
DRAG
LOW
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LOW

Yearly Event

DRAs in District Heating Networks:
Hydraulic-, Techno- and Economic Simulations

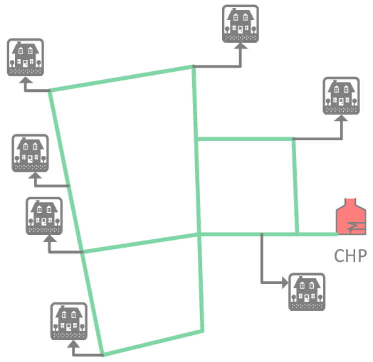
EnerTrans, 14-4-2022

Research questions

- Part 1: What is the potential impact of DRA's on district heating (DH) systems and geothermal wells/reservoirs, and are we able to **set up and validate simulation models** to determine this effect.
- Part 2: Can this effect be quantified by **exporting the resulting network and component design** to link up with the techno-economic phase of the project, comparing non-DRA system results with that of DRA systems.

Final result

- The outcome of this result will consist of models, **guidelines and procedures necessary for implementing DRA parameters** in geothermal well-designs and distribution network modelling, disseminated in the form of detailed reports.



Objectives overview

- Develop a realistic network model (Case study area) ← Activity 4.3
- Assess design implication in geothermal wells/reservoirs ← Activity 4.2
- Develop calibration model based on flow loop setup/design ← Activity 4.1
- Implement DRA's in simulation scenarios ← Activity 4.4
- Perform data analyses and setup export procedure ← Activity 4.5
- Establish guidelines for DRA implementation in heat networks ← Activity 4.6
- Planning:

Result 4	2021				2022				2023				2024			
Activities	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
4.1 Model calibration																
4.2 Geothermal well design implications																
4.3 Network model development																
4.4 Simulation and DRA implementation																
4.5 Analyses and data export																
4.6 Guidelines for DRA implementation in heat networks				MP1		MP2		R4 Critical		MP3			MP4	MP5		

Progress update

DH Model development: Case study model

- Starting points

Utility (heating)

Utiliteits-gebouw	Aansluit-vermogen [W/m²]
Kantoren	40
Winkels	70
Scholen	100
Industrie	40

ISSO Publication 7, 2012

- Based on area [m2] and type of building
- Meetings/Events modelled as office space
- Healthcare modelled at 110W/m2
- https://bagviewer.kadaster.nl/lvbag/bag-viewer/

Residential (heating)

Bouwjaar	<1946	1946-1981	1982-1998	1998-2010	2010 >
EPC (indicatief)	1,4	1,2	1	0,8	0,6
Aansluit-waardes (kW)					
Vrijstaand	22,0	19,5	16,0	13,0	10,0
Geschakeld	17,5	15,0	12,5	10,0	8,0
Hoek	15,0	12,0	10,0	8,0	7,0
Tussen	13,0	10,5	8,5	7,0	6,0
Appartement rand	13,0	10,5	8,5	7,0	6,0
Appartement tussen	11,0	9,0	7,5	6,0	5,0

Guideline connection values for residential heating, adapted from ISSO Publication 7-2012, figures P. Driessen, and the RVO's energy-saving explorer.

- Termis simulates instantaneous thermal and hydraulic conditions
- Peak load conditions for network dimensioning
- Nominal power [kW] demand also called connection value (P_{cv}):

$$P_{cv} = \Phi_{transmission} + \Phi_{ventilation} + \Phi_{heat\text{-}up} + \cancel{\Phi_{hw}} \quad [W]$$

Velocity (dimensioning)

DN	Max. Flow Velocity	
	Inside Built Environment	Outside Built Environment
	m/s	m/s
20	0.90	1.30
25	0.90	1.30
32	0.90	1.30
40	1.00	1.50
50	1.20	1.70
65	1.40	1.90
80	1.60	2.20
100	1.80	2.40
125	2.00	2.60
150	2.30	2.80
200	2.30	3.00

