Utilizing Geothermal energy in low temperature areas

Orkuveita Reykjavíkur

Economics of Geothermal Energy

-Built on Icelandic experience

What is important and how do we utilize this heat source.

Thrandur Olafsson (Tod) 11.06.2013
For a Polish delegation group of experts

Agenda - topics

- Foreword : The task is not as easy as it may seem.
- What is important regarding the resource?
- Technical foreword: design parameters, ideology
- What has to be kept in mind with respect to design?
  - What is the difference between district heating fed with burning of fossil fuels and geothermal?
- Brief cost issues
  - Directly related to choice of tarriff.

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Foreword : An easy task?

- Reykjavik [English: Smokey bay] is ideal for geothermal heating. The resource is just below our feet.
- There have been several hurdles on our way, some economically painful as well as politically difficult.
- Historically the chairman/president of the heating company has often been in direct conflict with city officials.
  - Some political parties promised to expand the heating network while others promised the opposite.
- Refer to Hildigunnur‘s lecture regarding technical milestones

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Foreword : Local issues

- There are always local issues that have to be solved:
  - Where does the heat source come from today?
    - Can we expect some kind of competition for heat as a product?
    - Can we expect cooperation/competition for peak load?
  - Who owns the land where the geothermal resource is taken?
    - Any resource rent will result in a higher tarriff to customers.
  - Who owns the land where the distribution pipes will lie?
  - What % of houses will connect and how are the houses heated now?
    - Are all existing buildings already connected or only a fraction? Will there be a change in neigborhoods (increased/decreased density)? A connection to the new heating network: voluntary or mandatory for new houses?

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Foreword : Structural issues

- Who will own the district heating company (DHC)?
  - If municipality/town or state owned -> lower interest rates
  - Lower need for profit, lower tarriffs to consumers
    - Problematic if co-operated or competing with private companies?

- Where are ownership boundaries between DHC and customers?
  - Important to have a specific outline in early stages, who is responsible for what.

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Foreword : Structural issues

- What metering system will be used?
  - Favorable to structure a metering system where customers are given incentives to act so that it benefits the heat source.
    - Colder water is often easier to re-inject into the resource, compared to hot water.
  - It is possible that a metering system at one site does not fit well at another site, this should always be checked.
- Will tap water be distributed separately or in the same network?
  - If re-injection is needed, heat exchangers are necessary (otherwise mass will be lost in tap water usage).

- All of these issues (and more) : very important for design and economics of the geothermal utilization.

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What is important regarding the resource?

- Temperature
  - Suitable for radiators or floor heating only?
- Mass flow
  - Production vs. draw down of water level in wells
    - Mechanical or geological upper boundary?
- Re-injection
  - Necessary from day 1 can it be postponed for a few years?
    - If postponed, it can make the re-injection easier, as the water level will be lower
- Chemical composition
  - Can we use the water directly for i) heating, ii) tap water uses?
    - Corrosion or scaling in pipes?
  - Is any pre-processing necessary (de-aerating)?

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What is important regarding the resource?

- In Reykjavik, we are utilizing 3 different geological low-temperature sites.
  - Laugarnes (120-125°C), the initial site. Used with mixing of return water to generate 80°C
  - Mosfellsbær (85-90°C), utilized after that
  - Elliðaár (80°C). Does contain oxygen and does create corrosion if used untreated.
- In addition, heated cold water from the high temperature areas of Nesajvellir and Hellisheiði is used.
  - Nesjavellir from 1994. At max. Load 1800-1900 l/s of 100°C water. Will not be expanded further
  - Hellisheiði from 2009. Only used to a small extent. Can be expanded to > 2000 l/s in future.
- The heated cold water from high temp areas and low temp areas are not allowed to mix. Mixing will create scaling.
- The capital city has abundant heat energy for the coming 20 – 25 years, because the latest expansion was very large.

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Technical foreword : parameters

- Temperature
  - Supply temperature (T_s)
  - Return temperature (T_r)
  - $\Delta T = T_s - T_r$
  - Outdoor temperature (T_o)
  - Indoor temperature (T_i)
  - Temperature design nonclamenture ($T_s/T_r/T_o/T_i$)
- Pressure (P: P_s, P_r ΔP, similar to T)
- Flow $\dot{m}$ (dm/dt) (kg/sek or m^3/h)
- Heat dissipated (W, kW, MW) : Q = constant * $\dot{m}$ * ΔT

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Technical foreword : ideology

- Heat dissipated (W) : $Q = \text{constant} * \dot{m} * \Delta T$

In thermal networks, mass flow is primarily used to cope with variable load. ΔT is (close to) constant

In geothermal temperature controlled networks (temperature contr. pressure equipment), the temperature drop will decrease when load increases (T_r will be higher). Hence, the resulting mass flow increases in the system. To prevent the flow to be too large, a peak boiler is favorable.

