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VIA University College

QThermonet

A thermonet dimensioning tool for QGIS

Tutorial 1 (v. 0.1 – June 2025)

Data Licenses

Please attribute Qthermonet/pythermonet with a link to:

> Poulsen, S. E., & Tordrup, K. W. (2023, okt. 12). Pythermonet - a Python library for designing thermonet. https://github.com/soeb1978/pythermonet (update when paper is published)

Data used in this tutorial is licensed under an Open Database License (?)

Introduction/1

- The aim of this tutorial is to introduce the capabilities of the QGIS-integrated QThermonet platform for the dimensioning of thermonets.

- The platform integrates the free and open-source dimensioning tool pythermonet (Poulsen & Tordrup 2023*) as a plugin within the desktop QGIS.

- To complete this tutorial basic knowledge of QGIS is required.

*Poulsen, S. E., & Tordrup, K. W. (2023, okt. 12). Pythermonet - a Python library for designing thermonet. https://github.com/soeb1978/pythermonet (update)

Introduction/2

Download and installation of the following software is required:

- QGIS version 3.34.15 Prizren (Note: v4 to-be-released in October)

This tutorial was succesfully performed within Windows 11 OS and using QGIS version 3.34.15 Prizren.

Introduction/3

This tutorial is divided in two parts.

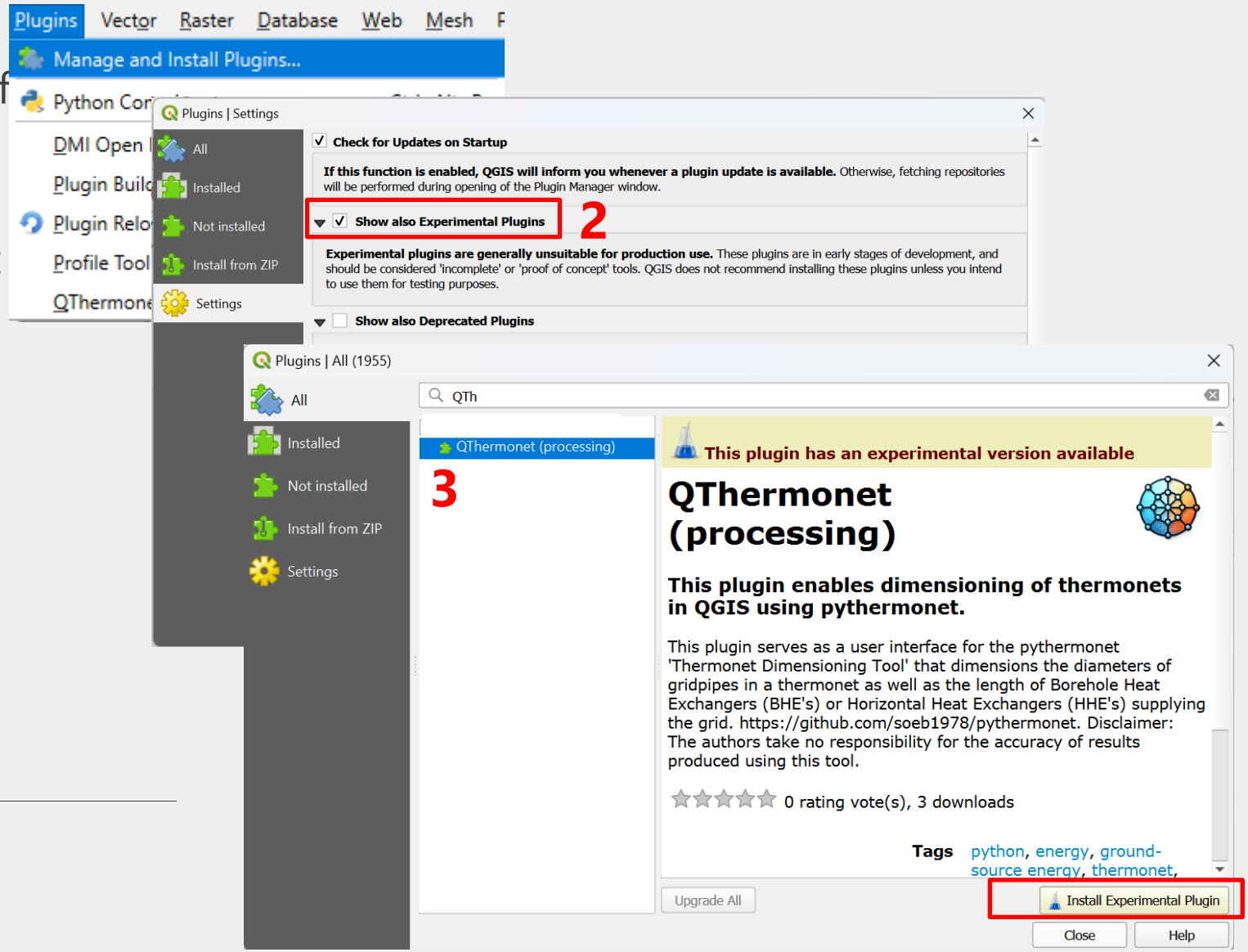
Part A covers pythermonet + QThermonet installation & requirements, and access to datafordeler.dk

Part B covers an example of full dimensioning of a simple thermonet with a case from Denmark.

