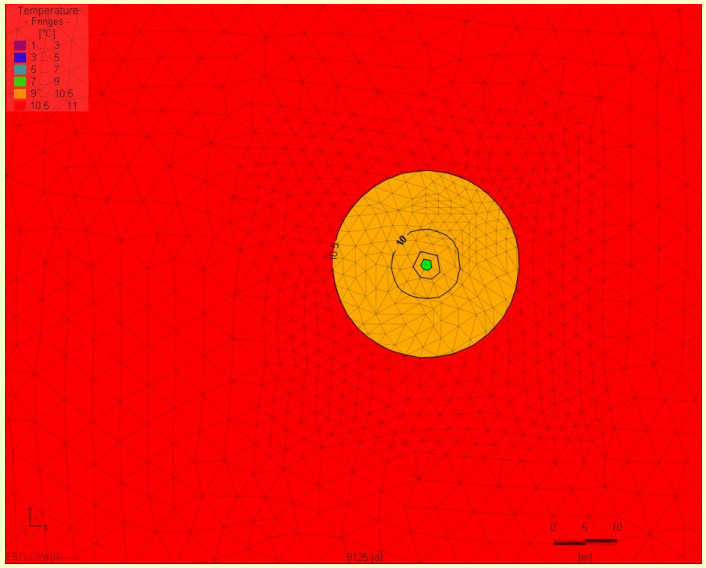
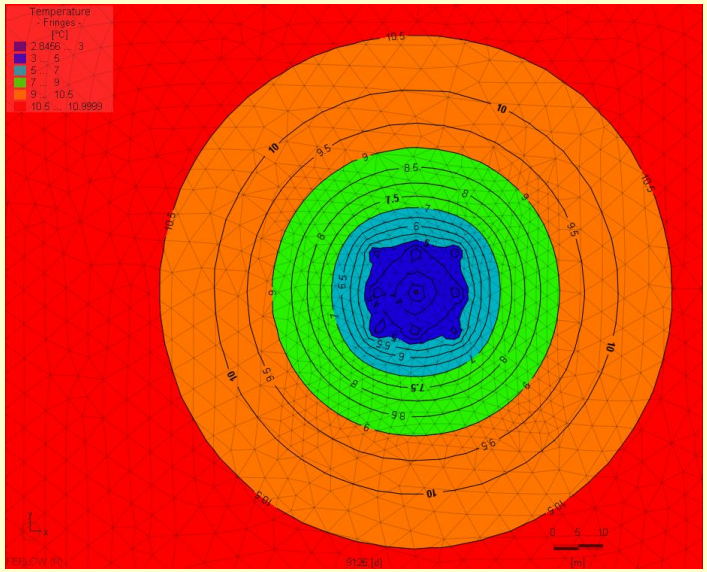
Thermal interactions between neighbouring shallow geothermal systems challenges and possible solutions

Dr. Henk J.L. Witte

GEO ENERGY SYSTEMS GROENHOLLAND





NL OFFICE: VALSCHERMKADE 26; 1059 CD AMSTERDAM; THE NETHERLANDS
UK OFFICE: 22 MANOR CLOSE; HAVANT; HAMPSHIRE; PO9 1BD; UK
WWW.GROENHOLLAND.NL WWW.GROENHOLLAND.COM

Growth of Ground Source Heat Pump systems in the Netherlands

- **Going Gasless**
  - Climate goals
  - Seismicity Groningen

2013 : Legislation with regard to shallow geothermal energy

- **The law requires:** *A study showing that the operation of the new system does not result in interference with existing systems that would compromise the effective functioning of the systems.*