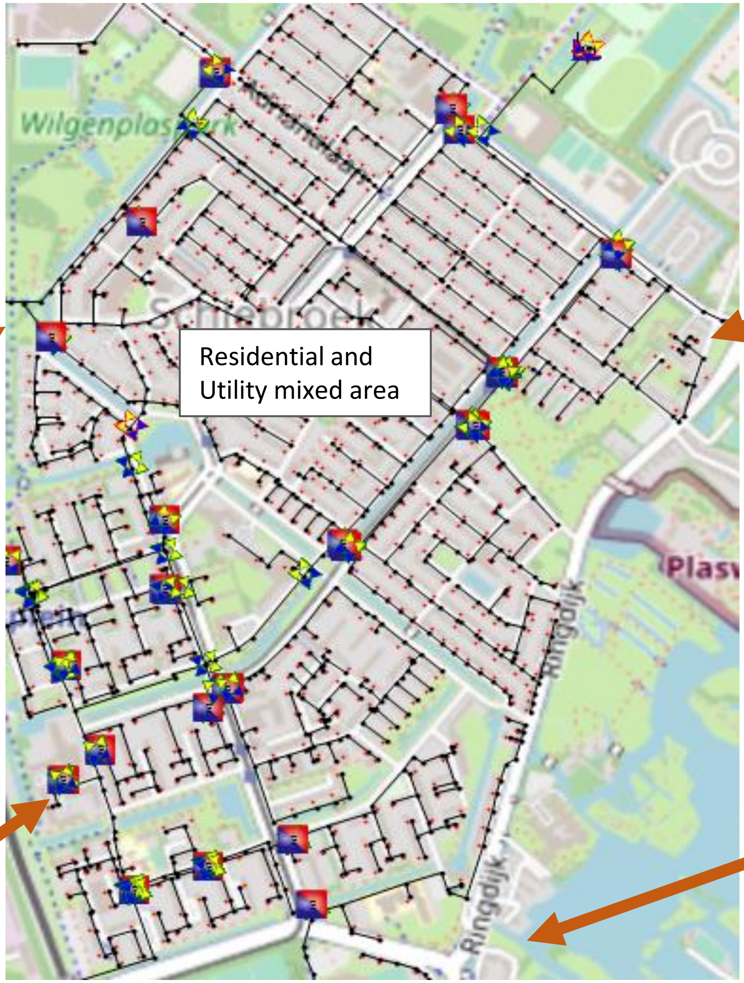
Progress update

DH Model development: Case study model

Network layout case study and typical networks

Future capacity increase
- DRA enhancement
- New sources

Various Station points WOS/WAS



Future demand

Future demand

Progress update

DH Model development: Case study model

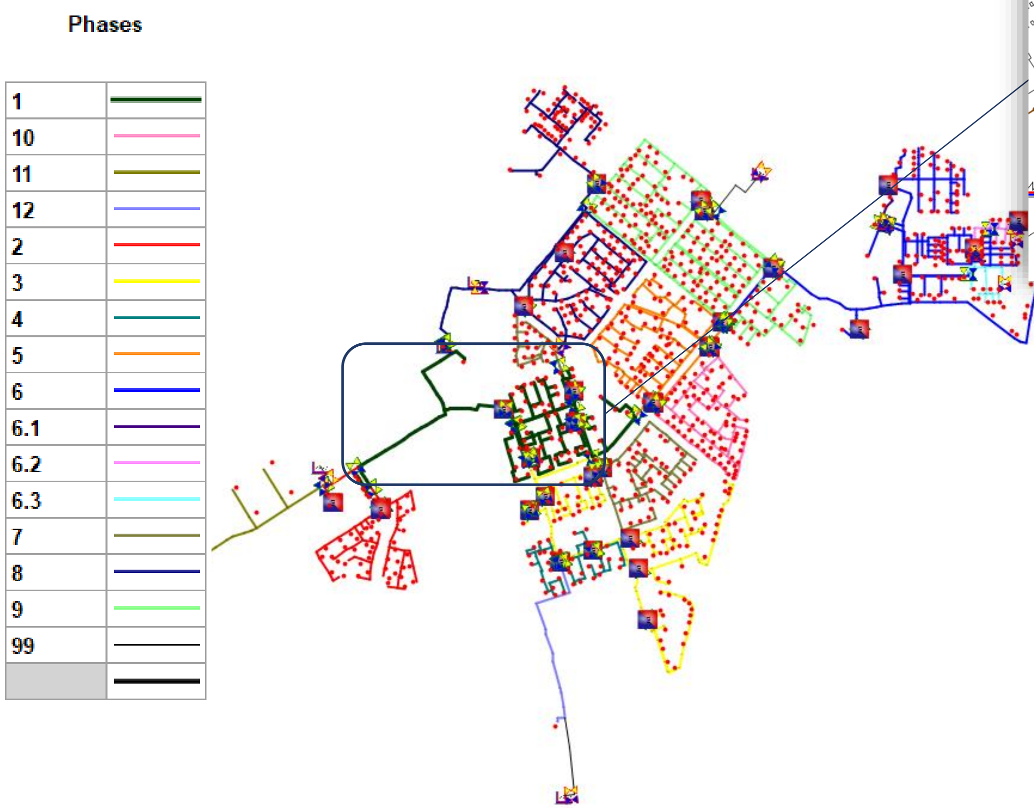
- Phase rollout, Consumer database

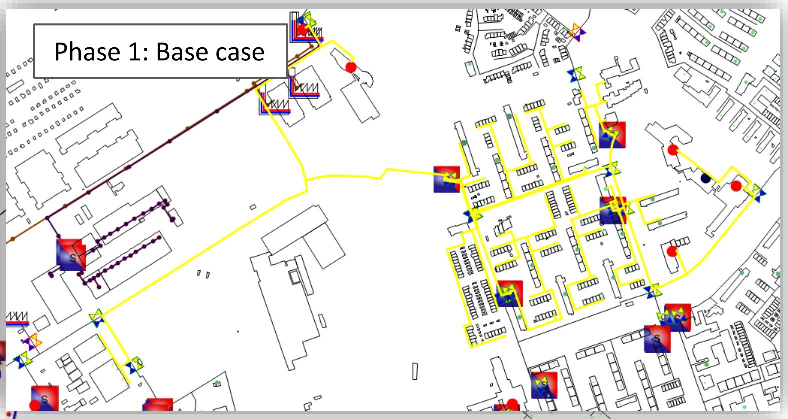
	Connections		Energy Demand (GJ/yr)		Modelled Capacity (kW)		Actual Capacity (kW)		HE Stations (WOS/WAS)
Phase	Residential	Utility	Residential	Utility	Residential	Utility	Residential	Utility	
1A	540	36	14040,00	34060,32	3780,00	4883,00	2192,40	2832,14	4
1B	347	7	9901,00	1392,05	3271,50	276,20	1897,47	160,20	2
2	474	-	13203,00	-	4227,00	-	2451,66	-	2
3	1018	91	28322,00	42576,26	8023,00	7123,93	4653,34	4131,88	6
4	1176	7	32952,00	268,92	10155,00	53,36	5889,90	30,95	3
5	1356	9	37532,00	4911,41	12031,00	928,80	6977,98	538,70	3
6	1547	12	41637,00	8342,11	10678,00	1655,18	6193,24	960,00	3
6.1	57	1	1482,00	5800,03	399,00	805,56	231,42	467,22	0
6.2	108	-	3024,00	-	648,00	-	375,84	-	1
6.3	189	2	5274,00	286,78	1323,00	56,90	767,34	33,00	0
7	663	16	19129,00	4849,69	6556,00	929,84	3802,48	539,31	2
8	837	75	25236,00	22120,42	8146,50	3647,70	4724,97	2115,66	3
9	1553	8	48476,00	3515,90	16999,50	697,60	9859,71	404,61	5
10	659	6	20167,00	3226,61	7016,50	640,20	4069,57	371,32	2
11	-	16	-	26674,30	-	5180,60	-	3004,75	0
12	-	1	-	86343,02	-	11992,09	-	6955,41	0
99	403	1	10750,00	54310,34	3003,50	4310,34	1742,03	2500,00	2
Total	**10524**	**287**	**300375**	**244368**	**93254**	**38871**	**54087**	**22545**	**36**