The estimated time required to go through part B is about **1-2 hours.**

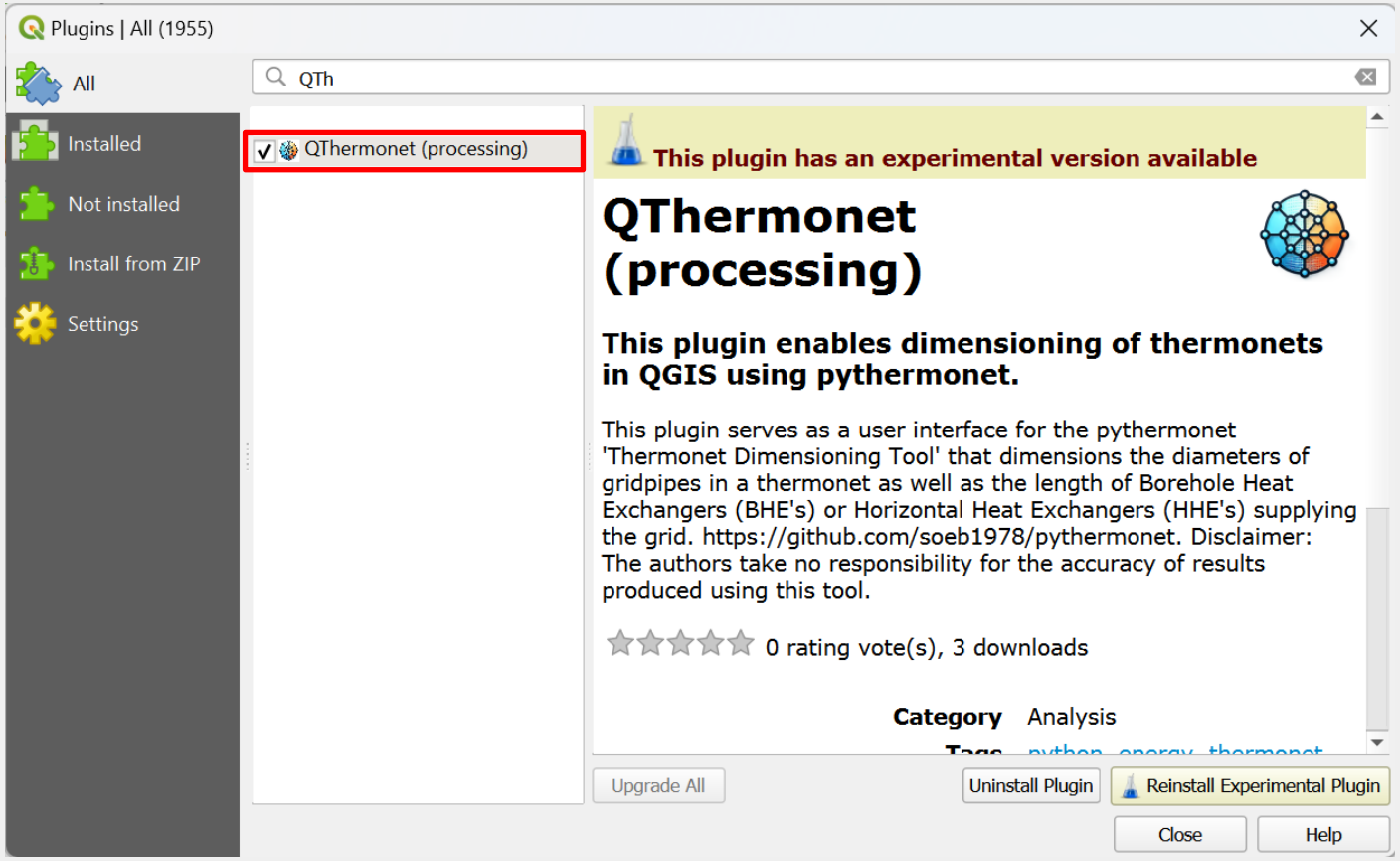
Part A / Installing QThermonet plugin 1

- First, ensure you have a recent installation of QGIS: 3.34 or later (performance tested on 3.34.15 Prizren)
- To get the latest version of the QThermonet plugin for QGIS go to 'Plugins' in the QGIS menu bar and click on 'Manage and Install Plugins…'
- In the dialogue window that opens go to 'Settings' and check 'Show also Experimental Plugins'
- Go to 'All' and search for "QThermonet"
- Click "Install Experimental Plugin"



