SHALLOW GEOTHERMAL ENERGY FOR COMFORT IN BUILDINGS

Proven solutions in evolution

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UNIVERSITEIT GENT

boydens engineering part of Sweco

SWECO

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Sweco in Belgium

- 2 600 experts in Belgium

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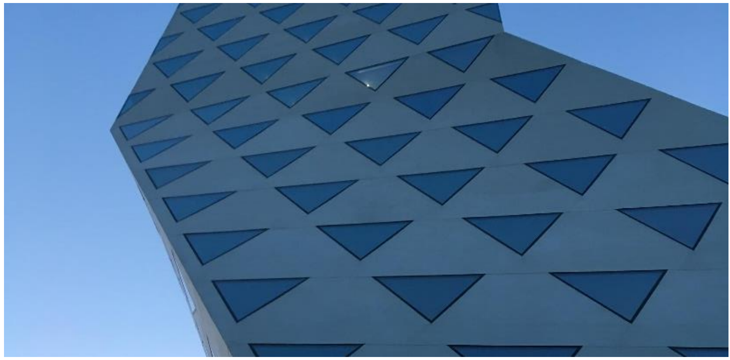
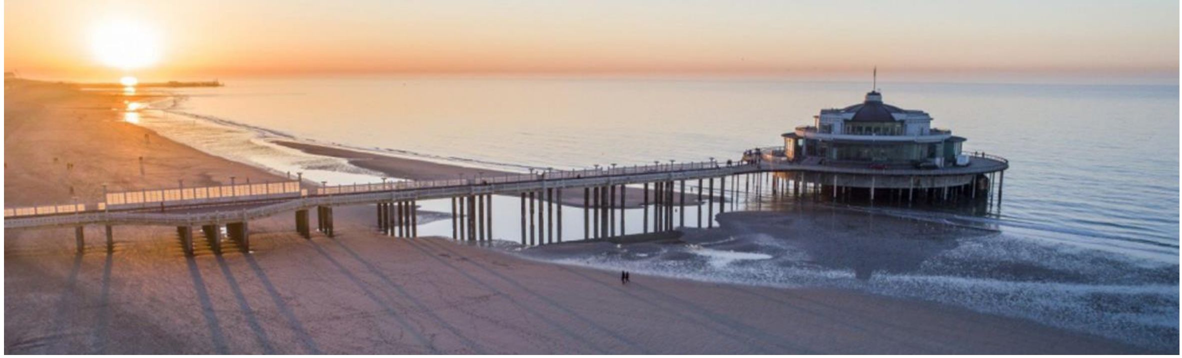
real projects: herman teirlinck/fluvius-sweco dilbeek/provinciehuis antwerpen/gare maritime/ the pier blankenberge





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real projects: Turnova Turnhout/ westbay luxemburg/ Ter Potterie Bruges/ Van Marcke distribution center Kortrijk

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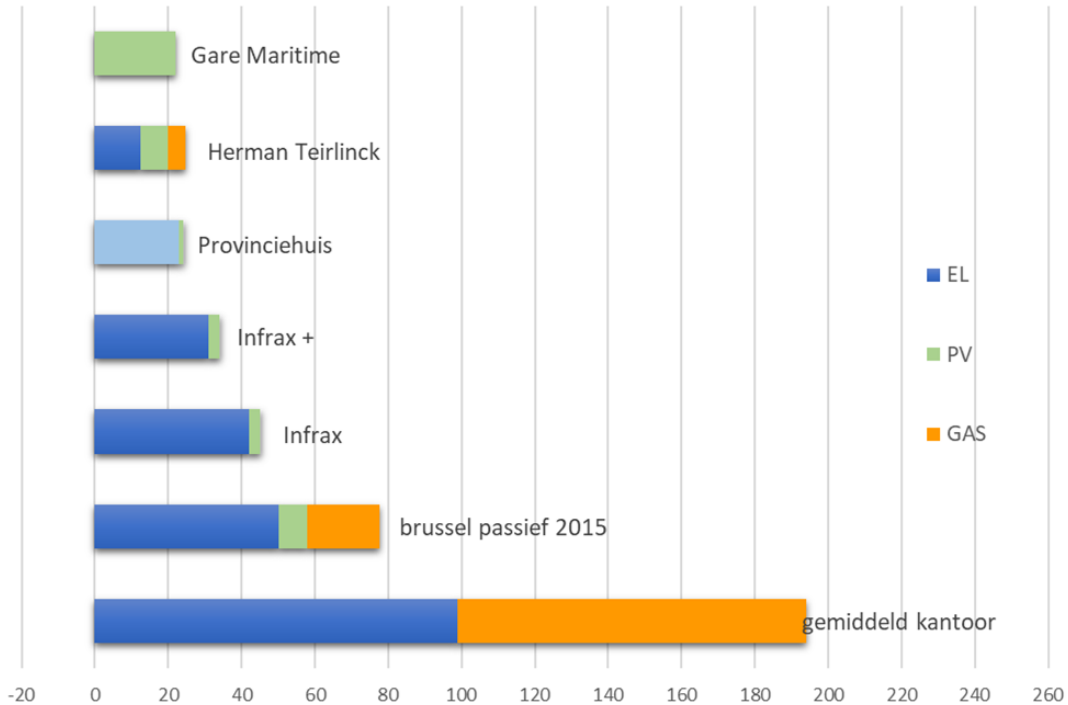
In real buildings performing as **frontrunners**

NEW and RETROFITTED buildings….. Towards 100 % clean energy Public, commercial and residential



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CONTENT

1. Shallow geothermal energy, concepts and history
2. Building applications - The ground
3. Building applications - System integration

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CONCEPTS & HISTORY

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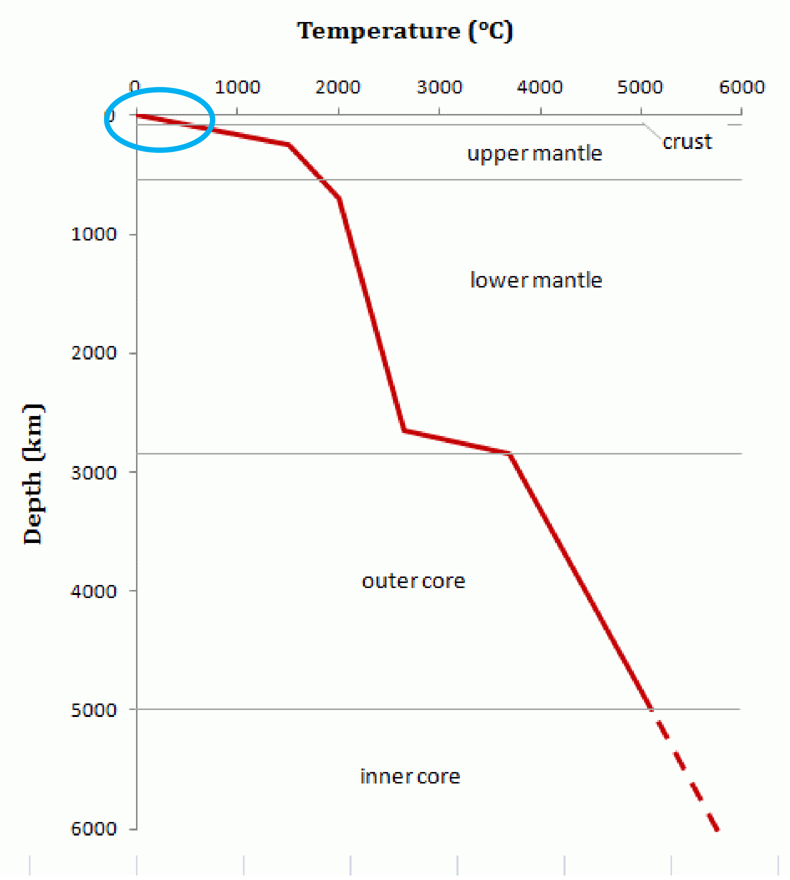
GEOTHERMAL CONCEPTS