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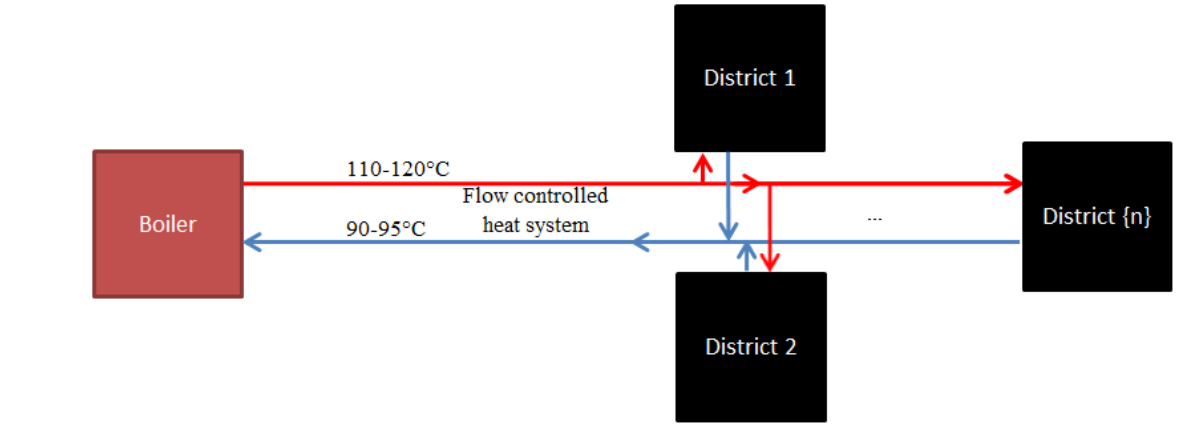
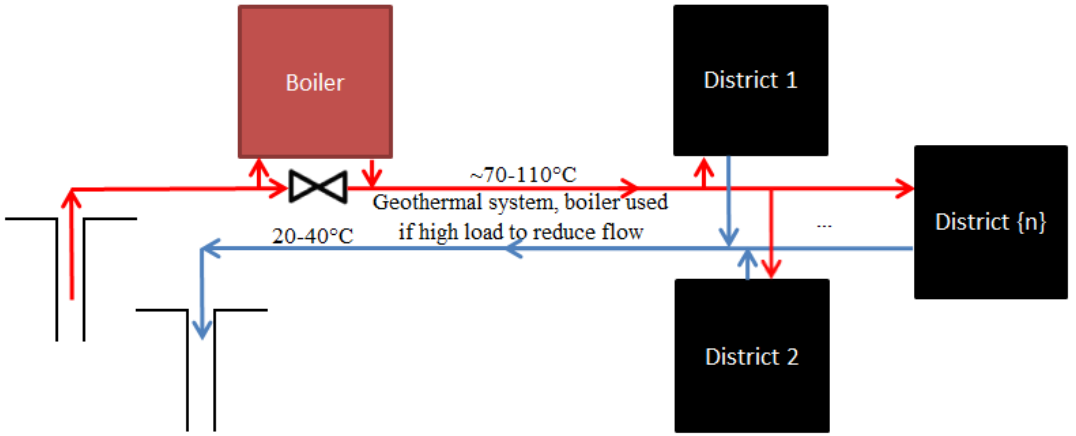
Technical foreword : ideology

- Heat dissipated (W) : $Q = constant * \dot{m} * \Delta T$
- Thermal:
- Geothermal:





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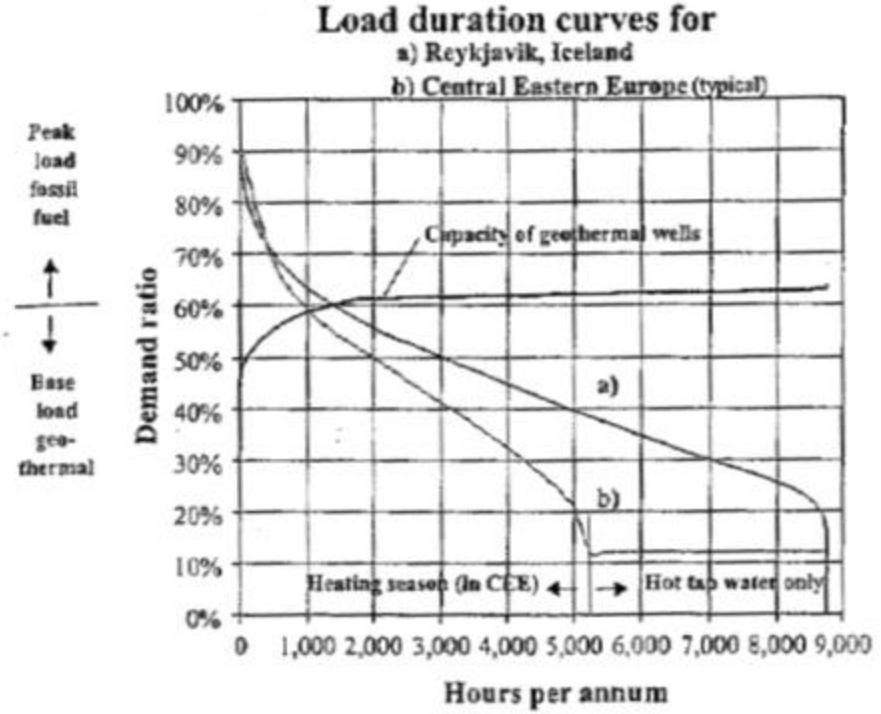
Technical foreword : Yearly load curve (cumulative presentation)