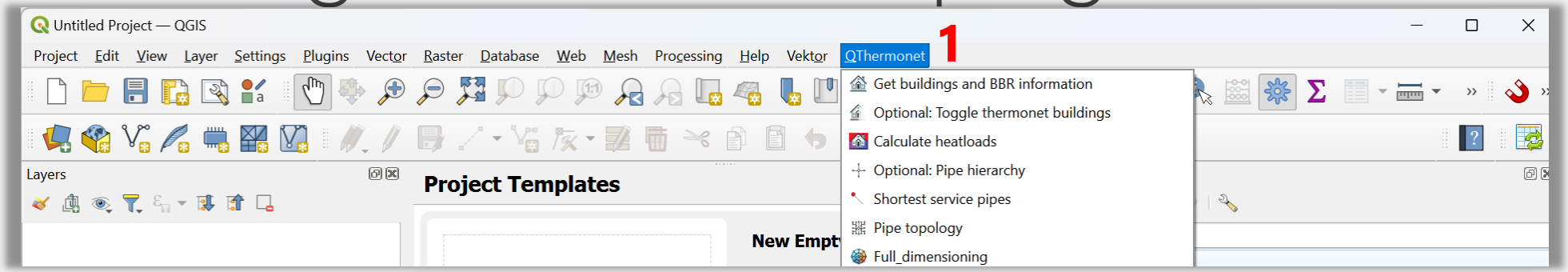
Part A / Installing QThermonet plugin 2

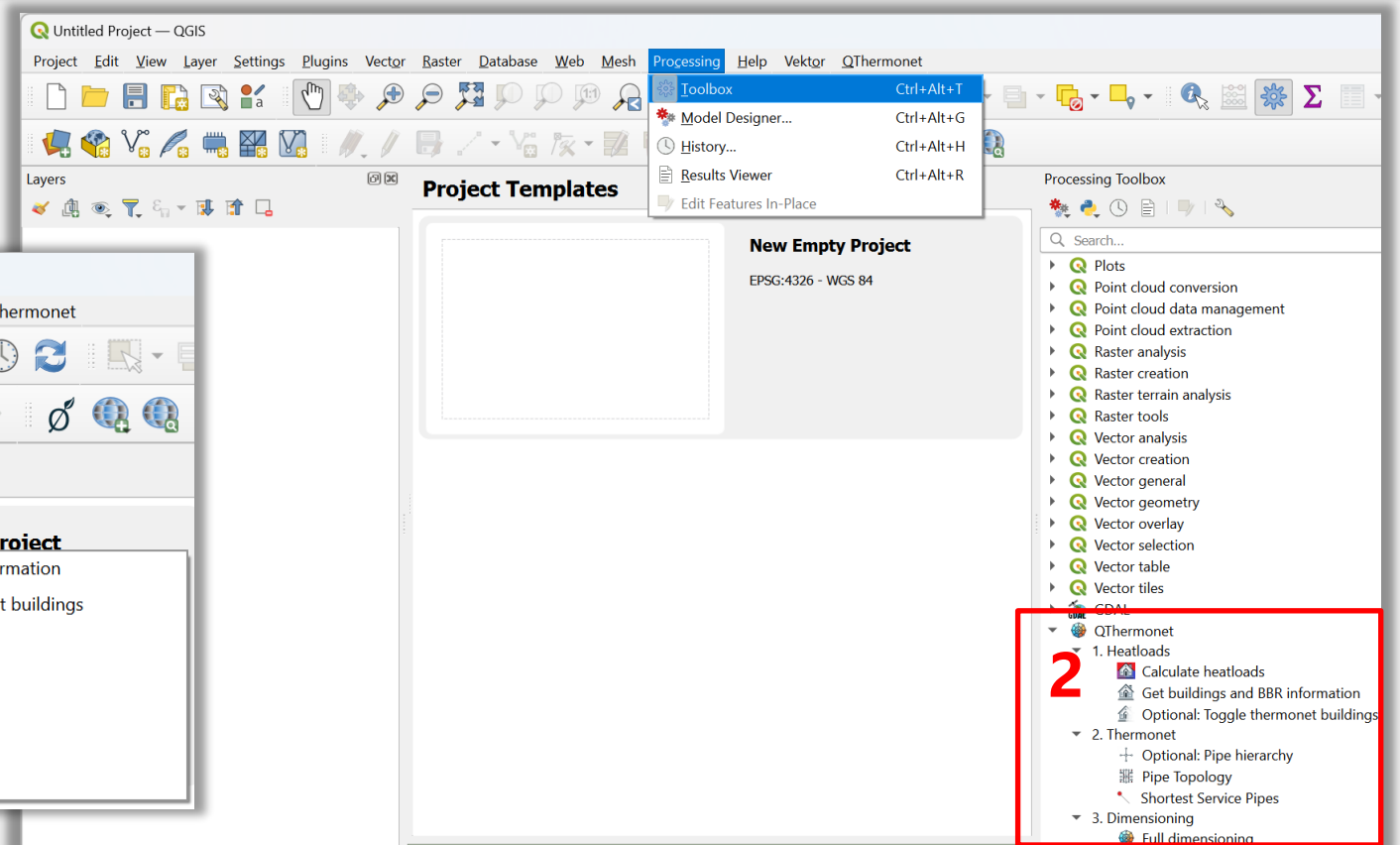
- QGIS will let you know whether installation was succesful.
- Make sure the plugin is checked and close the dialogue window.

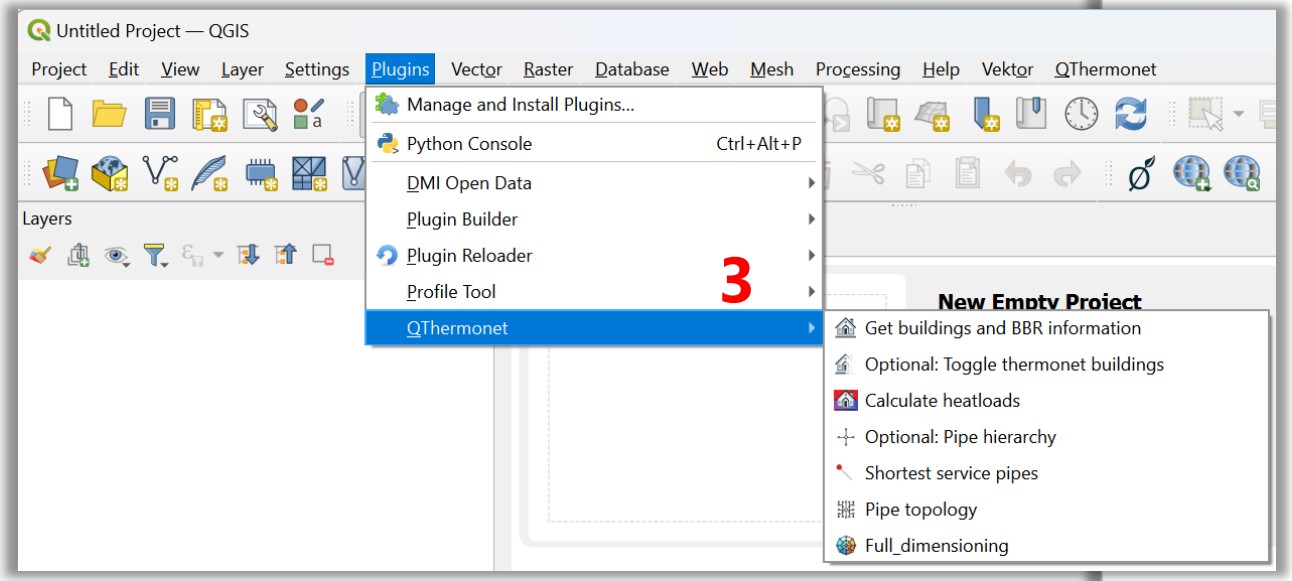


Part A / Installing QThermonet plugin 3

- The 'Qthermonet' plugin should now appear in three places:
  1. The menu-bar
  2. The processing toolbox
  3. In a submenu to the 'Plugins' menu.



