismic data sets?
- Have any offset wells been drilled in the area?
- What information can be concluded from local and regional geology studies?
- It's possible that some of this information may not be publicly available and it may be necessary to purchase this information at additional cost.

Milestone decision

Once the data gather is complete and assessed, a recommendation will be made at this point to continue or not based on the information in hand.

Milestone decision

Geological target assessment

The objective here is to assess the viability of the prevailing geothermal target reservoirs available.

The work will aim to address the following questions:

- Is there a Target reservoir?
- If several targets are present, can they be ranked?
- What are the anticipated parameters of the reservoirs (porosity, permeability, thickness and distribution etc.)?

- What is the anticipated energy in place?
- What are the anticipated production rates?
- What is the anticipated heat production?
- Are there any injectivity considerations?
- Are there anticipated challenges to the drilling process?

Milestone decision

Recommendation to drill

The RTD document contains specifics for a single well.

For a multi well project each well will normally require a dedicated RTD, however, for a multiple wells <u>within the same development</u> it may be possible to streamline this process.

The information summarised in the 'Geological Target Assessment report' shall be integrated with the results of other studies to produce a 'Recommendation to drill' (RTD). The purpose of this document is to 'lock' certain design criteria, allowing the well engineers to proceed with well concept selection and planning. The 'locked' criteria are:

Well surface locations, Well Target locations subsurface, Formation tops anticipated, The subsurface pressure regime

The subsurface geomechanical regime will be assessed on offset and regional data. An independent geomechanical study may be required as part of detailed well planning, but not at this stage.

Milestone decision

Well design and cost

The Recommendation to drill (RTD) document forms the basis for the conceptual well design. At this stage only design work necessary to allow accurate delivery of cost data will be completed. This is intended to minimise costs in early phase planning.

The final output will be a provisional well design with a focus on well integrity and environmental safety. Based on this design probabilistic time and cost estimates will be generated.

Project risk assessment

To facilitate the risk assessment, a workshop will be conducted with the multidiscipline project team.

A combination of risk assessment and Hazop tools will be employed to effectively consider the principle project risks, both technical and HSE based.

This will involve determining the consequences, probability, risk mitigation and ranking of the high level project risks. The output of this session will be formalised into a ranked Project Risk Register with the foremost resultant risks highlighted.

Environmental and legislative requirements

Interrogation of the legislative requirements to thoroughly determine the following:

- What are the regulatory requirements of both the planning and well construction process?
- What permissions are required to construct the wells?
- How shall the well examination process be conducted?
- What are the requirements of the Environmental Impact Assessment?

- How shall the USGS be involved?
- Who owns the geothermal asset?

Are there any regulatory or legislative show-stoppers?

Geothermal feasibility study

The information from the previous documents will be combined into a project feasibility summary. This document will place the client in a position from where they can make an informed decision to proceed, or not.

This process mean necessary due diligence has been carried out.

- The social and HSE requirements will be clear
- The key technical challenges will be clear and explicit
- The costs will be clear with likely errors quantifiable
- The key risks to the project will be understood
- The revenues can be modelled
- The predicted heat output of the system will be estimated

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