- The load curve shows more drastic heating needs in Central Europe compared to Reykjavík.

- The heating period depicted on the figure corresponds to a 5200 h heating period (7 mo.)



Source: Dickson, Fanelli

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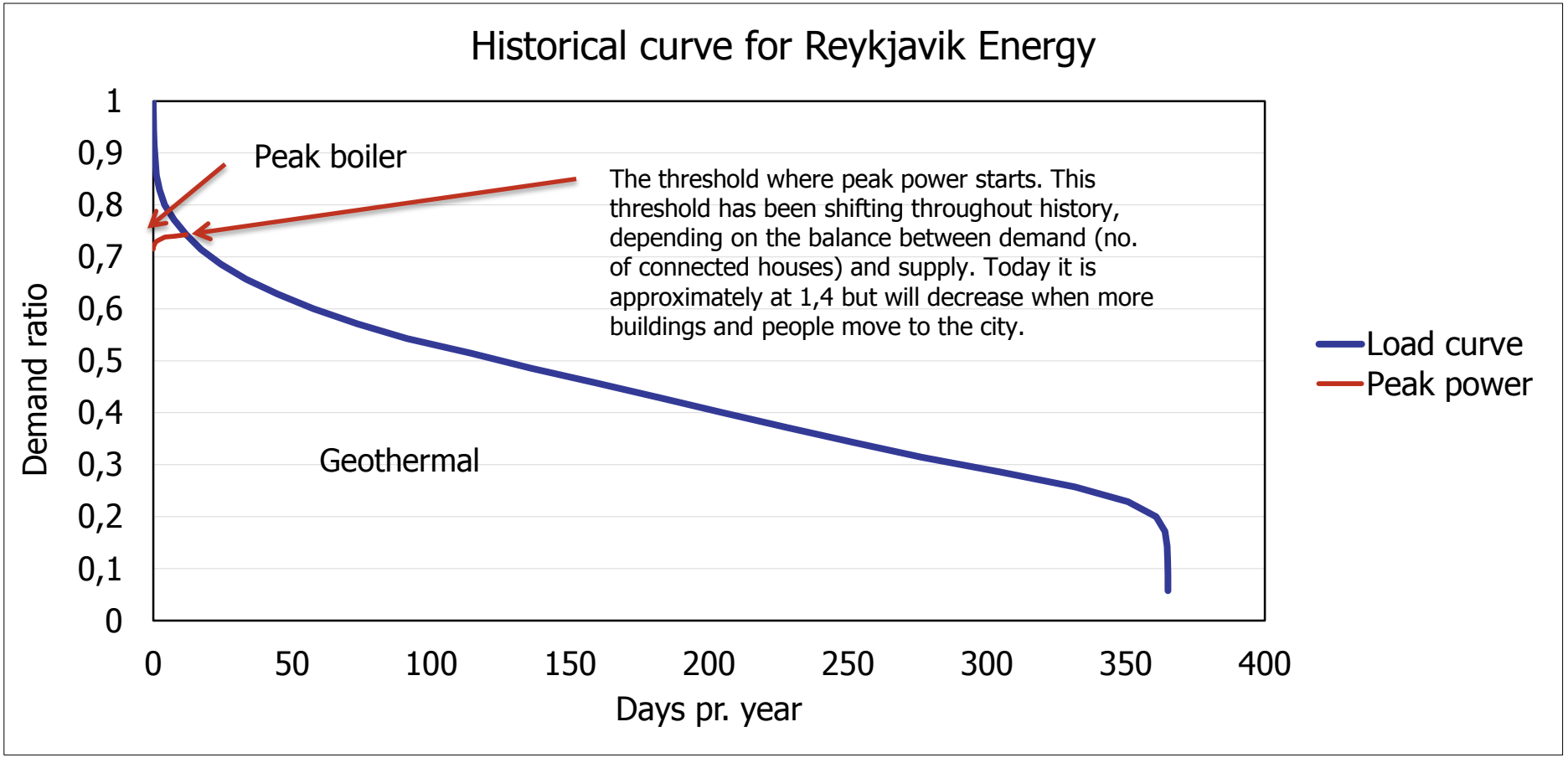
Yearly load curve (Reykjavik)



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What is the difference between district heating fed with burning of fossil fuels and geothermal?