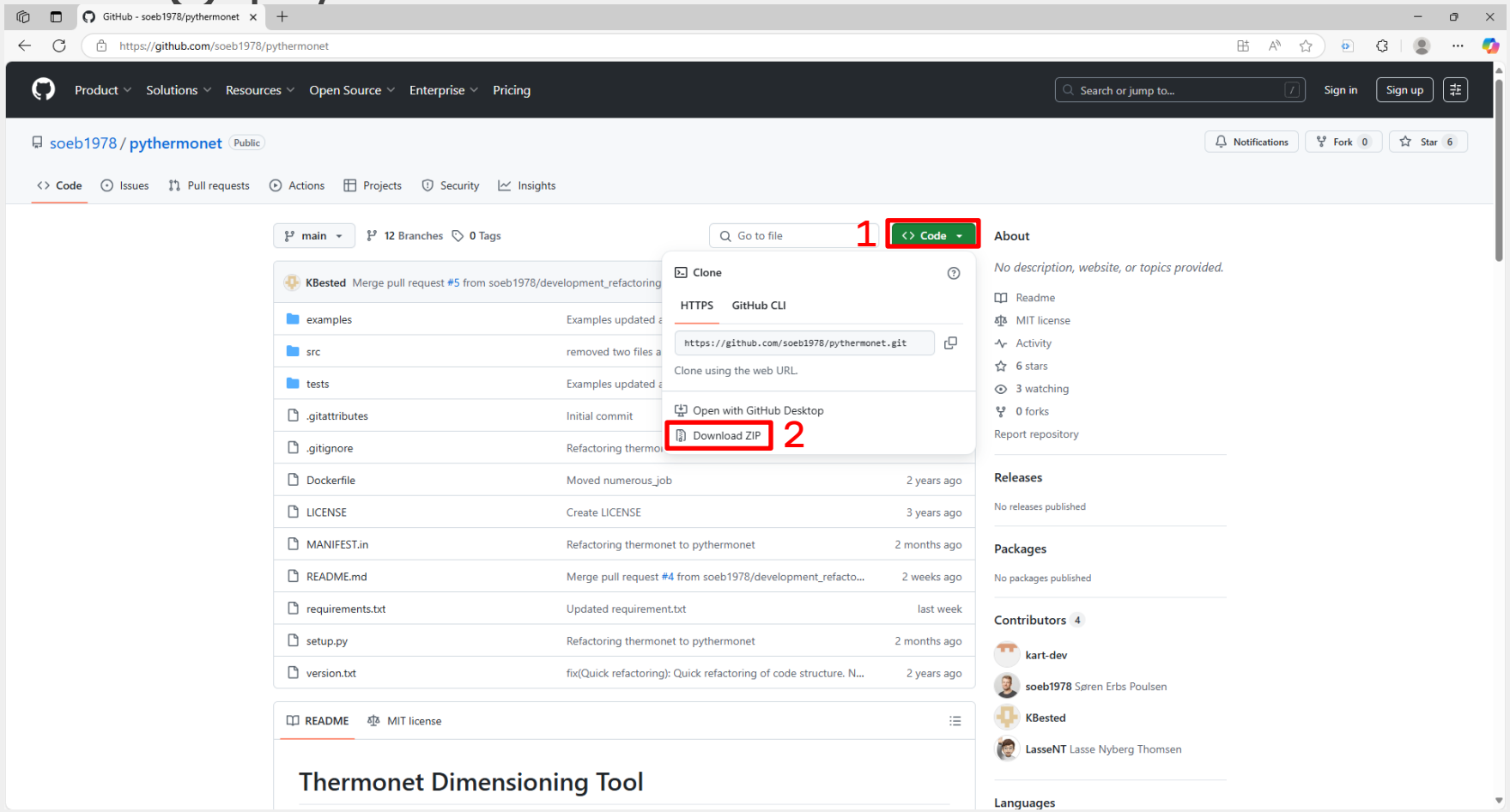




Part A / Installing pythermonet 1

- Please visit [GitHub - soeb1978/pythermonet](https://github.com/soeb1978/pythermonet) to download a copy of the pythermonet repository (Poulsen & Tordrup 2023*)

- Unzip the downloaded folder to your desktop or C-drive

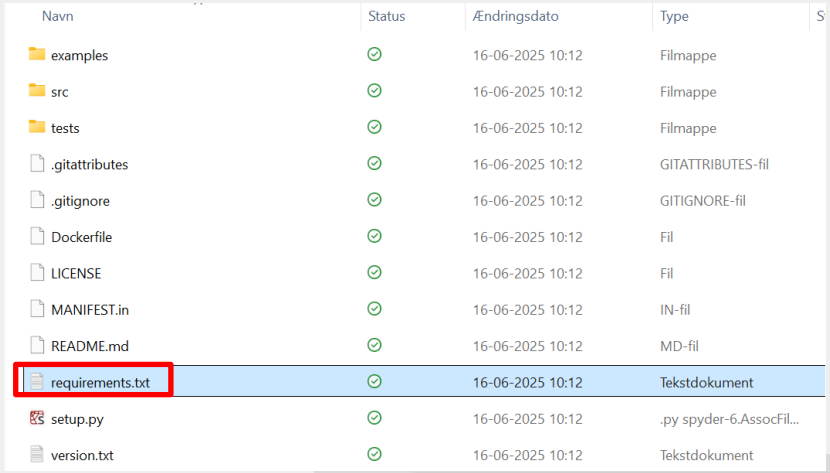


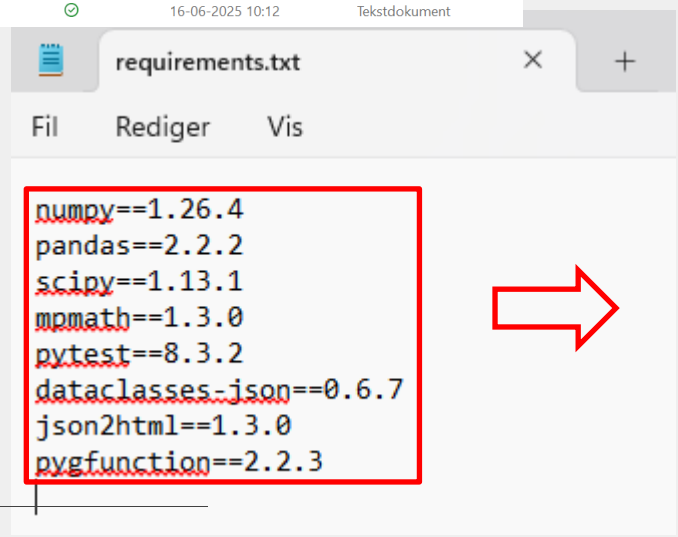
*Poulsen, S. E., & Tordrup, K. W. (2023, okt. 12). Pythermonet - a Python library for designing thermonet. https://github.com/soeb1978/pythermonet (update)