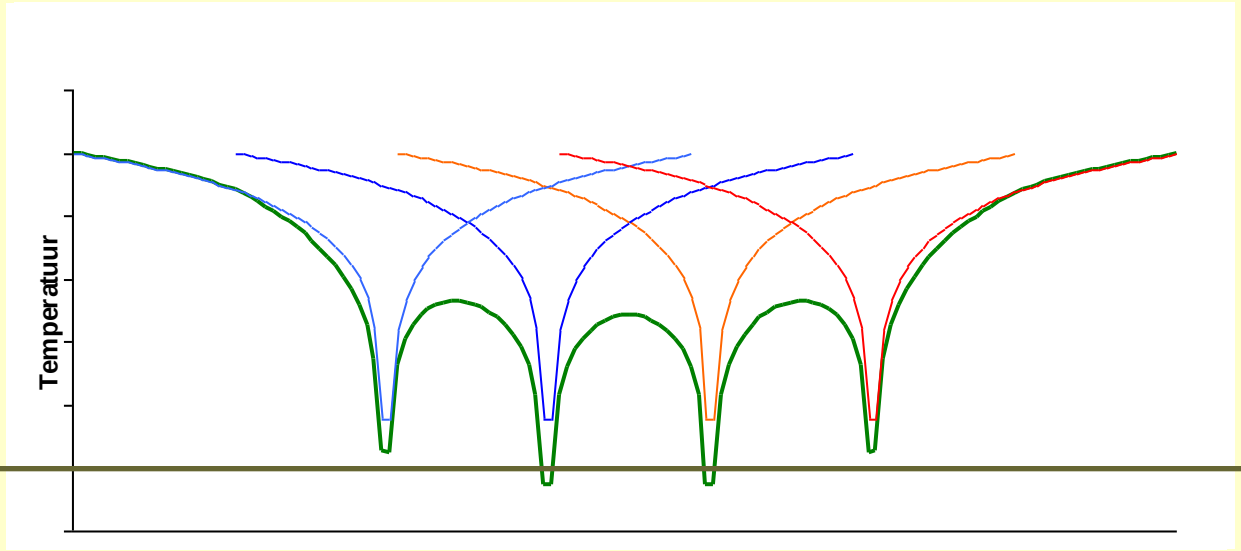
- **As performance and temperature are coupled:**
  - The design source temperature of the systems is not affected

Negative interference is a change of the local temperature due to effects of neighbouring systems

- **Activiteiten besluit, artikel 1.21a – 1,e**
- **Besluit lozen buiten inrichtingen, artikel 1.10a**

BOREHOLE HEAT EXCHANGER SYSTEMS

- Heat transport mechanism is conduction
- Individual temperature effects additive: superposition



Design software: average

Evaluation of negative interference

- Standard design methodology not able to calculate the thermal interactions

- Cannot make distinction between central and periferal systems
- Cannot work with
  - Different energy usage profiles
  - Different number and depth of borehole heat exchangers (per system)
  - Different distances between heat exchangers

- Method was needed to assess thermal interactions
  - Simple method for small (single family) houses, no complicated formulas

Analytical method for assesing temperature effects

- Line source method – well known analytical solution
  - Kelvin (1861); Ingersoll et. al (1954); Hart & Couvillion (1986)