- Traditional radiator designed with the parameters $T_s/T_r/T_o/T_i$: 80°C/40°C/-15°C/20°C.
- When the geothermal source is colder than 80°C approaches like 75°/35°/-15°/20°C or 70°C/30°/-15°C/20°C are often used.

  +25% larger +67% larger
- When the geothermal source is colder, radiator sizing is increased.
- Nowadays, floor heating is popular in new houses, which is especially favorable, when the resource is 70°C or colder.

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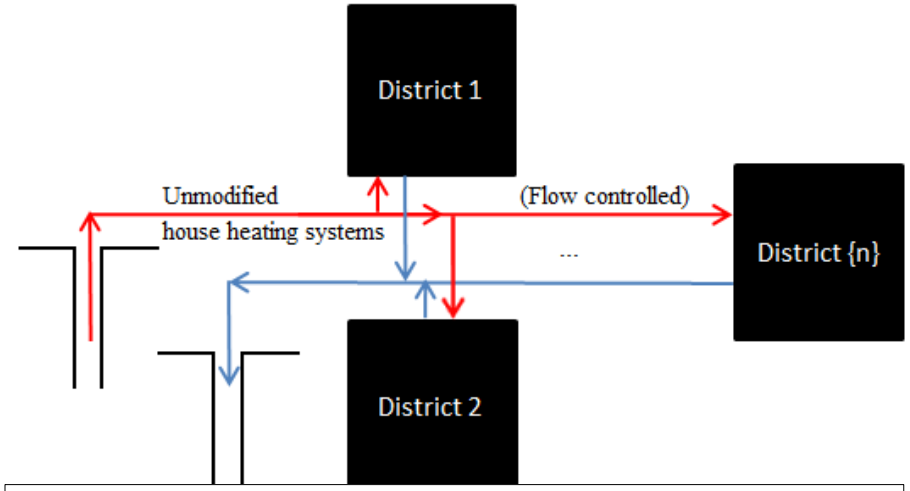
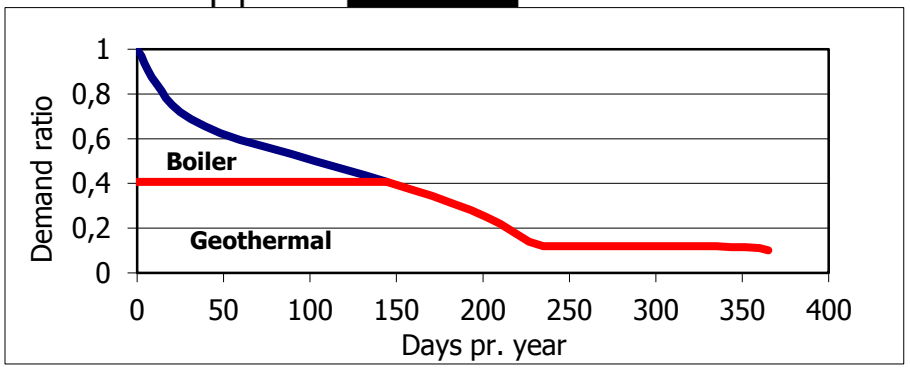
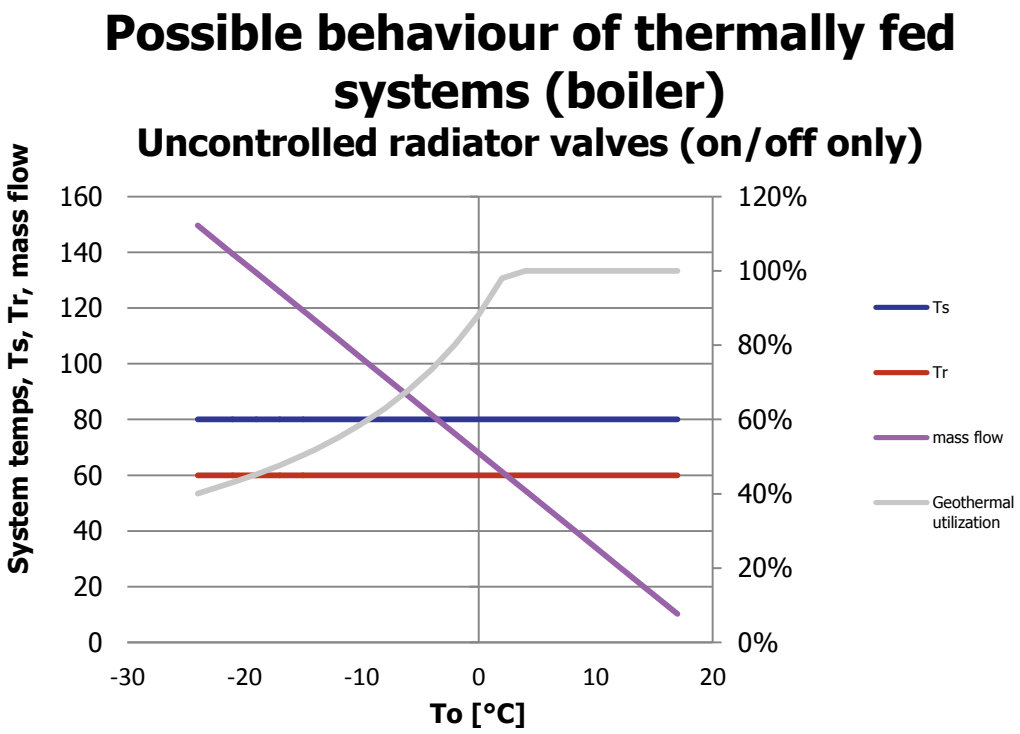
The success of geothermal utilization depends on the system design!