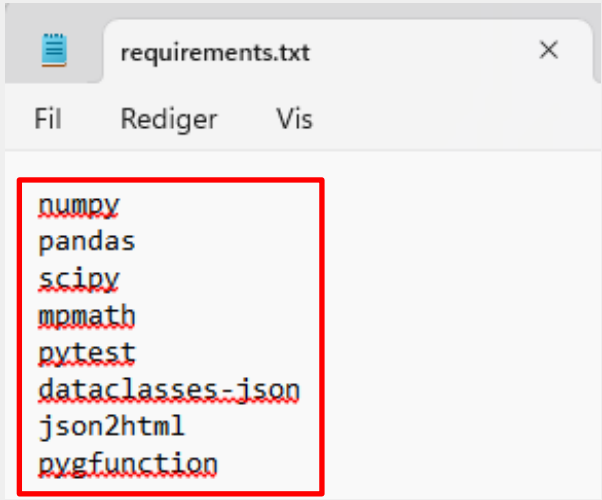
Part A / Installing pythermonet 2

Next, you need to make a few changes to connect the pythermonet codes with QGIS so that the plugin will work.

- From the unzipped pythermonet-main folder open the requirements.txt file
- Remove the version numbers from each line.
- Save and close the file.

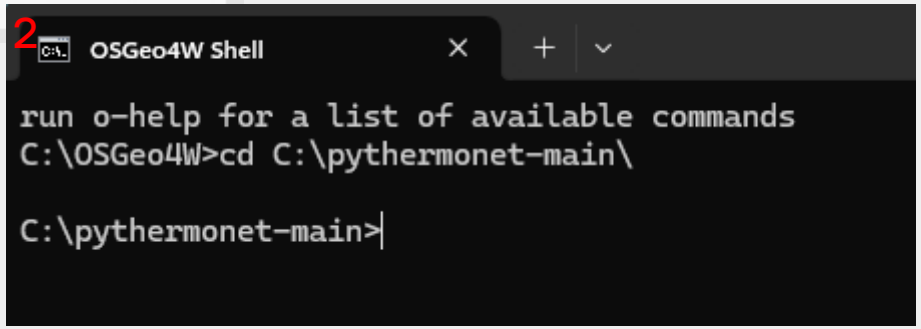


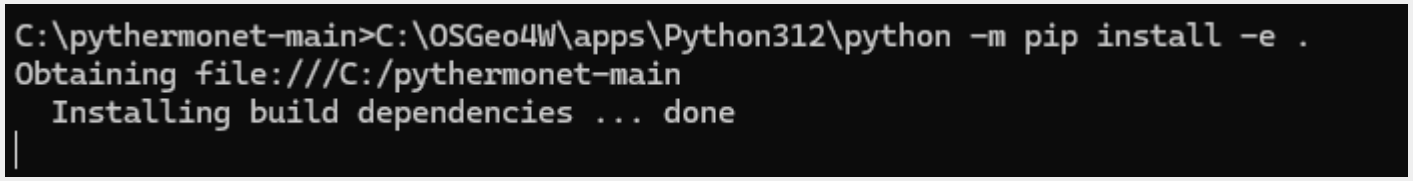


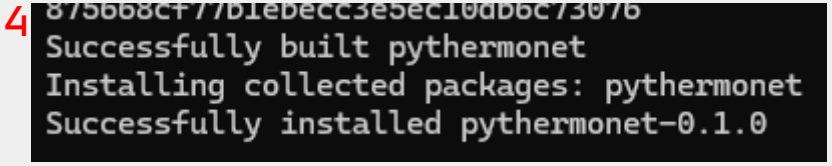


Part A / Installing pythermonet 3

1. Open the OSGeo4W shell (search for it on your computer)
2. In the shell, navigate to the pythermonet folder, e.g.: cd C:\pythermonet-main\ *(replace with path to pythermonet on your computer)*
3. In the shell, type: C:\OSGeo4W\apps\Python312\python -m pip install -e .
4. This should lead to succesful installation of pythermonet within QGIS