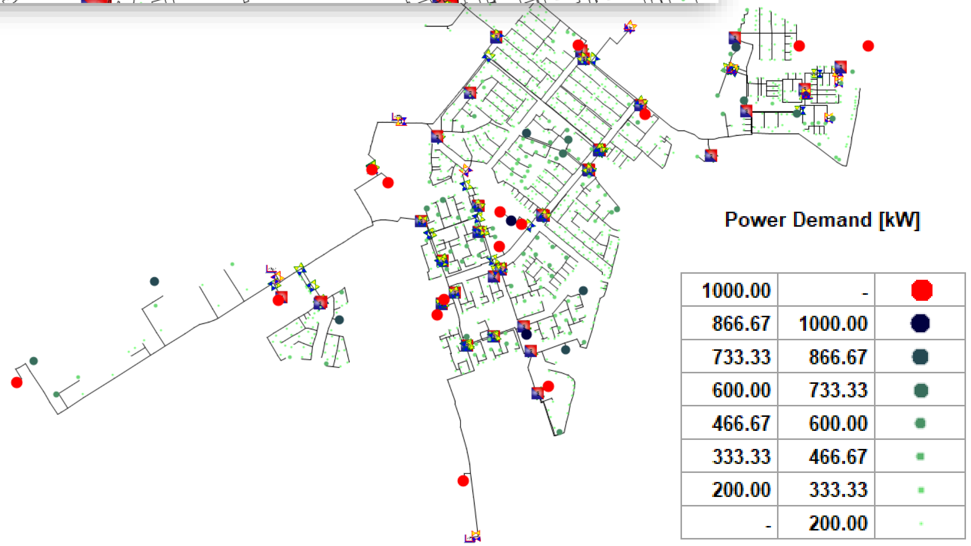
Progress update

DH Model development: Case study model

- Phase rollout, Consumer loads



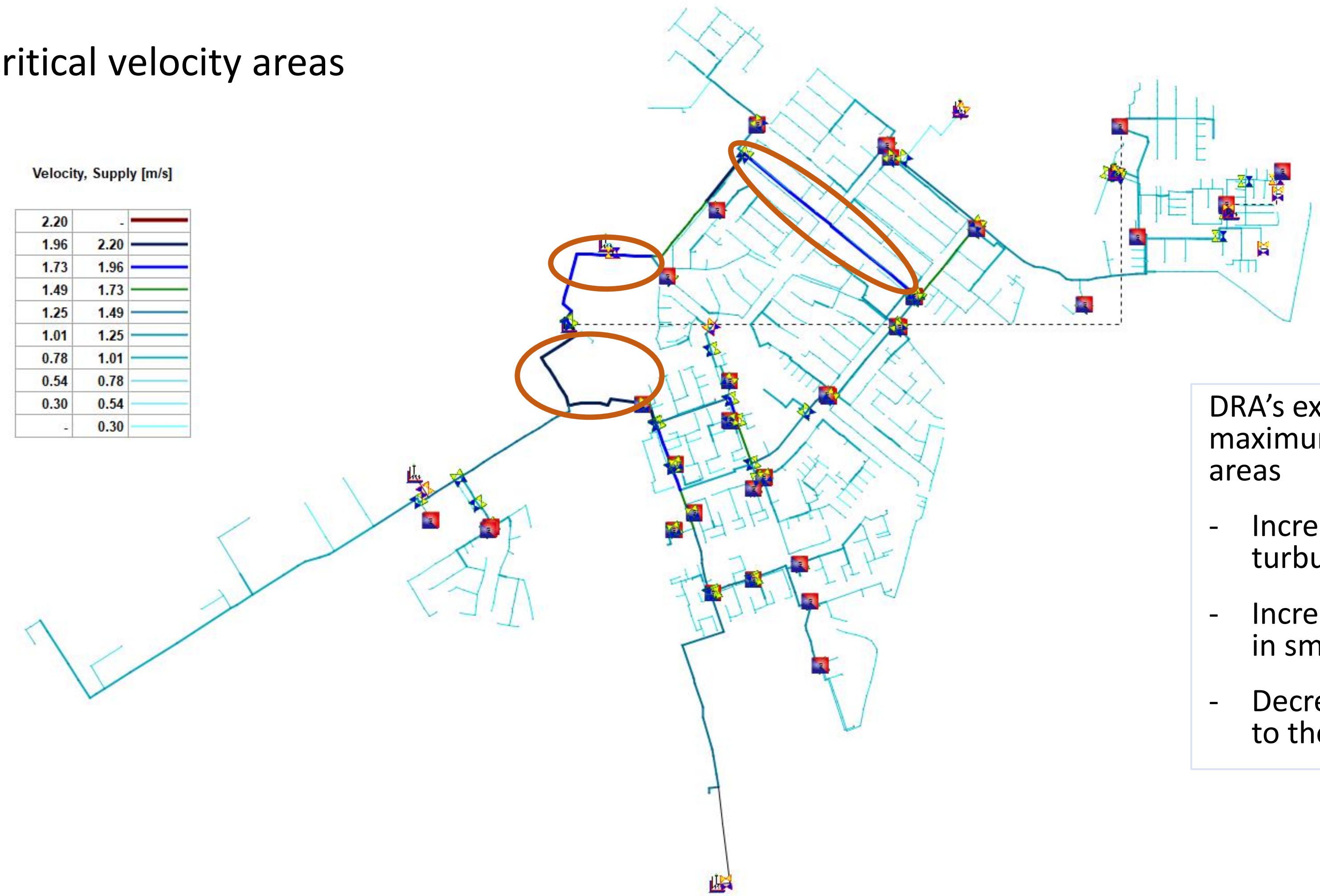




Progress update

DH Model development: Case study model

- Critical velocity areas



DRA's expected to have a maximum impact at these critical areas

- Increased chances of turbulent flow
- Increased shear stress effect in smaller pipelines
- Decreased diameters to add to the DRA effect