A broad spectrum (with acknowledgement to prof L Helsen, KU Leuven)

Earth temperature

- Earth crust: reachable by drilling
- Average gradient: 25°C per km



Source: https://www.e-education.psu.edu/eme807/node/712

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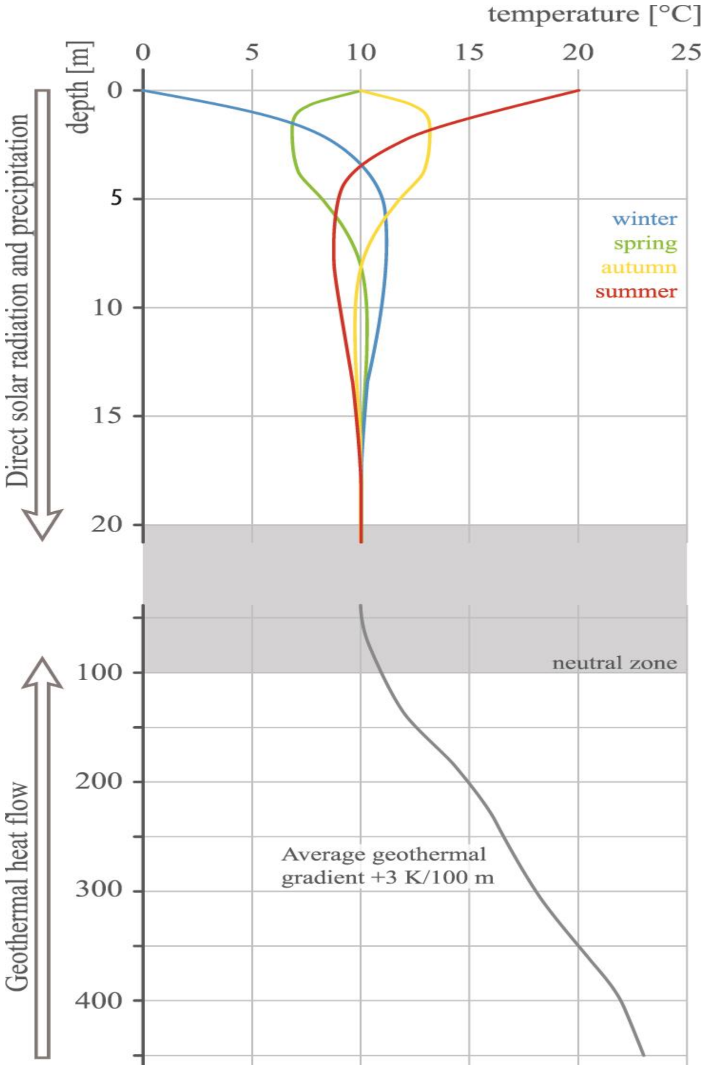
GEOTHERMAL CONCEPTS

Shallow geothermal energy

Ground temperature in Central Europe:

- Near surface
- Neutral zone



Source: REHVA 2013

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GEOTHERMAL CONCEPTS

Geothermal energy systems

Using local opportunities (natural or artificial)

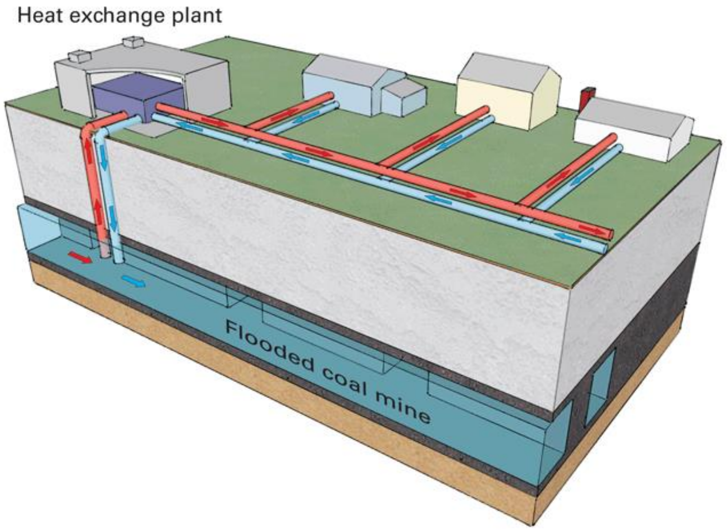
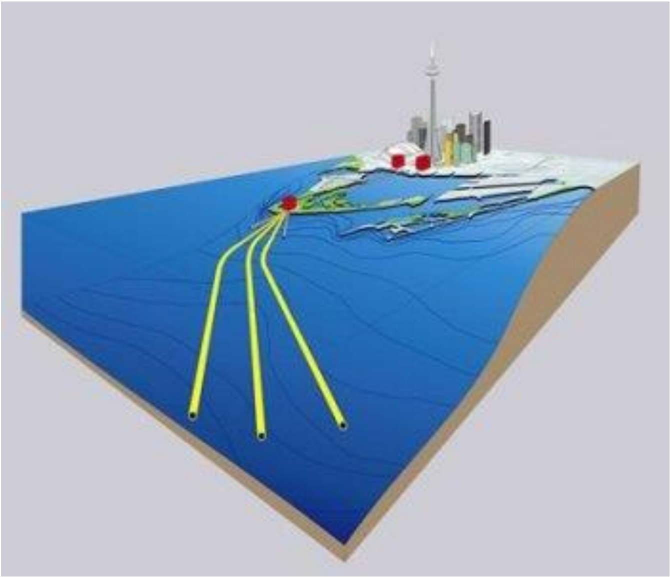


Diagram illustrating the use of water from a flooded coal mine to heat and cool a district. The heat pump cycle uses refrigerant to extract heat from the mine water, which then goes to the exchange plant that provides heat to the buildings. The process can be reversed to provide cooling during warmer periods of the year.

Source: http://geosurvey.ohiodnr.gov/energy-resources/geothermal-energy/shallow-geothermal



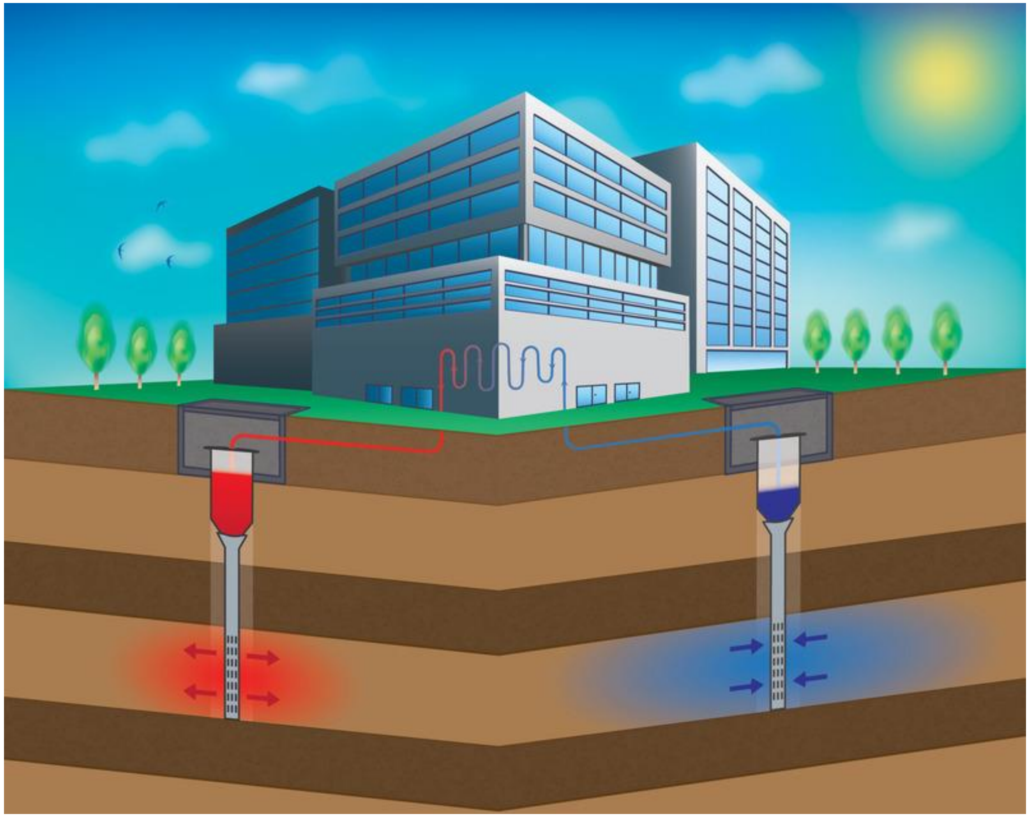
http://www.daviddarling.info/encyclopedia/D/AE_deep_lake_water_cooling.html