- Lets say, a resource with 80°C.







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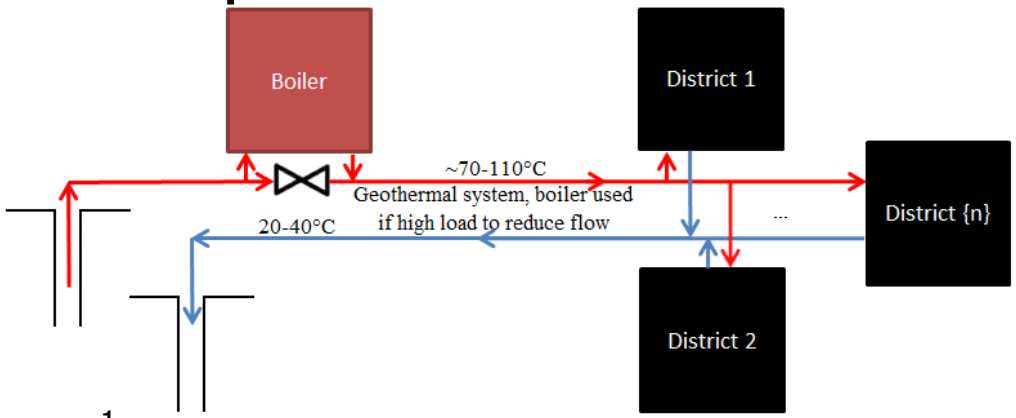
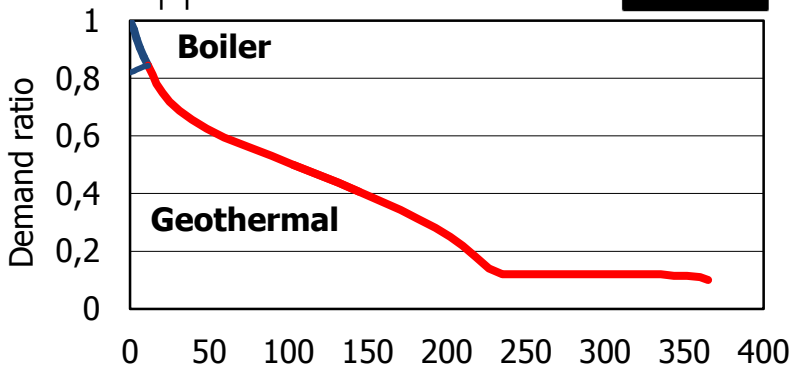
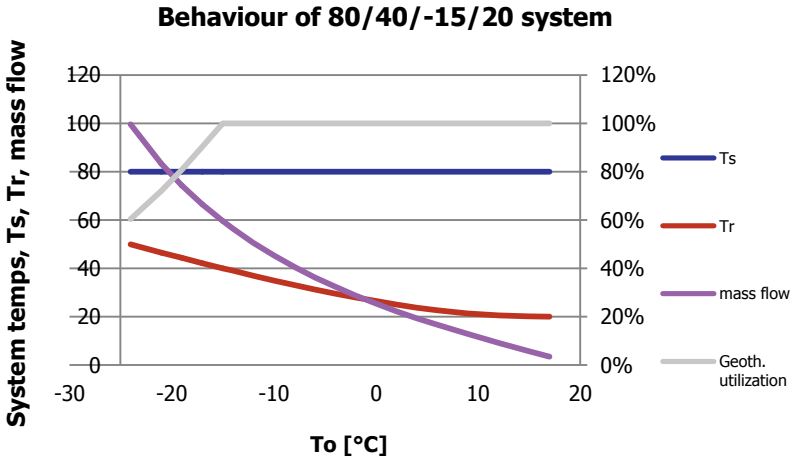
The intensity (success) of geothermal utilization depends on the system design!