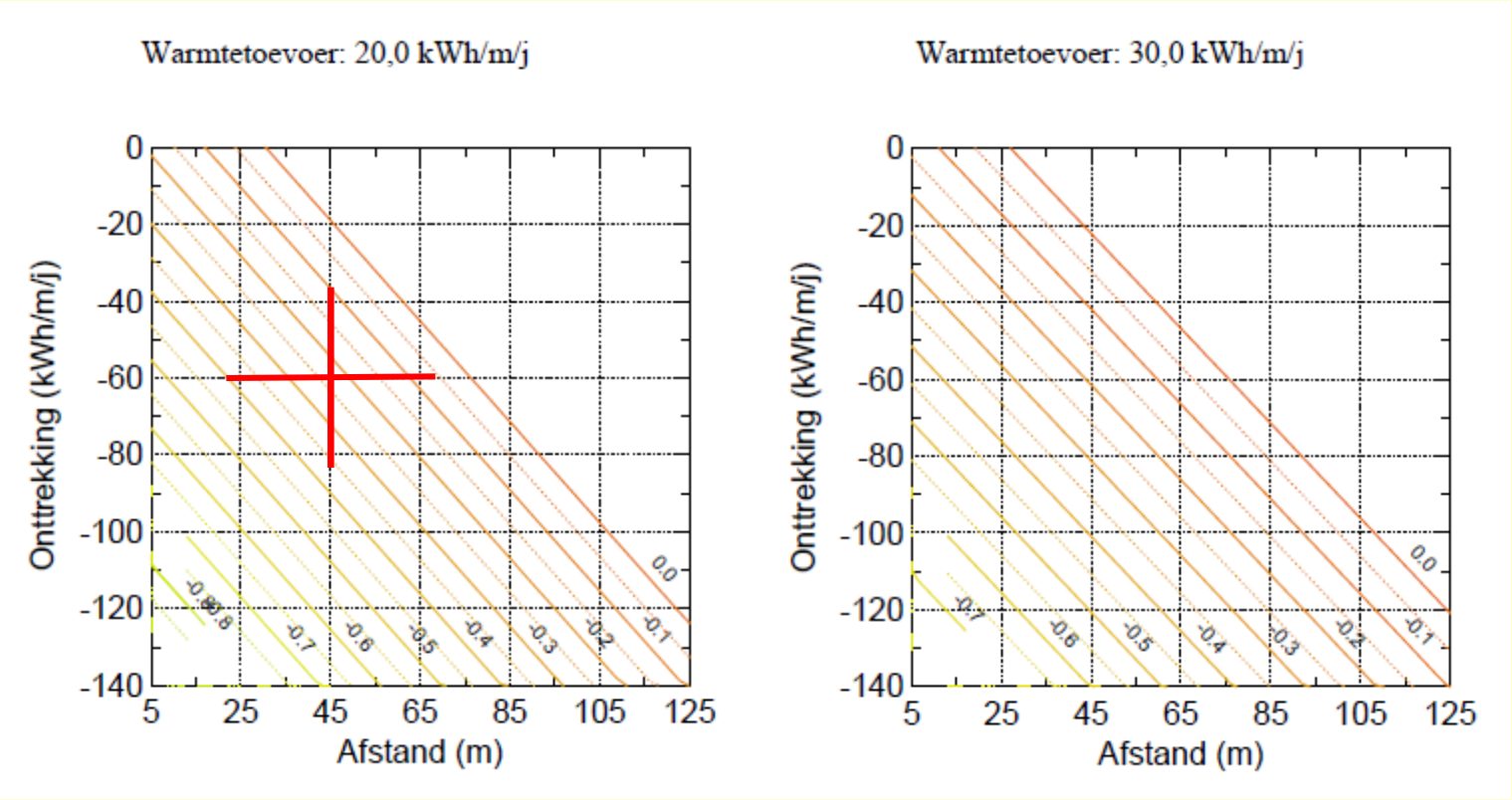
$$\Delta T(r,t) = \frac{q}{4\pi k}\left[\ln\frac{r_\infty}{r} - 0.9818 + \sum_1^n \frac{(-1)^{n+1} y^n}{n(n!)}\right]$$

- Results simplified to linearized nomograms for small systems, no additional calculation tool needed
- Although somewhat conservative usefull for first assesment of small systems

- Procedure includes also
  - Limits for groundwater flow
  - Establish search radius (what is a neighbour?)

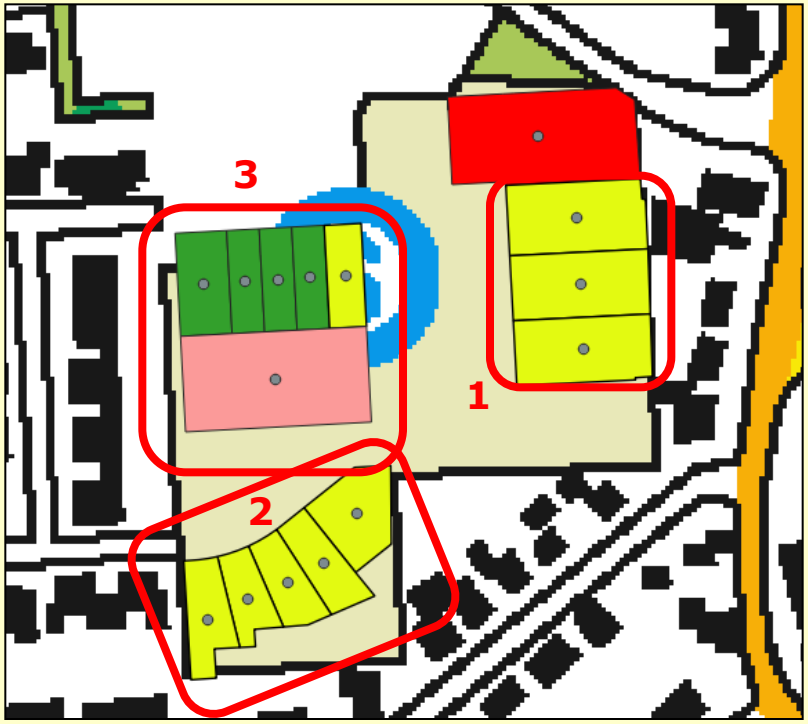
Line source results translated to linearized nomograms

- **Heat transport: calculation method relatively complex**
- **Simplified method to estimate temperature effect at distance**