GEOTHERMAL CONCEPTS

Shallow geothermal energy systems

Open system: aquifers

Thermal energy storage (TES), sensible heat



Source: http://www.vhgm.nl/

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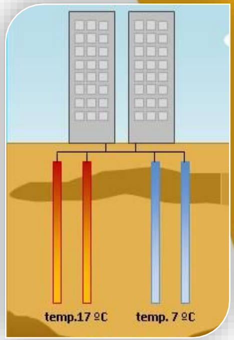
GEOTHERMAL CONCEPTS



Aquifer, open system   ATES

- Cold and warm well (distance 50-250 m)
- Wells (depth till 300 m) are used to carry water to/from the aquifer, allowing transport of heat (based on advection), fast and efficient heat transfer
- High energy transfer: per m^3/h pumped water and per degree ΔT: 1.16 kW
- Amount of energy stored depends on allowable temperature change, thermal conductivity, natural ground water flow
- Separation ground water - refrigerant

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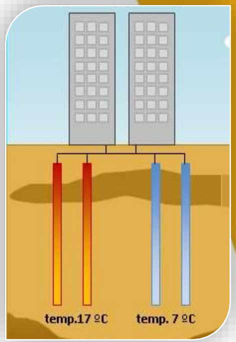
GEOTHERMAL CONCEPTS



Aquifer, open system

- More complex exploitation compared to borefield
- Investment cost per kW installed power lower compared to borefield (500-1250 €/kW)
- Not always applicable, aquifer needed
- Use is restricted by environmental, geological and water laws
- Interesting for thermal power > 100 kW, not for individual dwellings
- Potential for economical large scale and long term (seasonal) storage, thermal balance long term

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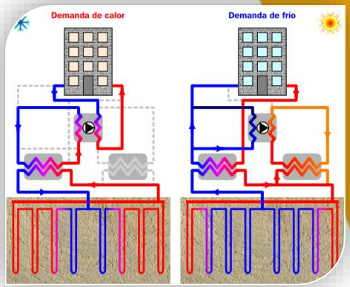
GEOTHERMAL CONCEPTS



Borefield, closed system BTES

- Ground is drilled to insert tubes, in which a heat transport fluid circulates, injecting/extracting heat in/from the ground or groundwater
- Tubes: vertical (depth till 150 m) or horizontal
- Energypiles can also be integrated in foundation
- Usually connected with a heat pump (for heating) and heat exchanger (for direct cooling)
- Energy transfer: 30-50 W/m borehole with heat pump, 15-25 W/m borehole when direct cooling
- Can be applied anywhere if space for borefield available

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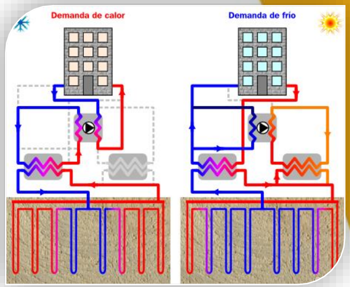
GEOTHERMAL CONCEPTS



Borefield, closed system

- Small projects: heat conduction in the ground leads to natural regeneration
- Large projects: long term thermal balance needed
- Thermal energy storage versus energy dissipation: depends on thermal conductivity and groundwater flow
- Low-cost system since soil is free, however drilling is expensive (21-24% of total storage system cost)
- Total investment cost: 1250-1750 €/kW
- Easy exploitation
- Feasible for single building and low thermal power

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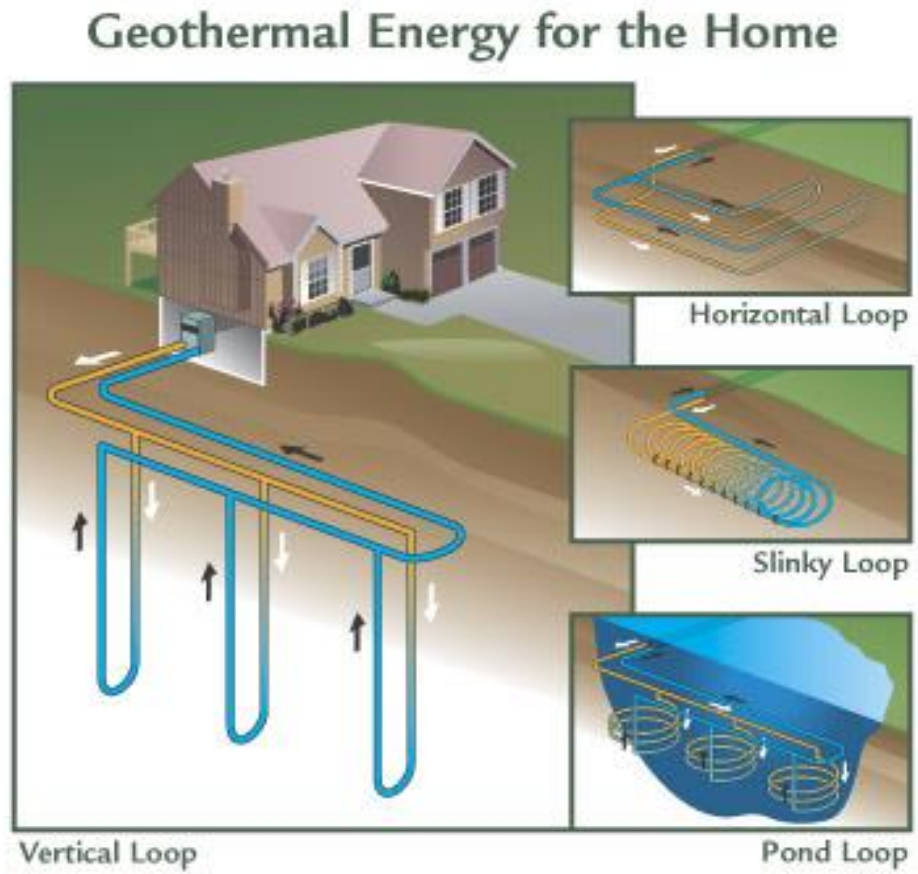
GEOTHERMAL CONCEPTS

Shallow geothermal energy systems

Closed system: horizontal HEx or borehole HEx

Thermal energy storage (TES), sensible heat



Source: http://www.conserve-energy-future.com/

GEOTHERMAL CONCEPTS

Shallow geothermal energy systems

Closed system:
foundation piles and
foundation slabs

Thermal energy storage
(TES), sensible heat

Source: http://www.geoenergiasrl.eu/en/collectors.html

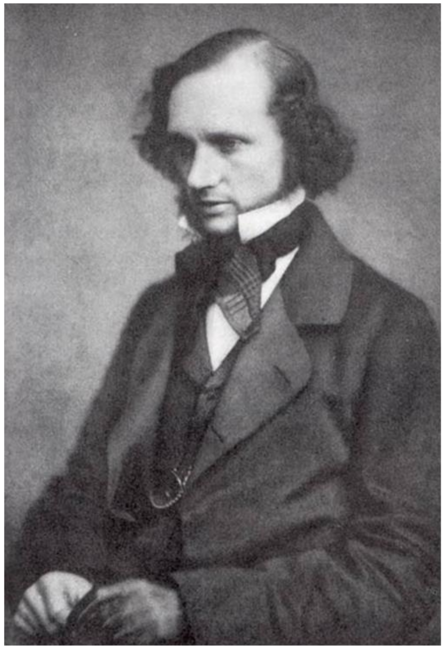
HISTORY

A long history (with acknowledgement to prof J Spittler, Oklahoma university)

Shallow geothermal energy systems

William Thomson (Lord Kelvin)

- 1852: proposed a heat pump for heating buildings or, in tropical climates, cooling them.
- He envisioned air as the working fluid.