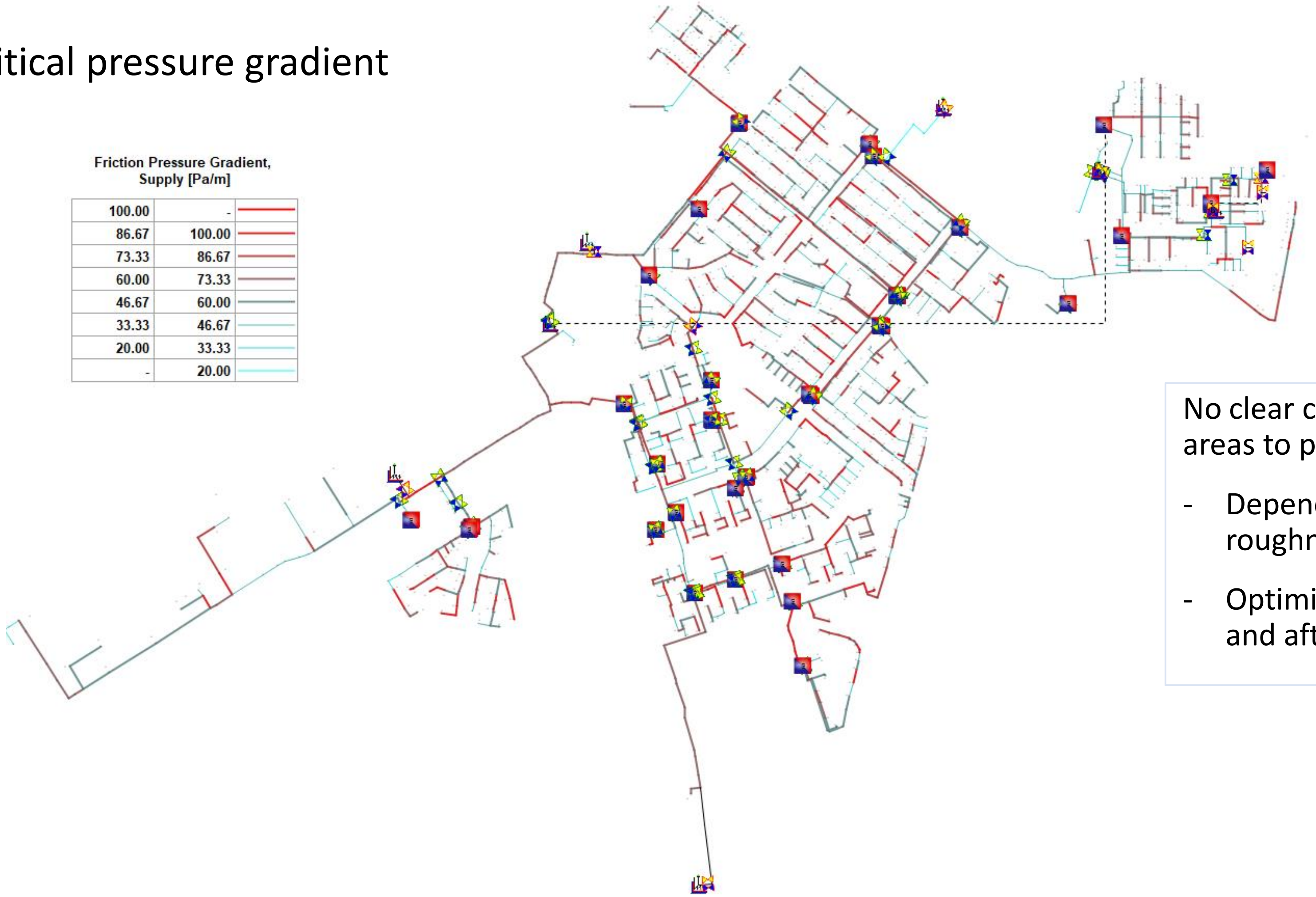
Progress update

DH Model development: Case study model

- Critical pressure gradient

Friction Pressure Gradient,
Supply [Pa/m]

100.00	-	
86.67	100.00	
73.33	86.67	
60.00	73.33	
46.67	60.00	
33.33	46.67	
20.00	33.33	
-	20.00	



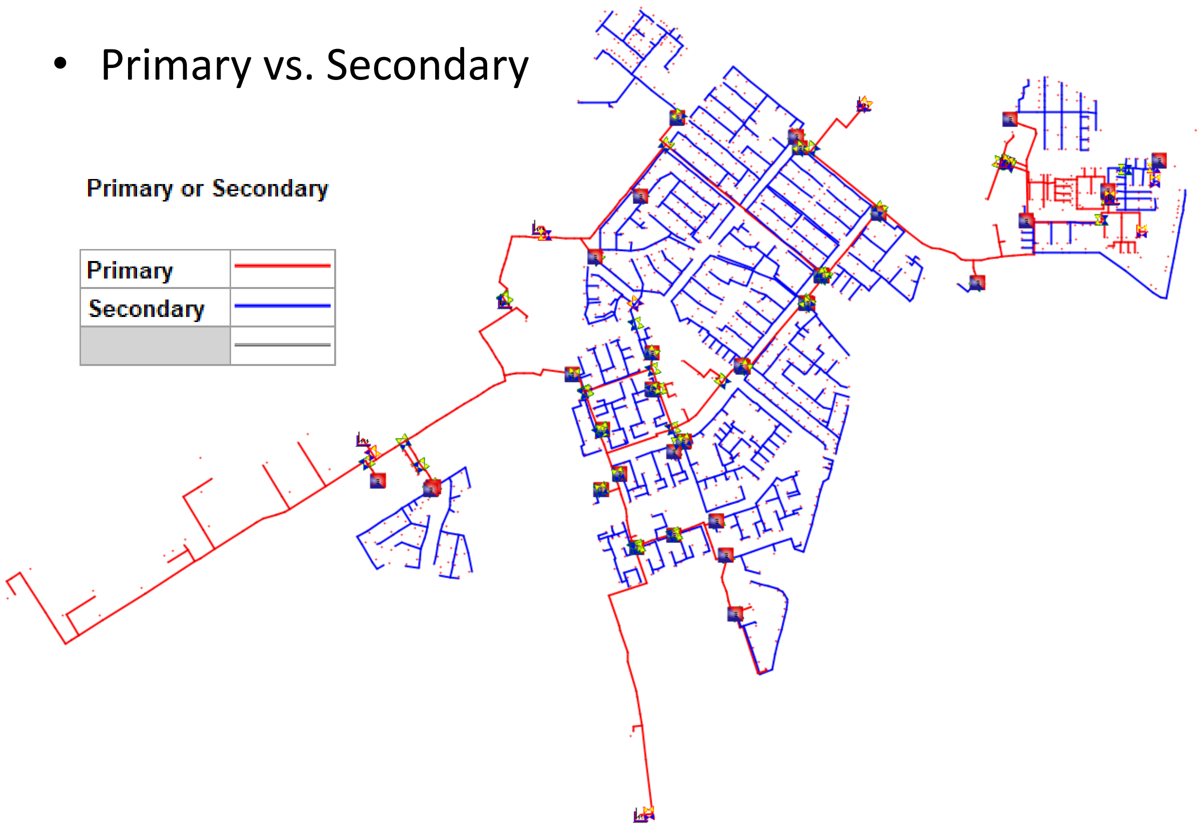
No clear critical pressure loss areas to predict:

- Dependent on pipe sizes and roughness
- Optimization required before and after DRA implementation

Progress update

DH Model development: Case study model

- Primary vs. Secondary



Pipe Types	Total
N020	637,07
N025	2728,05
N032	6614,58
N040	3628,30
N050	7346,77
N065	8440,32
N080	5424,64
N100	6103,96
N125	5702,32
N150	2765,98
N200	2702,10
N250	1337,72
N300	928,35
N350	768,13
N400	1364,94
N450	373,85
N500	0,00
N600	6,09
	56873,17