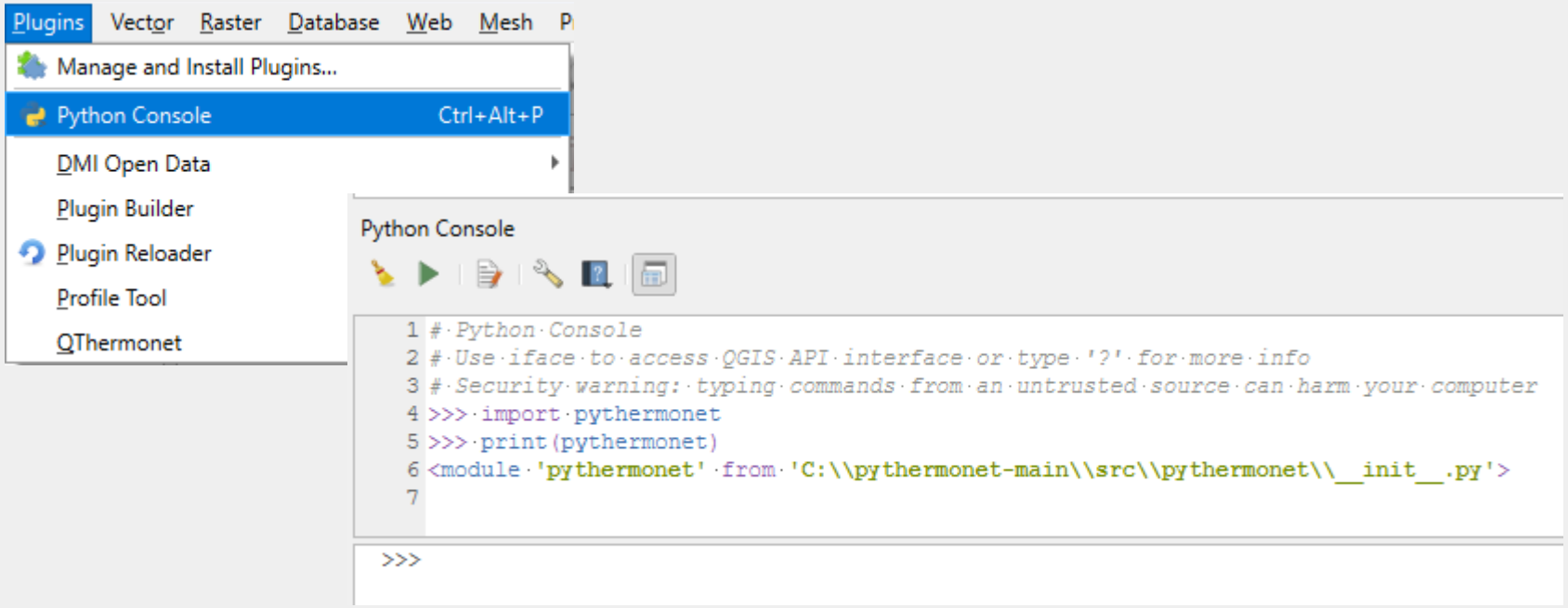


Part A / Installing pythermonet 4

Check that the installation was succesful by

- Restarting QGIS
- Opening the QGIS "Python Console"
- Run 'import pythermonet'
- Run 'print(pythermonet)'
- Check that the path is correct

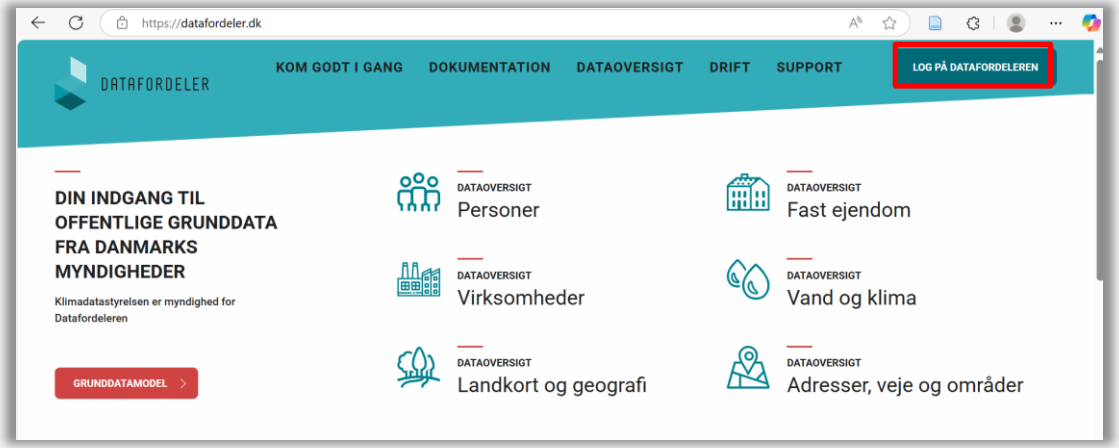
NB: if you are re-installing pythermonet, you need to delete the old version or change the filepath.



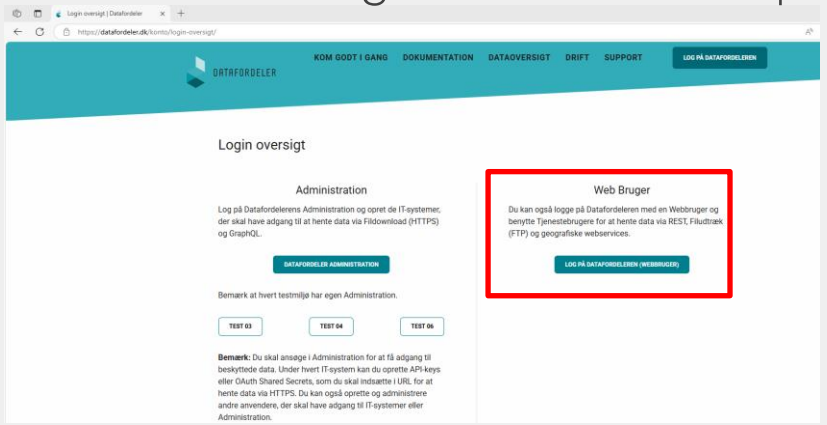
Part A / DATAFORDELER login 1

To calculate heatloads for existing buildings in Denmark you need to retrieve BBR information within the QThermonet plugin.

For this, you need a login to DATAFORDELER.dk which you can get after creating a user (ctrl+click left image to follow link):



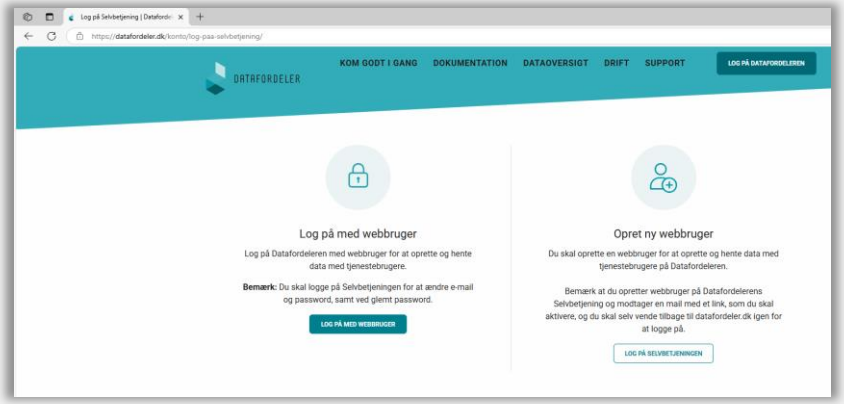
Select 'Web Bruger' in the next step

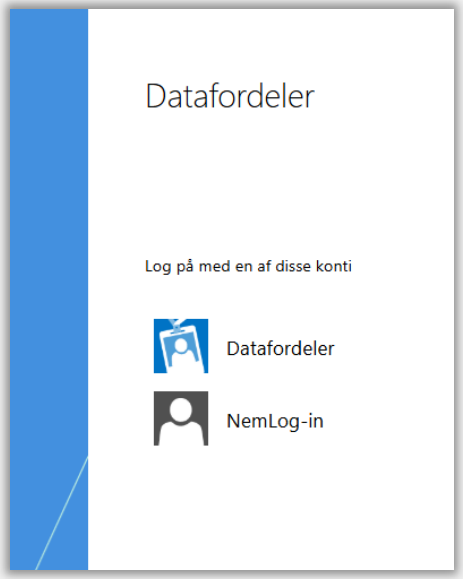


Part A / DATAFORDELER login 2

If you have not used datafordeler before, you need to create a new user ('opret ny webbruger' - follow the guidelines on the homepage).