William Thomson, 1852
(Age 28)

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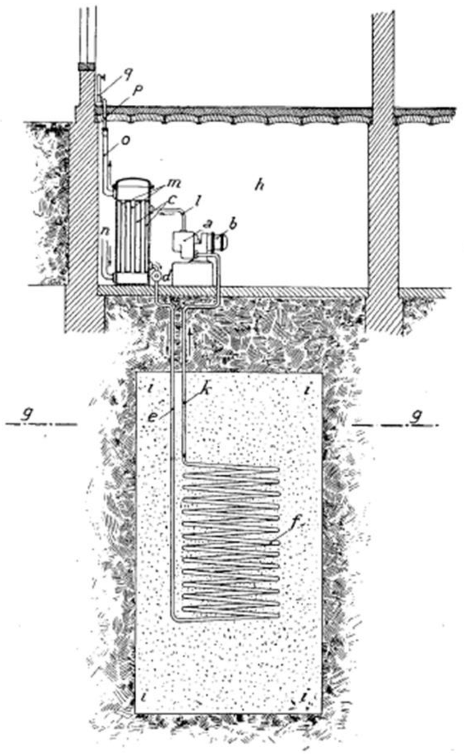
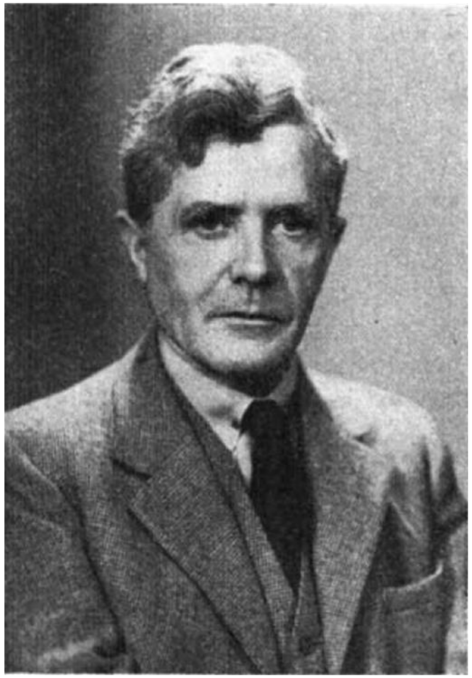
Heinrich Zoelly

- A Mexican-Swiss turbine engineer, born in Mexico in 1862.
- Better known for development of steam turbine as an alternative to steam engines for locomotives.
- Issued Swiss patent 59350 in 1912 for a ground source heat pump.



T.G.N. Haldane

- 1897-1981
- Well known British electrical engineer
- Late 1920s: Builds a vapor (ammonia) compression heat pump
- Laboratory tests
- Home installation in Perthshire, Scotland



Haldane, 1949

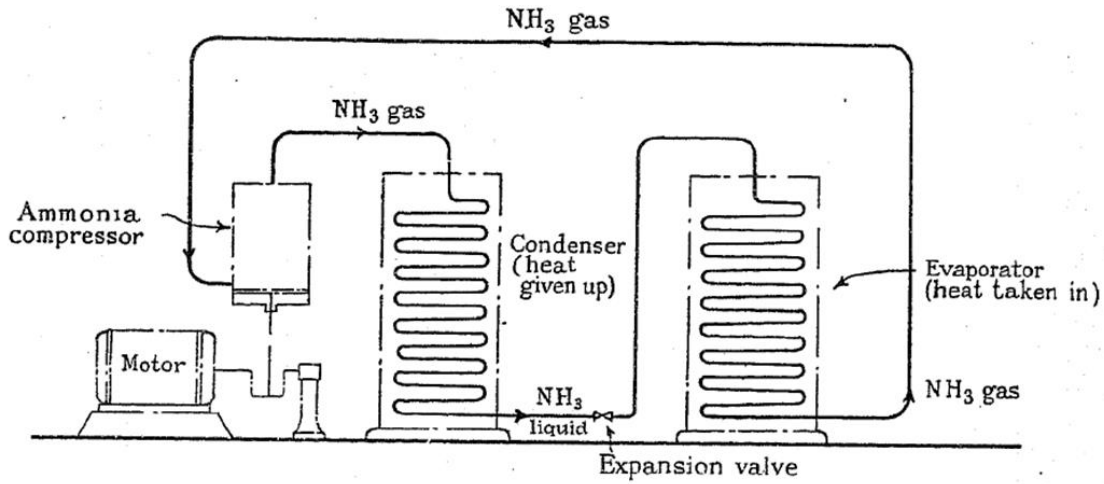


FIG. 2.

Haldane, T. G. N. 1930. The heat pump - an economical method of producing low-grade heat from electricity. *Journal of the Institution of Electrical Engineers.* 68:666-703; 1075-1077.

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Home(!): Foswell Estate

Source: www.ckdgalbraith.co.uk/file/170417/ *Accessed 22 April 2016*

The ground

BUILDING APPLICATIONS

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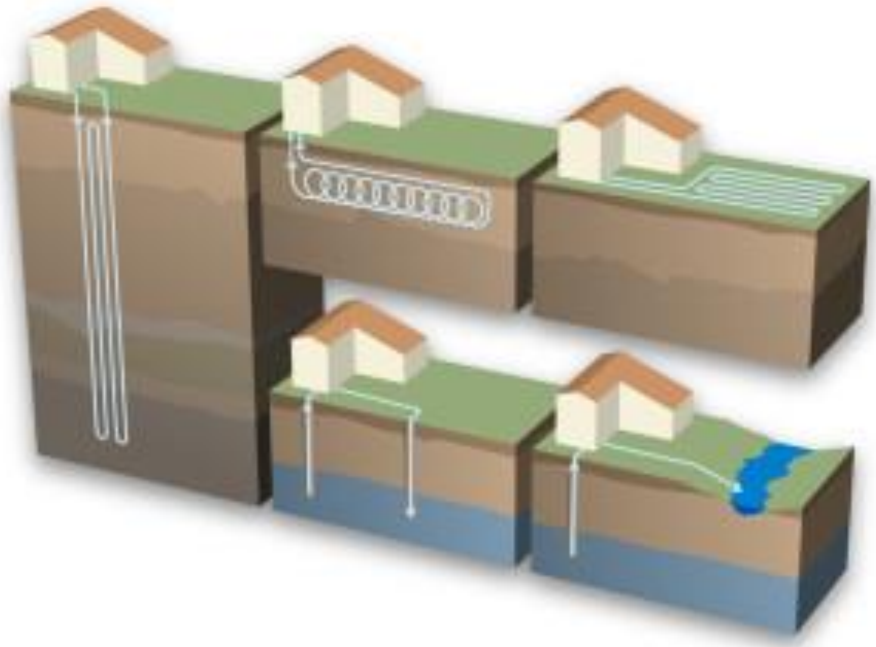
BUILDING APPLICATIONS - GROUND

Shallow geothermal energy



Source: http://www.geoservsolutions.com/shallow-geothermal-energy/

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THE GROUND

Thermal energy storage: ground used as a battery

- Geological formations
- Hydraulic parameters (permeability)
- Thermal parameters (conductivity, capacity, temperature undisturbed ground)
- Groundwater flow, groundwater quality
- Pollution
- Influence on surrounding ground, existing installations
- Permits
- Energy efficiency (reduction energy use, CO_2)