Evaluation of thermal interactions with simplified tool

- Case: gassless development with different users
  - Appartments (not considered in this example)
  - Different types of single houses (terraced,
  - Social housing



- Semi detached & detached
  - 75kWh/m/y heating
  - 20 kWh/m/y cooling

- Terraced
  - 60kWh/m/y heating
  - 20 kWh/m/y cooling

Development in three phases

Evaluation of thermal interactions with simplified tool

- Thermal interactions phase 1 and phase 2

Number	3	5	7
3	0.00	-0.51	-0.39
5	-0.51	0.00	-0.51
7	-0.39	-0.51	0.00
TOTAL	-0.90	-1.02	-0.90

Number	3	5	7	9	11	13	15	17
3	0.00	-0.51	-0.39	0.00	0.00	0.00	0.00	0.00
5	-0.51	0.00	-0.51	0.00	0.00	0.00	0.00	0.00
7	-0.39	-0.51	0.00	-0.08	0.00	0.00	0.00	0.00
9	0.00	0.00	-0.08	0.00	-0.54	-0.45	-0.37	-0.28
11	0.00	0.00	0.00	-0.54	0.00	-0.56	-0.48	-0.39
13	0.00	0.00	0.00	-0.45	-0.56	0.00	-0.56	-0.47
15	0.00	0.00	0.00	-0.37	-0.48	-0.56	0.00	-0.55
17	0.00	0.00	0.00	-0.28	-0.39	-0.47	-0.55	0.00
TOTAL	-0.90	-1.02	-0.98	-1.72	-1.97	-2.04	-1.96	-1.69

Evaluation of thermal interactions with simplified tool

- Thermal interaction all phases together

Number	2	4	6	8	10	3	5	7	9	11	13	15	17	26	24	22
2	0.00	-0.48	-0.41	-0.35	-0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.37	-0.38	-0.36
4	-0.48	0.00	-0.50	-0.43	-0.36	0.00	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	-0.35	-0.36	-0.37
6	-0.41	-0.50	0.00	-0.50	-0.43	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00	-0.30	0.34	-0.35
8	-0.35	-0.43	-0.50	0.00	-0.50	-0.01	-0.02	0.00	-0.07	0.00	0.00	0.00	0.00	-0.26	-0.29	-0.32
10	-0.27	-0.36	-0.43	-0.50	0.00	-0.08	-0.09	-0.05	-0.08	0.00	0.00	0.00	0.00	-0.20	-0.25	-0.28
3	0.00	0.00	-0.03	-0.10	-0.16	0.00	-0.51	-0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	-0.04	-0.10	-0.17	-0.51	0.00	-0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	-0.01	-0.07	-0.14	-0.39	-0.51	0.00	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	-0.08	-0.12	-0.15	-0.16	-0.16	0.00	0.00	-0.08	0.00	-0.54	-0.45	-0.37	-0.28	-0.22	-0.25	-0.27
11	-0.03	-0.05	-0.06	-0.06	-0.06	0.00	0.00	0.00	-0.54	0.00	-0.56	-0.48	-0.39	-0.19	-0.21	-0.23
13	-0.01	-0.02	-0.03	-0.02	-0.01	0.00	0.00	0.00	-0.45	-0.56	0.00	-0.56	-0.47	-0.18	-0.20	-0.20
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.37	-0.48	-0.56	0.00	-0.55	-0.18	-0.18	-0.19
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.28	-0.39	-0.47	-0.55	0.00	-0.15	-0.15	-0.14
26	-0.37	-0.35	-0.30	-0.26	-0.20	0.00	0.00	0.00	-0.14	-0.11	-0.10	-0.10	-0.07	0.00	-0.51	-0.48
24	-0.38	-0.36	0.34	-0.29	-0.25	0.00	0.00	0.00	-0.16	-0.13	-0.11	-0.11	-0.06	-0.51	0.00	-0.53
22	-0.36	-0.37	-0.35	-0.32	-0.28	0.00	0.00	0.00	-0.19	-0.14	-0.12	-0.11	-0.05	-0.48	-0.53	0.00
20	-0.33	-0.36	-0.37	-0.35	-0.32	0.00	0.00	0.00	-0.23	-0.16	-0.13	-0.10	-0.04	-0.40	-0.45	-0.49
18	-0.30	-0.35	-0.38	-0.36	-0.35	0.00	0.00	0.00	-0.25	-0.16	-0.13	-0.09	-0.03	-0.36	-0.41	-0.45
16	-0.28	-0.34	-0.36	-0.37	-0.36	0.00	0.00	-0.02	-0.25	-0.17	-0.12	-0.08	0.00	-0.32	-0.37	-0.41
14	-0.24	-0.30	-0.35	-0.37	-0.37	0.00	-0.04	-0.06	-0.26	-0.16	-0.11	-0.06	0.00	-0.38	-0.33	-0.36
12	-0.20	-0.28	-0.33	-0.35	-0.38	-0.02	-0.08	-0.10	-0.26	-0.15	-0.10	-0.04	0.00	-0.24	-0.29	-0.33
TOTAL	-4.09	-4.67	-4.26	-4.96	-4.77	-1.01	-1.25	-1.21	-3.71	-3.15	-2.96	-2.65	-1.94	-5.09	-4.82	-5.76
						-0.90	-1.02	-0.98	-1.72	-1.97	-2.04	-1.96	-1.69			