- Curves are for imagined case, not in reality.
- Shape will be similar.







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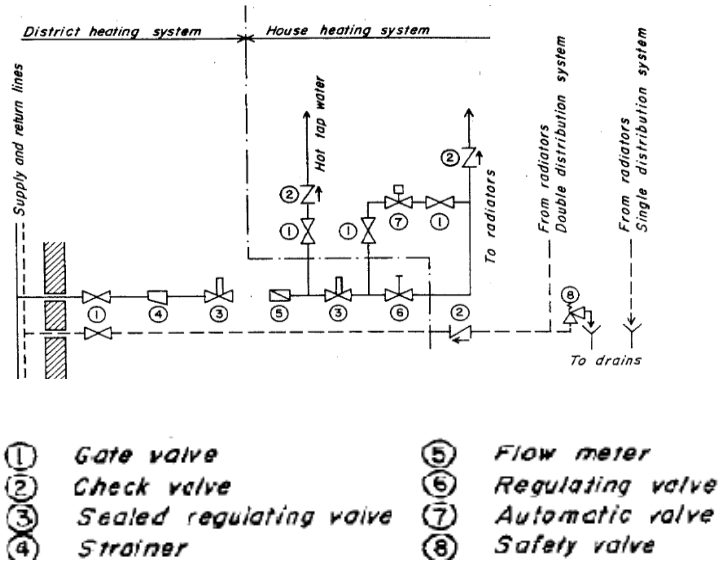
Design issues – three connection designs for various places in Iceland.

- Valves no. 6 and 9 reduce the pressure from P_s to P_r + „wp"
- Where „wp" is working pressure for house system.

- Double distribution systems are not needed everywhere in Iceland. This cannot be expected in Poland.



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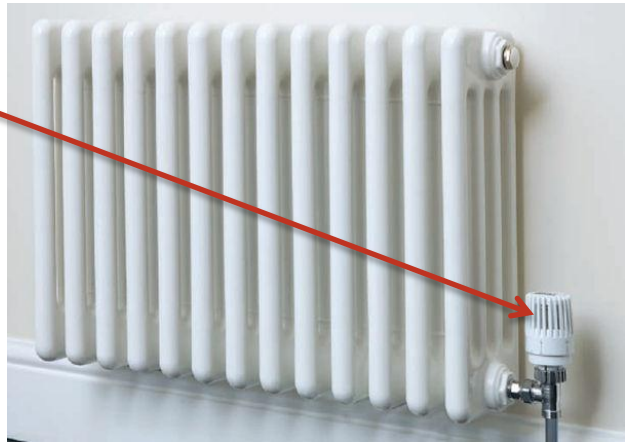
What is the difference between district heating fed with burning of fossil fuels and geothermal?

- A general way in thermal networks: Use valves to open/close flow into and from heating devices.

- An Icelandic geothermal approach: Use thermally activated pressure valves.
  - To have the pressure easily controlled, the main pressure drop is in a regulating valve in the intake of each building (item 6 on last slide)



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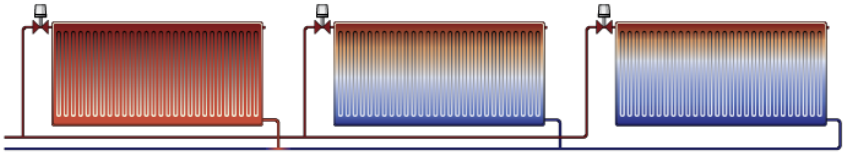
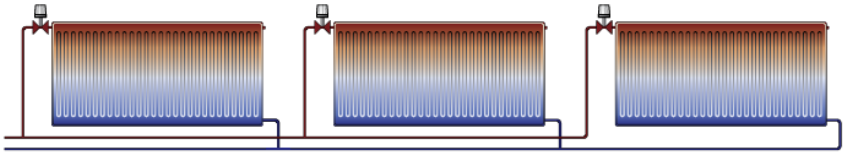
General outlines when the responsibility of heating is put upon the customer

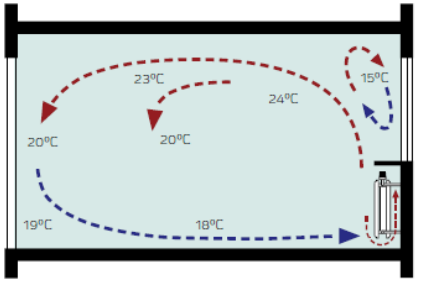
- Due to the fact that incoming water is at 80°C radiators do not need any cover; covering them is **not advised**.
- Reykjavik Energy encourages customers to utilize free air flow around radiators. A leaflet „Improved heating principles" for customers can be found on the web and a printed version by the main entrance.
- An emphasis on ballancing radiators is also mentioned.