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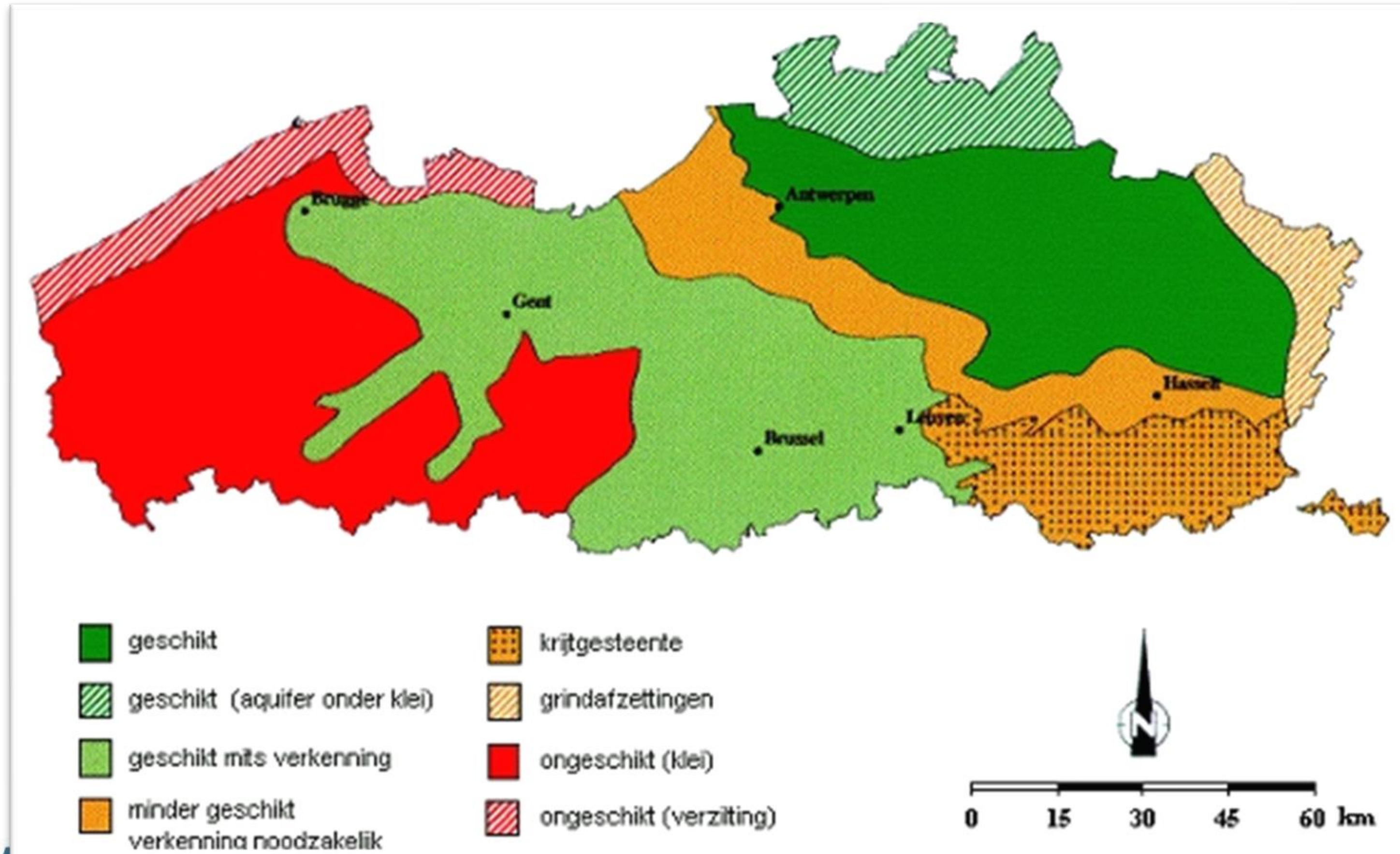
THE GROUND

Aquifers: suitability in Flanders



Source: VITO

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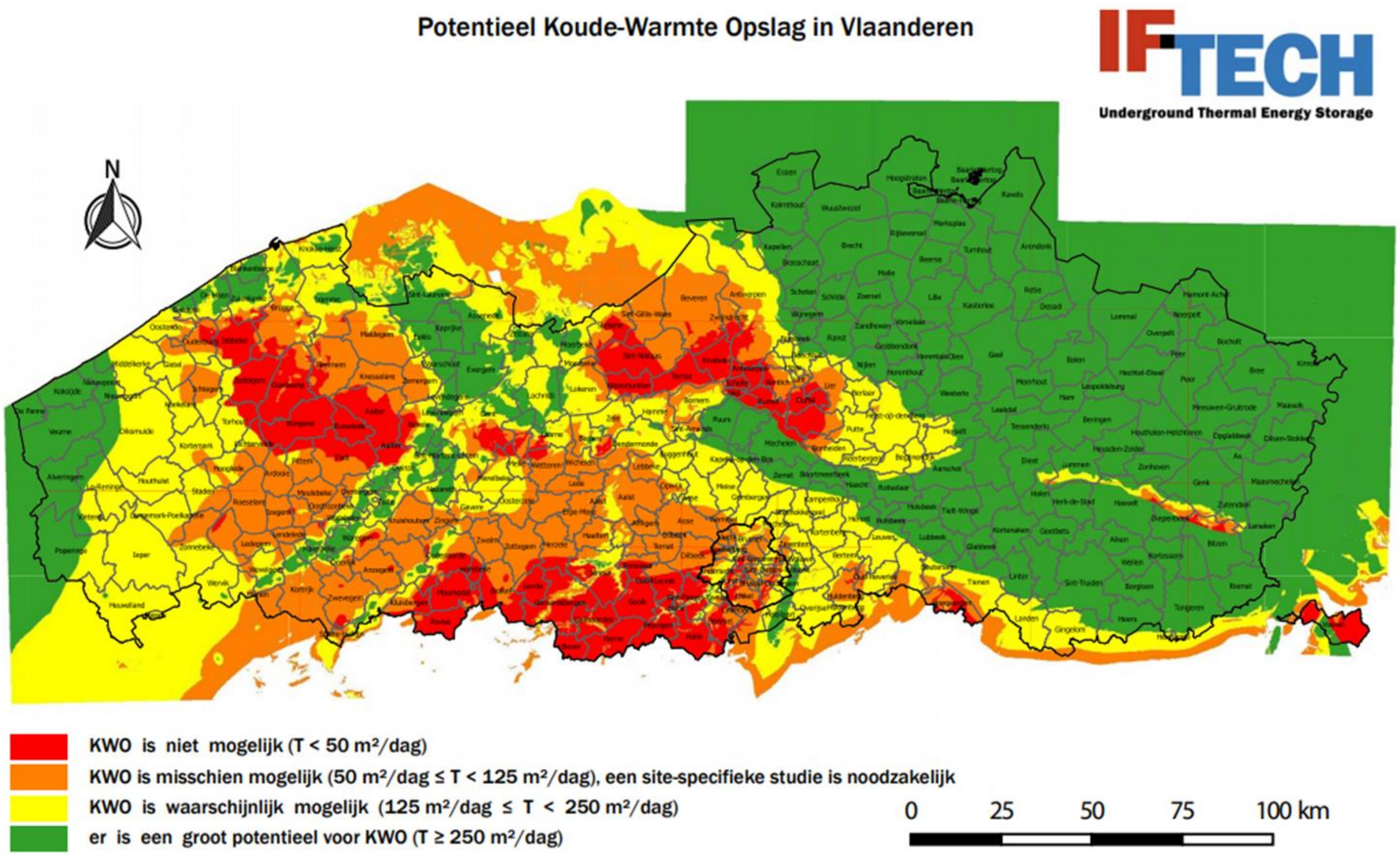
THE GROUND