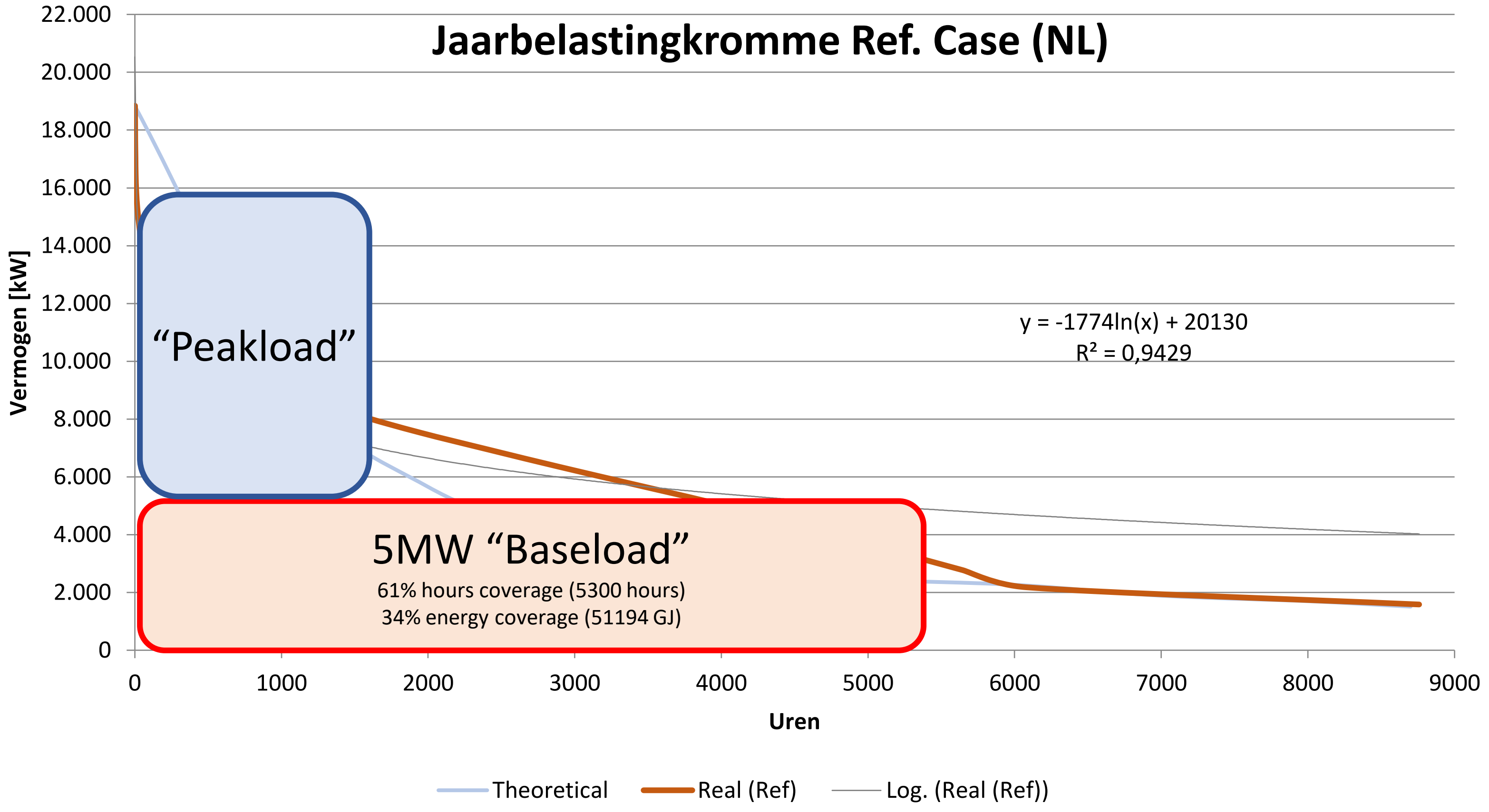
Estimated pipe lengths and diameters (30% Primary)

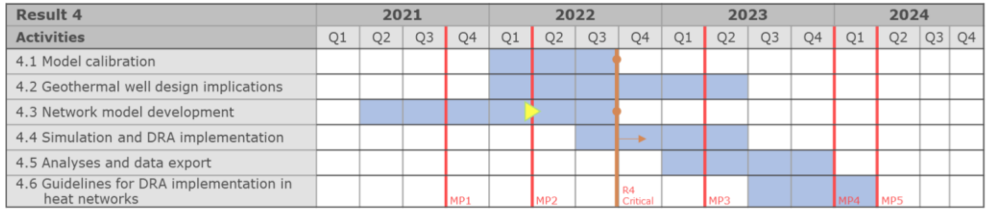
- Higher proportional CAPEX saving in primary network
- Reducing pre-investment required for future developments
- **18-20%** CAPEX saving reducing entire network with 1 size

Progress update

DH Model development: Case study model

- Source planning: base load vs. peak load





Next steps

Flow loop model: Calibration module (Q1-Q2, 2022)

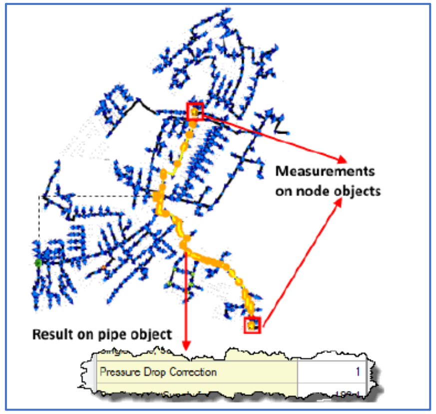
- Model to represent the experimental **flow loop** setup
- Process and system boundary conditions considered during DRA performance testing (T, Q, P)
- Input Result 2: Measurements at **various test conditions and DRA concentrations**
- DRA parameters as pressure correction factors or modified object properties (i.e. roughness in pipes)
- To implement in case study network in activity 4.4