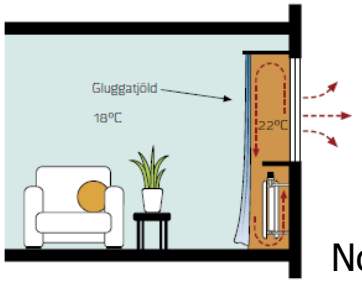
An imbalanced system ☹



A balanced system ☺



Ok



Not ok

Not ok

Source: Hitamenning OR (2007)

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Cost issues

- How are Icelandic cost for heating and how can we convert it to Polish conditions?
- Reykjavik energy tarriff: common cost numbers:
  - For a 120 m2 apartment: 5.500 ISK/month or ~149 PLN/month
  - For a 200 m2 single house : 8.500 ISK/month, ~230 PLN/month
- Changes/modifications needed to convert to Polish condtions:

"+"	" - "
Double pipeline for return water always needed.	Lower investment cost, equipment
Re-injection needed.	Lower investment cost, labor cost.
Boiler fuel	Lower operational cost, workforce.
	EU Grants or Carbon quota ?
	Lower interest environment

- If the right technique is used, tarrifs could be within (-50%,+200%) range.
- Difficult to give price indications for an arbitrary Polish site.
  - It is clear that the tarriff will always be lower if tap water is included (3000 h)..

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Cost issues - metering

- It is **very** important that metering gives the user incentives to cool the incoming temperature stream as much as possible.

- Some fixed fee is also necessary to create a minimum guaranteed revenue stream for the heating company.

- Flow metering is possible and inexpensive
- Energy metering **does not necessarily fulfill these conditions**. (Q * ΔT does not guarantee a high ΔT)

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Real issues

- Icelandic theory works well at low temperatures but bad at high temperatures **(!)**
  - We are experiencing highest return water temperatures in hottest days during summer
    - But with little flow.
  - Possible reasons :
    - People forget to shut off snow melting and it goes on during summer?
    - People forget to turn off heat in spaces which are infrequently visited (garages ...)

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Geothermal in Europe and Poland

- Planned increases in utilization of geothermal energy in Poland are ambitious.
  - The most increase is expected between 2015-2020

- Icelandic companies, Verkis, Mannvit have been assisting and working in Hungary and Slovakia and other countries.