Aquifers: suitability in Flanders



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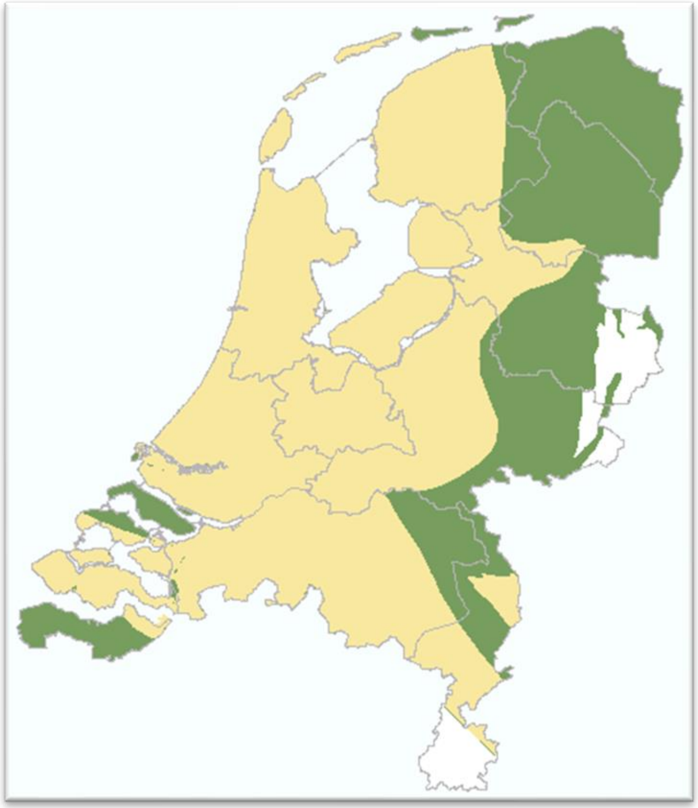
THE GROUND

Aquifers: suitability in The Netherlands



Legend:
white: no aquifer
yellow: 1 aquifer
green: > 1 aquifer

Source: AGT

THE GROUND

Aquifers: installations (> 500 kW) in The Netherlands

2000 (200x)

2011 (2500x)

Source: AGT

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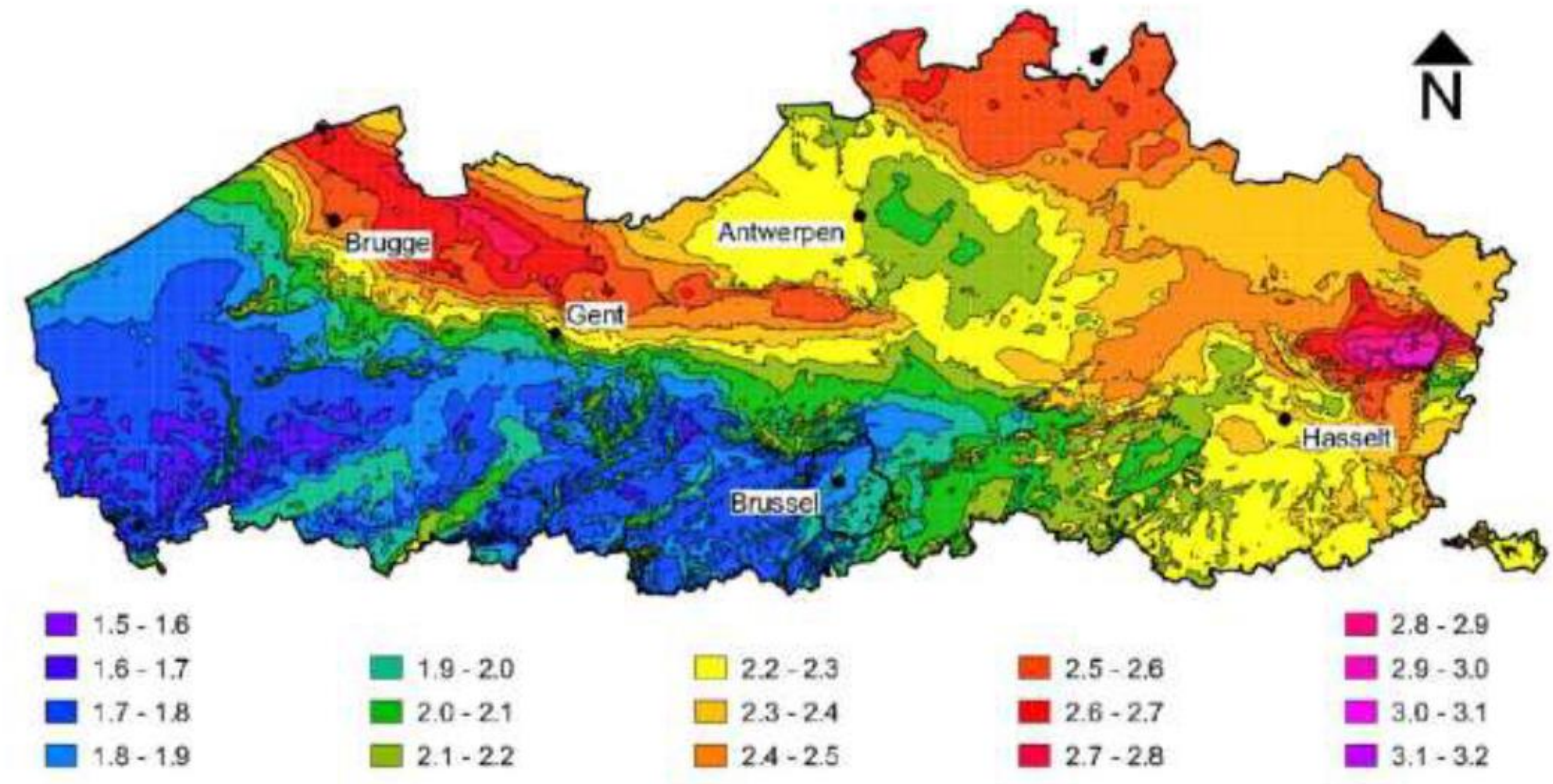
THE GROUND

Boreholes: heat conductivity in Flanders



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THE GROUND

Heat extraction and injection power

- Approximate benchmarks (early design stage)

Ground system	Values
Well	5-6 kW/(m^3/h)
Borehole heat exchanger	30-100 W/m
Energy piles	10-80 W/m

- Detailed sizing by expert planner: multiple-year simulations (uncoupled or coupled)
- Thermal conductivity difficult to estimate (local groundwater conditions, different ground types in layers)
- Determine ground characteristics by TRT