Possible solutions, action planned system

- Address two types of negative interference:
  - Existing systems on the new system:
    - Adjust design of new system by increasing the design temperature criterium with the calculated thermal interaction.
  - New system on the existing systems:
    - Reduce thermal influence by adjusting the length of the planned system
    - Reduce thermal influence by reducing heat extraction or better energy balance
  - Re-calculate thermal interactions with less conservative approach

NL OFFICE: VALSCHERMKADE 26; 1059 CD AMSTERDAM; THE NETHERLANDS
UK OFFICE: 22 MANOR CLOSE; HAVANT; HAMPSHIRE; PO9 1BD; UK
WWW.GROENHOLLAND.NL WWW.GROENHOLLAND.COM

Planning of large scale developments

- Standard situation: **First come – first served**:
  - Cost of increasing interference is with later systems
  - Every designer may use different design parameters (e.g. soil thermal parameters), no harmonisation of design

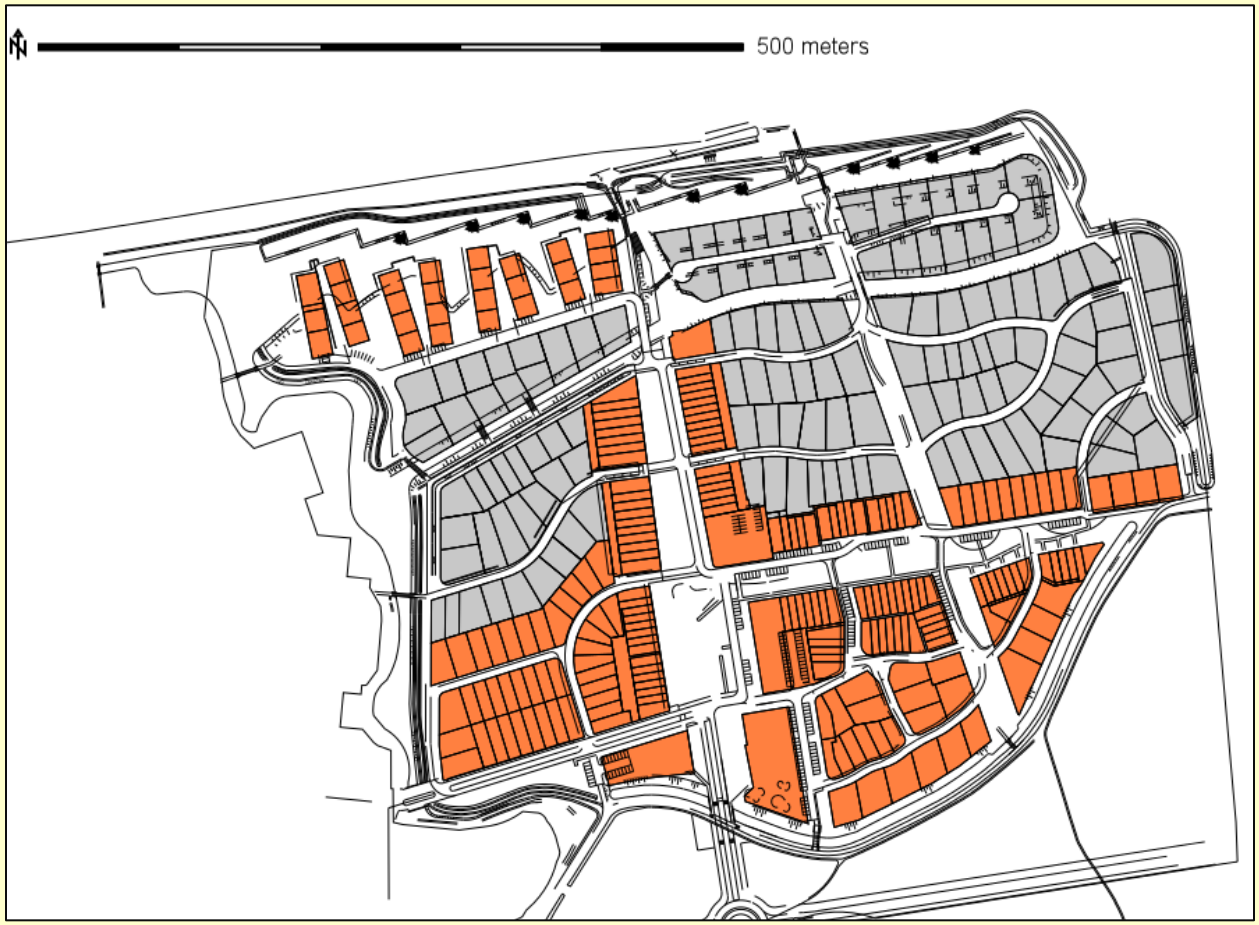
- Netherlands: Designate area of high interference (municipality): permit required for all systems