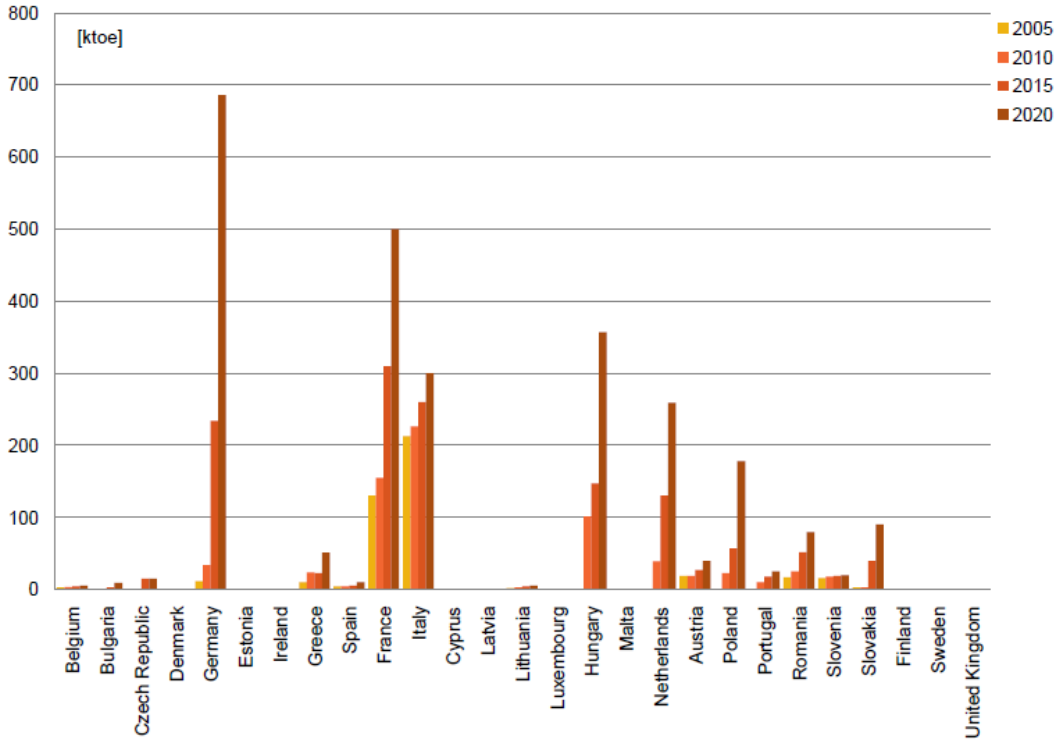

Figure 45: *Projected total geothermal heat energy [ktoe] for the period 2005 - 2020*

Source: Beurskens L.W.M., Hekkenberg M., Vethman P. (28 nov. 2011) EEA report: Renewable Energy Projections as published in the National Renewable Energy Action Plans of the European Member States (27 states)

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Final words

- A few of the tasks involved in design of geothermal district heating networks have been introduced.
- It is possible to use geothermal the „easy and inefficient way"; just switching heat sources. Doing it correctly requires a bit more, lowering T_r is the main issue.
  - This is the main issue and needs special treatment, if a renovation is forced upon each owner.

- I wish you the best of luck in your geothermal projects!

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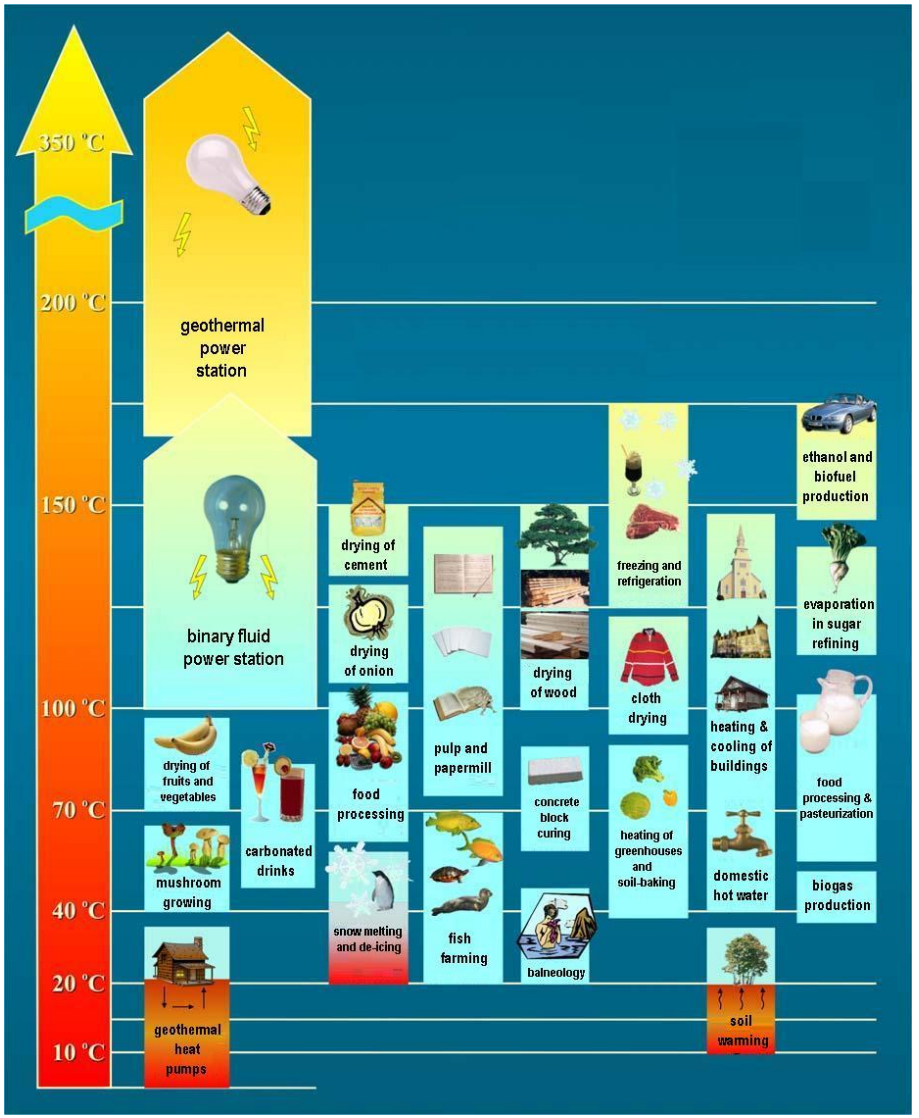
Final words

- There are lots of possible projects in geothermal besides heating:

- I wish you the best of luck in your geothermal projects!



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