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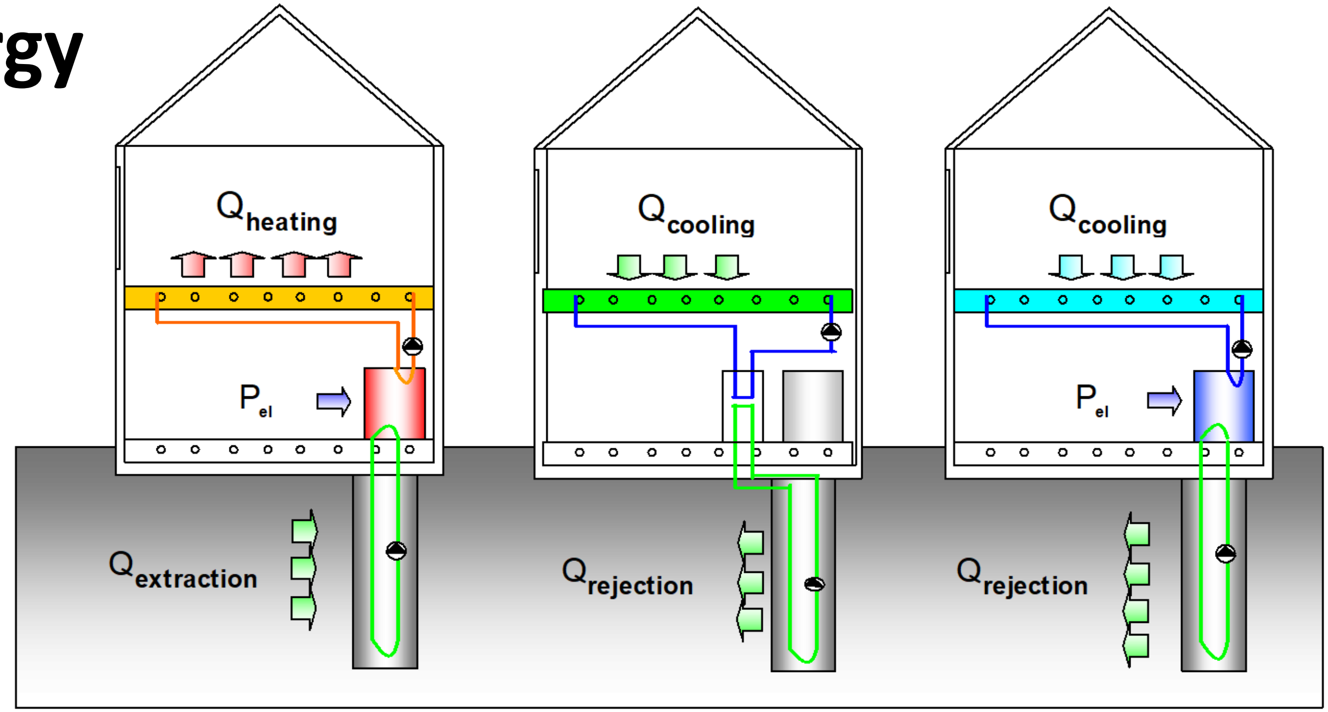
System integration

BUILDING APPLICATIONS

SYSTEM INTEGRATION

Geothermal heat and/or cold = RENEWABLE energy



Source: Clara Verhelst

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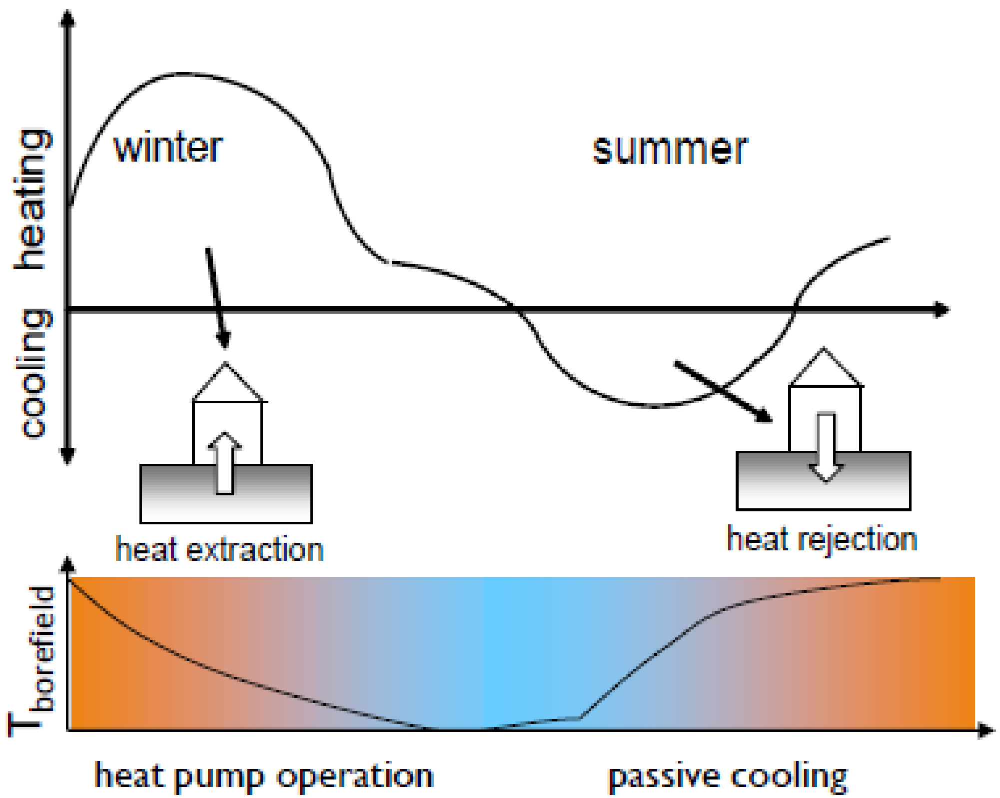
SYSTEM INTEGRATION

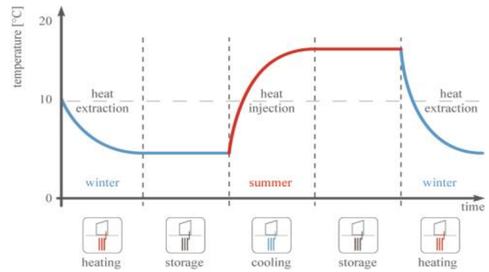
Sustainable operation: thermal balance ground

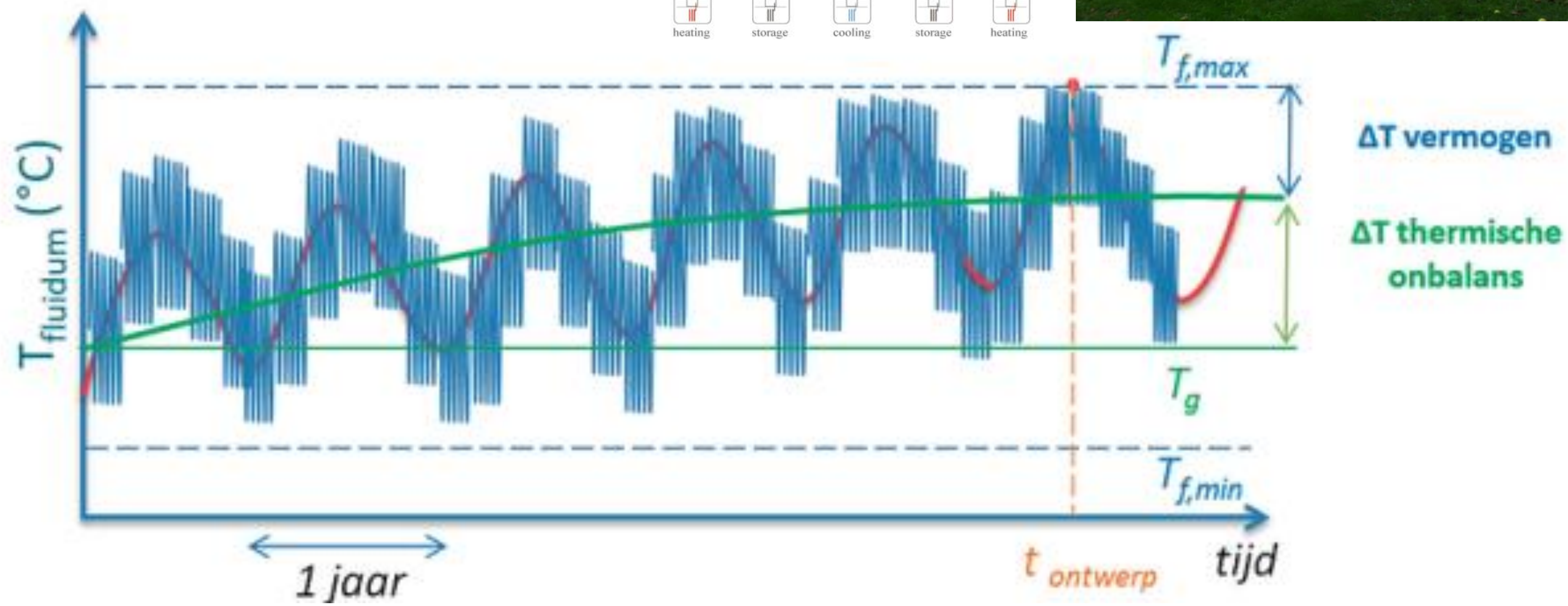


Source: Clara Verhelst

SYSTEM INTEGRATION

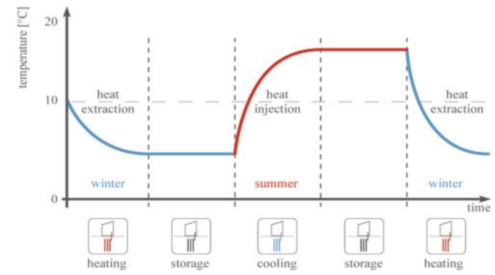
Sustainable operation: thermal balance ground