- Coupled with optimization procedure the thermal interaction tool can be used in the planning of geothermal systems

- Harmonization of design and construction
  - All designers use the same soil parameters
  - All drillers use same criteria for construction of boreholes

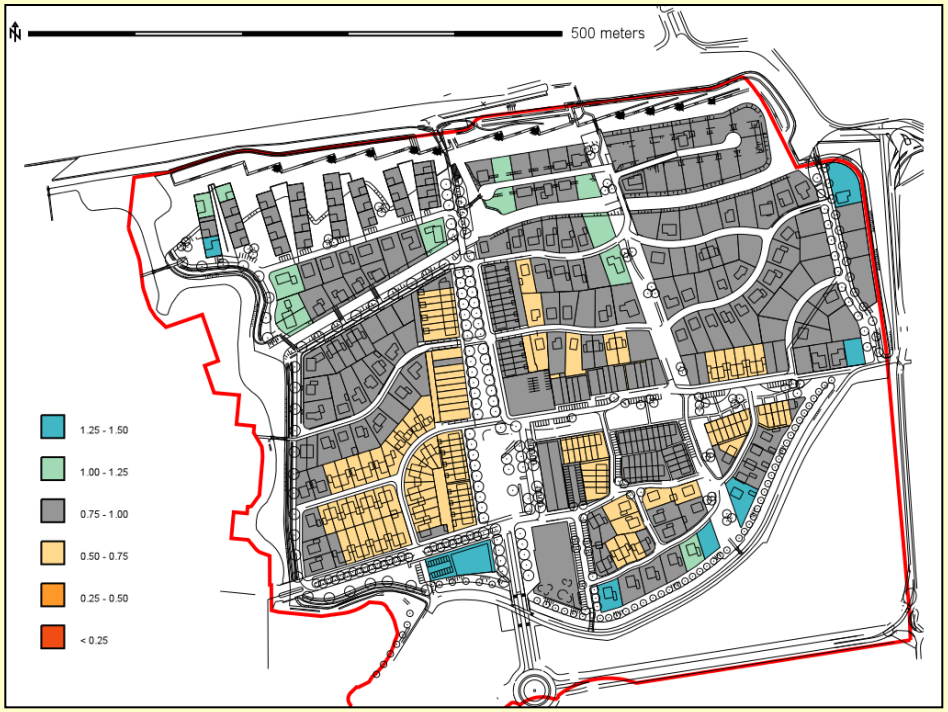
Planning of large scale developments

- 365 systems, 123 with existing geothermal system
- Number of systems developed integrally, others individually