- Calibration

Targeted at a path with comparison between two node objects

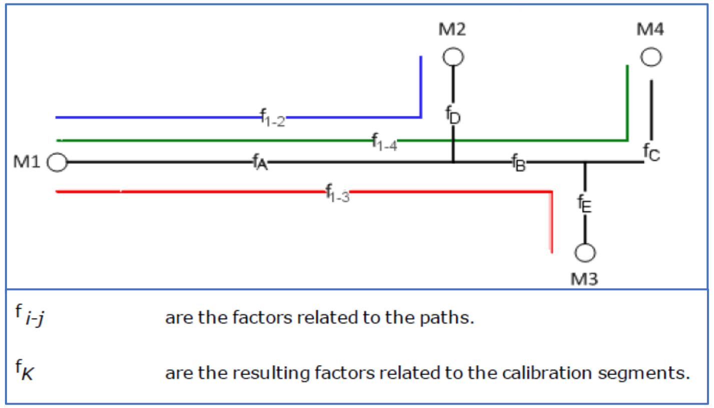
Comparison between simulation- and measured results

Output: <u>correction factor</u> that is stored as an attribute for all pipes.



Correction factor calculation:

$$\oint = \frac{\Delta X_{Measured}}{\Delta X_{Simulated}}$$



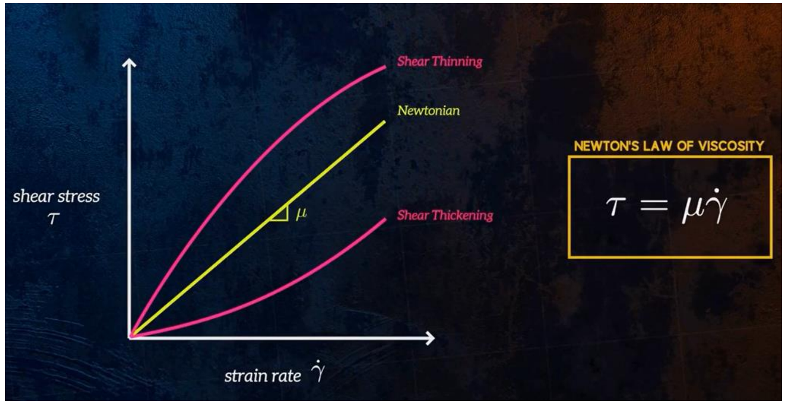
Next steps

Calibration parameters (Q3-Q4, 2022)

- Pipe roughness (25-30%)
- Fluid parameters (>50%)

Dynamic viscosity $\mu = \exp(a_v + \beta T)$

- Development in progress

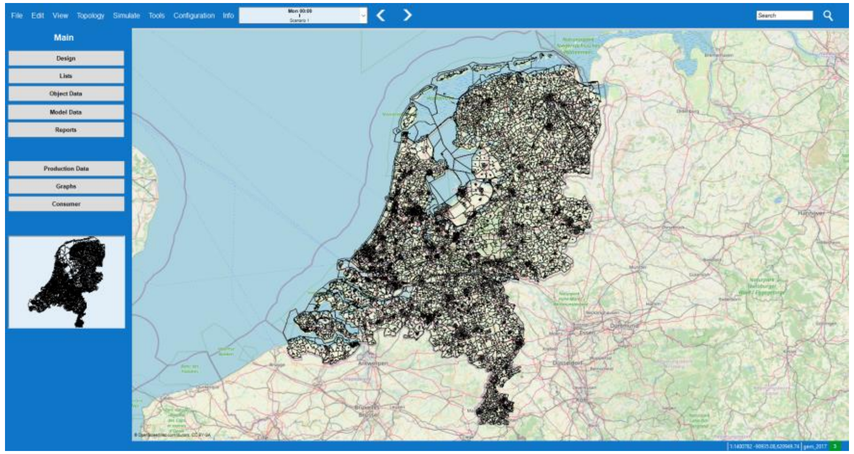


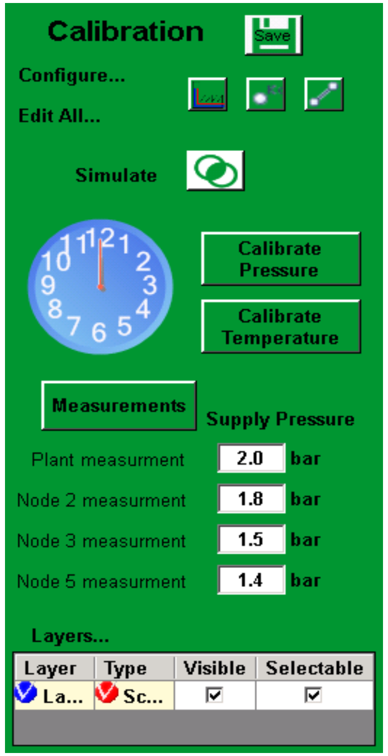
Next steps

Simulation and DRA implementation (Q3-Q4, 2022)