Else you can log on with your existing user and then NemLog-in + MitID

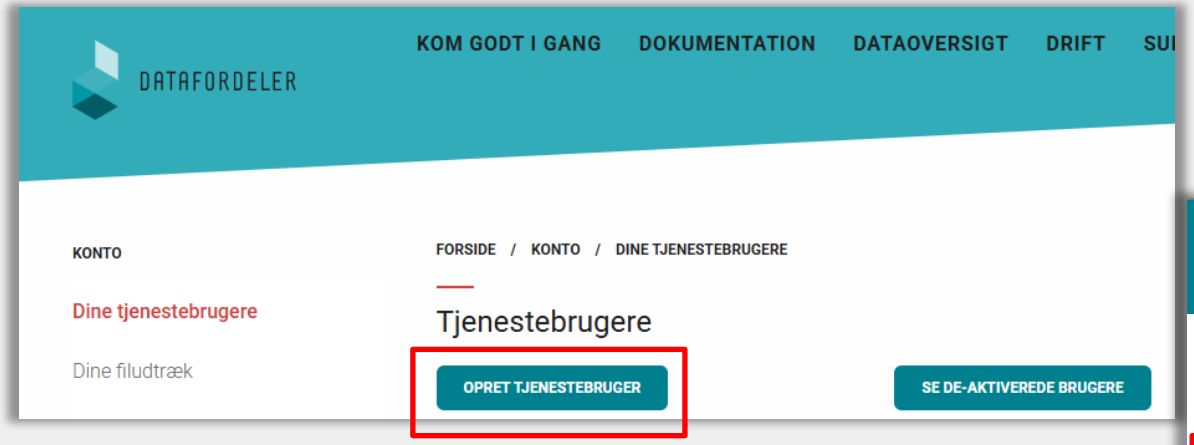


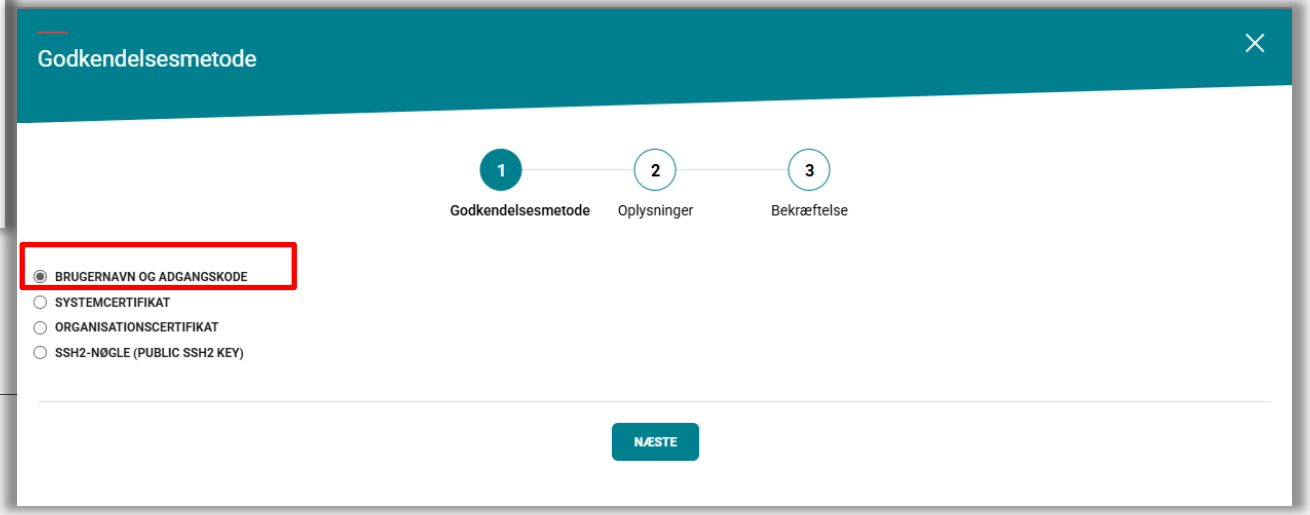


Part A / DATAFORDELER login 3

After entering the system you have to:

- Create a 'Tjenestebruger'
- Select 'Brugernavn og adgangskode'
- Type your username and password which you will use in QThermonet.