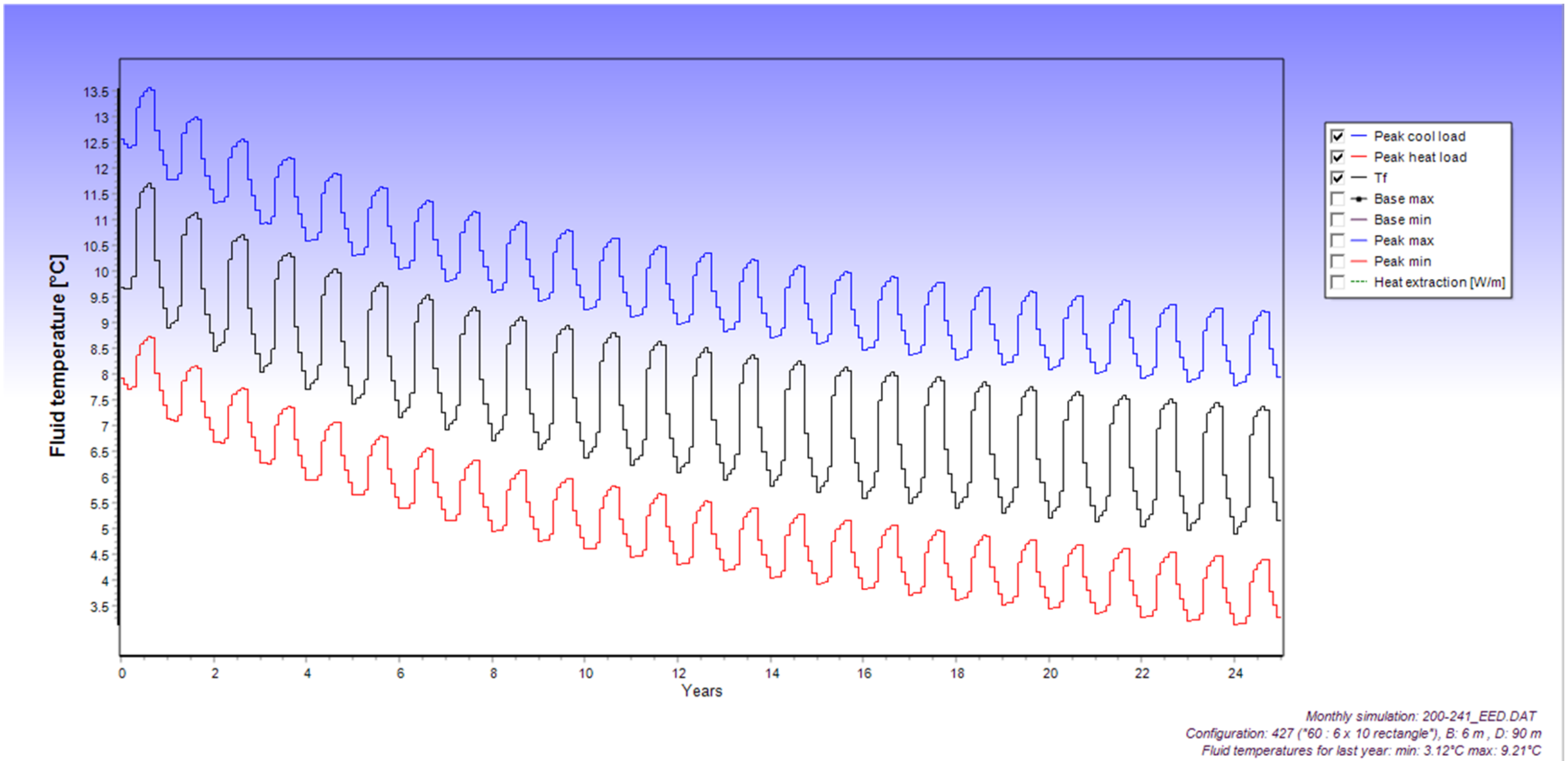


Source: Clara Verhelst

SYSTEM INTEGRATION



Sustainable operation: thermal balance ground



Source: boydens engineering part of sweco

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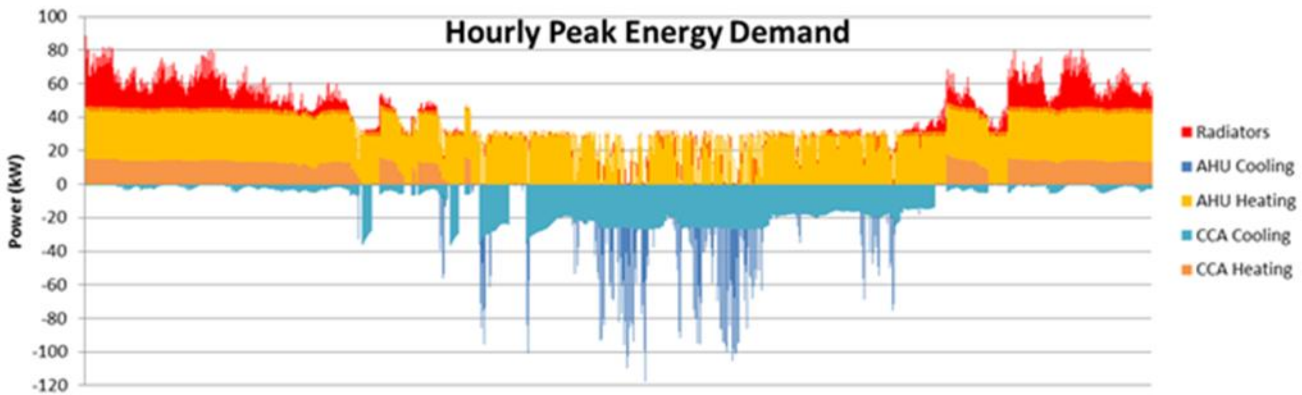
But,
We almost forgot the free part!



the cooling side is very welcome too

SYSTEM INTEGRATION

Efficient operation: low T heating and high T cooling

TABS = thermally activated building system

Source: Studiebureau Boydens

SYSTEM INTEGRATION

Flexibility in energy system by energy storage

- short and long term energy storage

  TABS, ground, building, storage tanks ...

SYSTEM INTEGRATION

- **Holistic** system approach of utmost importance in all building phases, from design to operation
- **Clean hybrid supply** is part of the solution
- **Collective** supply enables synergies

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Evolution and scientific foundations of the concept through almost two decades…

2011-2013 → 2016-2020

GEOTABS

hybrid GEOTABS

Smart Geotherm

Departement Industriële Wetenschappen en Technologie

Opleiding Master in de industriële wetenschappen: energie

Afstudeerrichting hernieuwbare energie

Hydraulische integratie van grondgekoppelde warmtepompen in klimaatinstallaties

Katholieke Hogeschool Sint-Lieven
Departement Industrieel Ingenieur
Technologiecampus Gent
Gebroeders De Smetstraat 1, 9000 Gent

Opleiding
Master in de industriële wetenschappen:
Bouwkunde

Thermac tetra research project 2005-2007
GEOTABS erasme research project 2010-2012
Smart Geotherm 2011-2017
hybridgeotabs 2016-2020
…
Optimization research @
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Advanced controls

and advanced design approaches

Are part of our walk towards future friendly systems

Embrace them

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