- Create scenarios to simulate
  → Non-DRA vs. DRA system
- Test calibration module and verify DRA parameter implementation
- Execute conventional system calculation
- Execute DRA system calculation
- Increase flexibility in dataset if necessary (export phase)
- (Bonus): Set up DRA model template for future models/systems

DRA enabled Template model



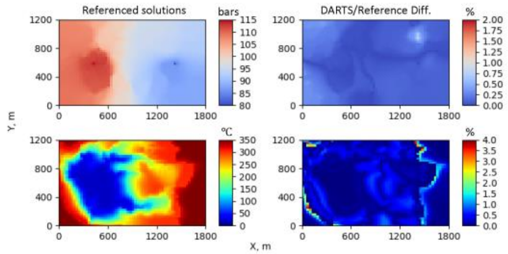


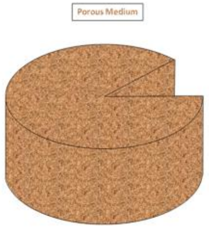
GUI Calibration module dashboard

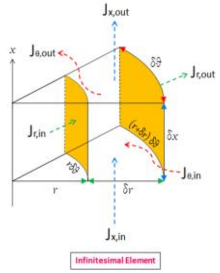
Next steps

Geothermal well design implications (Q1-Q2, 2022)

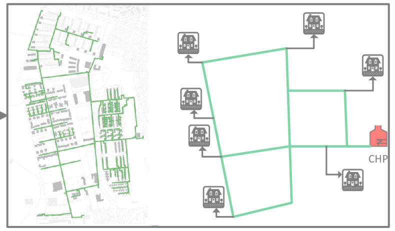
- Effects of DRA injection on geothermal well design
- Simulate effects of DRA mixture on dynamic well and reservoir pressure loss
  → Operational limits (Injection pressure, ESP design, erosional velocity, etc.)
  → Design guideline - parameters required to modify well designs – long term impact, cold water breakthrough
  → **Integration** with DH networks, input to DH modelling as boundary conditions (flowrate etc.)







DH Network



Geothermal results as input boundary conditions (P, Q)

Next steps

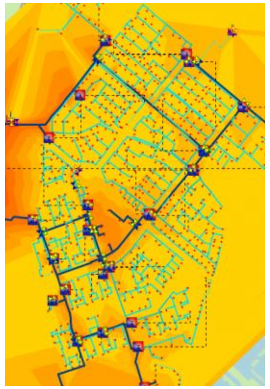
Analyses and data exports (Q1, 2023)

- Export format and procedure
- BuCa requirements (Result 6)
- Pipe data export per scenario/simulation
- Non-DRA vs. DRA system results
- Various object exports (plants, stations, valves, etc.)

Sim12: Primary line connected to StFranciscus in the South.

Plant Control	PL_110Mc	PL_110Mc	PL_WP_H
Power Control [kW]			
Flow Control [kg/s]			
Inlet Temperature Control [°C]	75,00	75,00	75,00
Static Supply Pressure [bar]			
Static Return Pressure [bar]	2,00	2,00	2,00
Static Pressure [bar]			
Percent of Pressure Difference			
Control Node	PL_110Mc	PL_110Mc	NO_1369
Node Supply Pressure Control [bar]			
Node Return Pressure Control [bar]			
Node Pressure Change Control [bar]	-1,50	-1,50	-1,50

Plant Results	PL_110Mc	PL_110Mc	PL_WP_HTO
Power [kW]	0,00	0,00	73584,63
Flow [kg/s]	1,00	1,00	520,18
Volumetric Flow [m³/h]	3,56	3,56	1886,43
Temperature, Supply, Plant [°C]	75,00	75,00	75,00
Temperature, Return, Plant [°C]	5,00	5,00	41,26
Temperature, Difference [°C]	70,00	70,00	33,74
Pressure, Supply [bar]	3,50	3,50	7,49
Pressure, Return [bar]	2,00	2,00	2,00
Pressure, Difference [bar]	1,50	1,50	5,49
Power, Pump [kW]	0,15	0,15	287,56
Energy Cost, Production [CU/s]	0,00	0,00	0,00
Actual speed [rps]	NaN	NaN	NaN
Energy Cost, Pump [CU/s]	0,00	0,00	0,00
Production Units			
Actual Control Node	PL_110Mc	PL_110Mc	NO_1369



- Master file **link** with techno-economic model (Result 6)
- Online available BuCa assessment tool for public use

PHASE	DSIM_1	DSIM_2	DSIM_3	DSIM_4	DSIM_5	DSIM_6	DSIM_7	DSIM_8	DSIM_9	DSIM_10
1	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
2	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
3	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
4	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
5	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
6	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
7	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
8	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00	€ 1 000,00
9	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00
10	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00
11	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00	€ 1 000,00
12	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 0,00	€ 1 000,00
Total	**€ 2 000,00**	**€ 3 000,00**	**€ 4 000,00**	**€ 5 000,00**	**€ 6 000,00**	**€ 6 000,00**	**€ 7 000,00**	**€ 8 000,00**	**€ 11 000,00**	**€ 12 000,00**

Looking forward

Guidelines for DRA implementation in DH and geothermal design and modelling (Q3, 2023)

- Best “tools” for the job (software, methods, etc.)
- DRA parameter development
- Most effected areas using DRA’s (“low hanging fruit”)
- Most significant effects on CAPEX and OPEX
- Sensitivity analyses
- General knowledge share

Thank you for listening