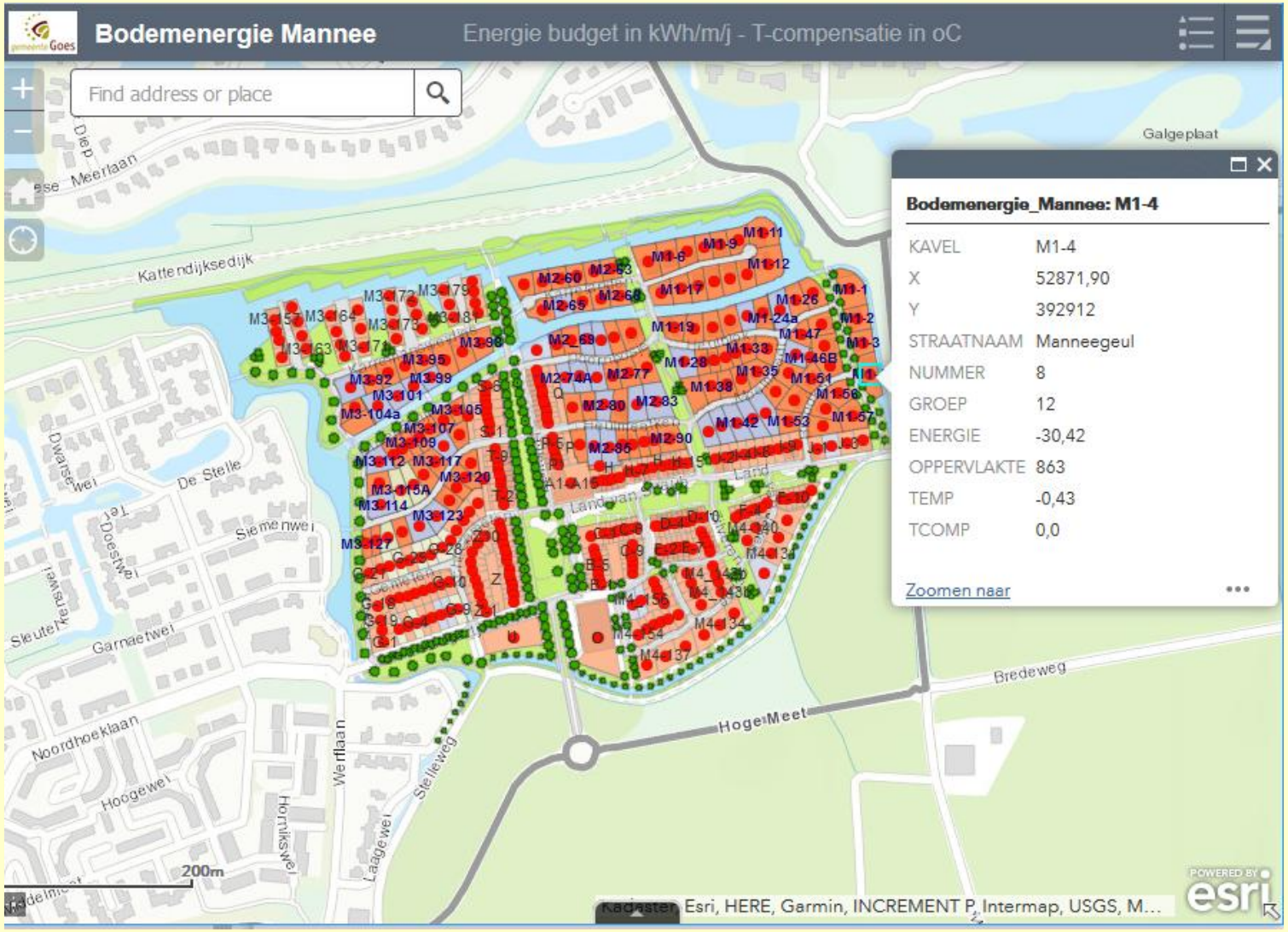


Planning of large scale developments

- Optimization routine:
  - Existing systems fixed with design parameters
  - Collectively designed systems, internal interactions not calculated
  - Optimization results in assigned energy budgets (and possibly adjustment of design temperature for individual systems)



Municipality publishes results on WEB-GIS portal



Municipality reviews permit applications

- **Tool for automated permit verification**

Blanco formulier afdrukken

Rapport afdrukken

BODEMENERGIEPLAN MANNEE, GEMEENTE GOE

gemeente Goes

rekenmodule controle eisen bodemenergieplan, behorende bij project GHNL15T90 / 15ENNL01220.15UIT01546, versie 1.0 dd 10-06-2016

Aanvraagnummer **Invullen door gemeente**

GEGEVENS INVOER

Systeemgegevens - overnemen uit aanvraagformulier

Aanvullende systeemgegevens (BEP, Bijlage II)

Aanvrager	
Contactpersoon	
Telefoonnummer	
Emailadres	
Kavelnummer	Z-1
X-coordinaat	52462
Y-coorindaat	392676
Straatnaam	Acht gemeten a
Huisnummer	2
Energiebudget (kWh/m²/j)	-26
Temperatuurcompensatie (oC)	0
Uitgangspunt ontwerptemperatuur (oC)	
Toegepaste ontwerptemperatuur (oC)	1
Energievraag ruimteverwarming (kWh/jaar)	11500
Rendement warmtepomp ruimteverwarming	4.8
Temperatuur verwarmingscircuit (oC)	35
Energievraag tapwaterbereiding (kWh/jaar)	2250
Rendement warmtepomp tapwaterbereiding	2.7
Energievraag ruimtekoeling (kWh/jaar)	2200
Rendement levering ruimtekoeling	22
Vermogen bronpomp (kW)	0.12
Bodemzijdig vermogen (kW)	4.6
Totale lengte bodemwarmtewisselaars (aantal x boordiepte)	180

BASISCONTROLE INVOERGEGEVENS

Om deze controles uit te voeren moet de bijlagetabel geopend zijn!

Aanvraagnummer	0	
Kavelnummer	Z-1	
Straatnaam	Acht gemeten	Adresgegevens komen niet overeen
Huisnummer	1	Adresgegevens komen niet overeen
X-coordinaat	52467.63	Coordinaat wijkt meer dan 3 meter af
Y-coordinaat	392674.23	
Energiebudget (kWh/m²/j)	-26.108	
Temperatuurcompensatie (oC)	0	

CONTROLE ENERGIEBUDGET BODEMENERGIEPLAN

1. Systeem rendement		
Pompenergie ruimteverwarming	238	kWh/jaar
Pompenergie tapwaterbereiding	46	kWh/jaar
Rendement (SPF) ruimteverwarming	4.37	OK
Rendement (SPF) tapwaterbereiding	2.56	Moet tenminste 2.7 zijn
Rendement (SPF) ruimtekoeling	22.00	OK
2. Netto energie bodemenergiesysteem		
a. Verwarming (onttrokken aan bodemenergiesysteem)	10236.87	kWh/jaar
b. Koeling (warmte toegevoerd aan bodemenergiesysteem)	2300	kWh/jaar
3. Specifieke netto warmteonttrekking bodemener	-44.09	kWh/m/j
Komt dit overeen met het bodemenergieplan? - verschil met BEI	-17.39	**Netto warmteonttrekking te groot!**
Lengte nodig volgens het bodemenergieplan:	304.00	
Extra lengte nodig	124.00	

Future

- Experience shows the principle method works well both for installers and authorities

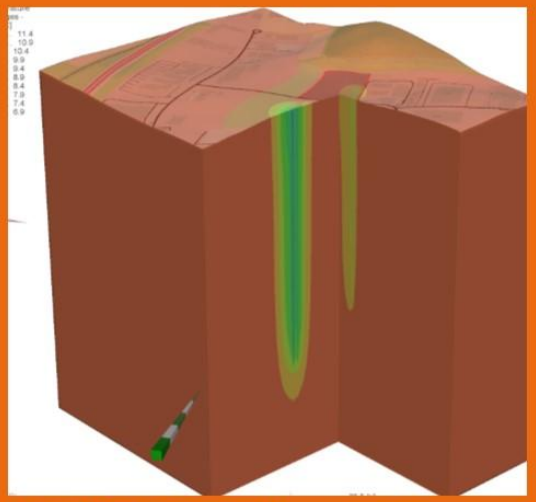
- Based on experience past years the basic procedure is being improved
  - Developing an automated procedure
  - Improving the selection of which systems need to be included
  - Improving how to account for groundwater flow

- More fundamental research is currently submitted
  - Develop better fundamental models and optimization method (with TU Delft, NWO)
  - Implement monitoring with fibre optics to collect data on heat flow in the ground with and without ground water flow (with Deltares, TKI)

Bundesverband Geothermie

geoENERGIE Konzept

Erdwärme. Planen. Testen. Überwachen.



WORKSHOP

Nachbarschaftliche Beeinflussung von Erdwärmeanlagen in dicht besiedelten Gebieten

22.05.2019

13:00-17:00 Uhr

GIZEF Freiberg

Im Vorfeld des geoENERGIE Tags

Zielgruppen:
Behörden, Kommunen,
Planer, Wissenschaft

Danke!