Part B / Test Case Overview

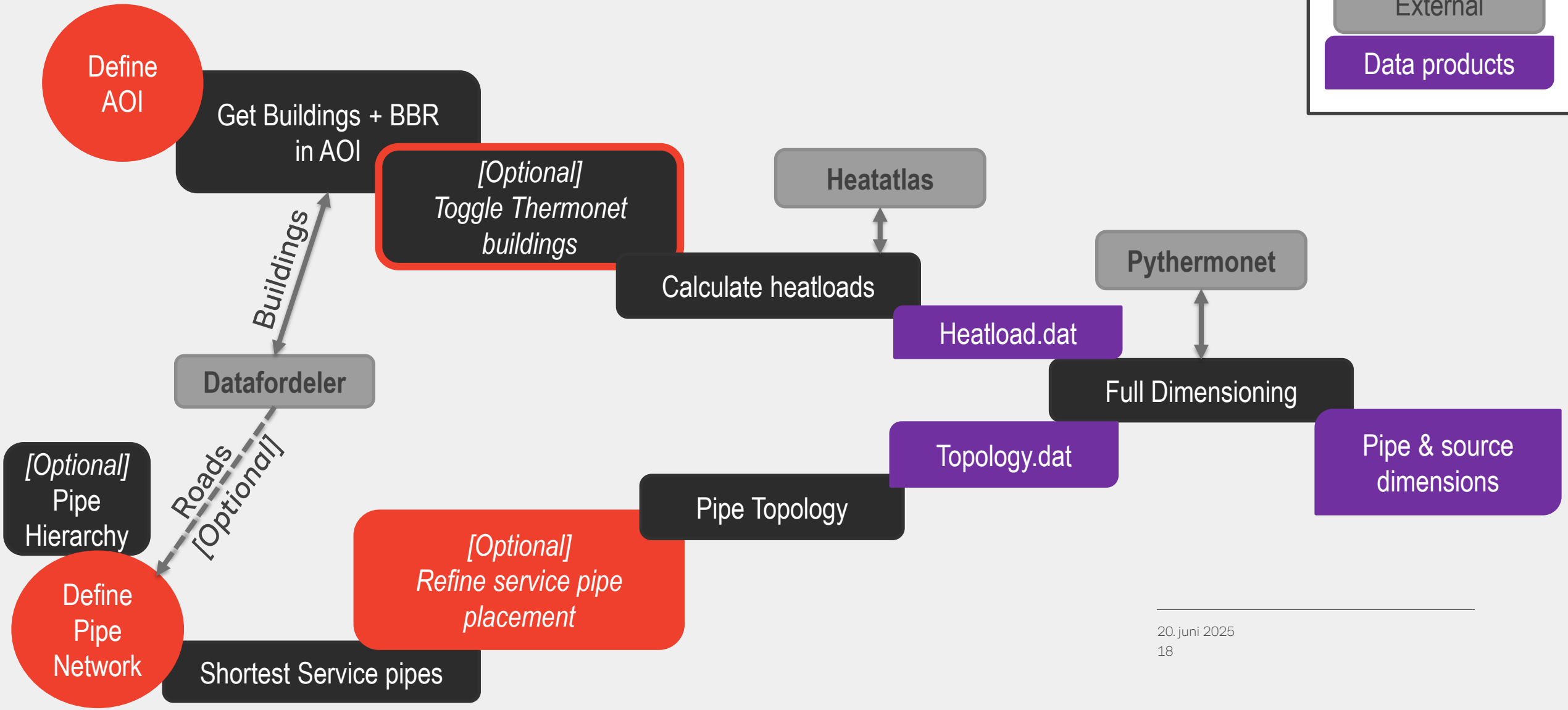
In part B of this tutorial we will work through an example of how to perform full dimensioning of a thermonet for a test case in Denmark.

It is divided in three parts:

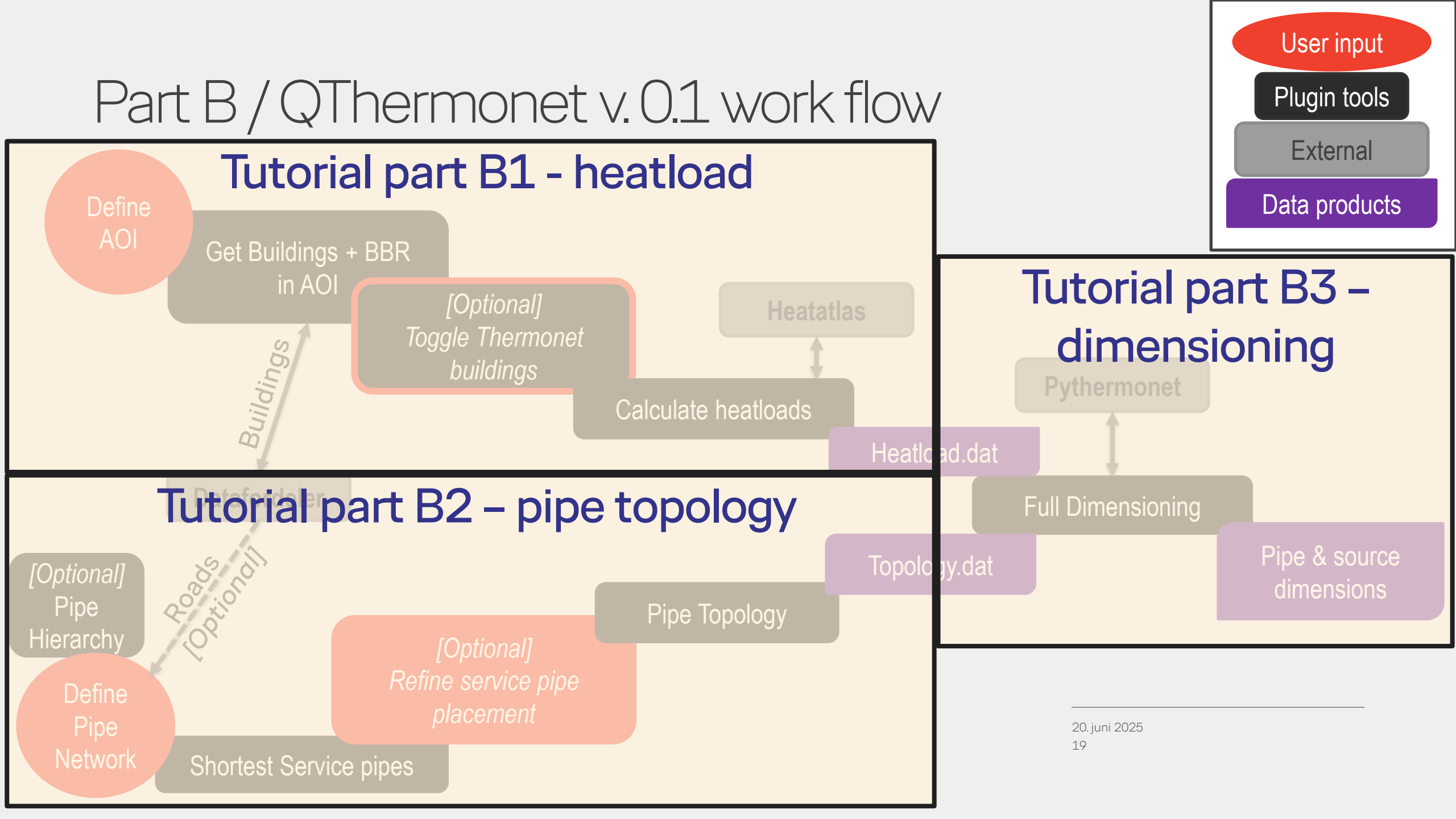
- In part **B1,** the expected heatloads are calculated for a defined AOI
- In part **B2**, the thermonet pipe layout and topology is developed
- Finally, in part **B3**, dimensioning of the thermonet source is performed

The workflow diagram on the following slide shows how the different tools are connected

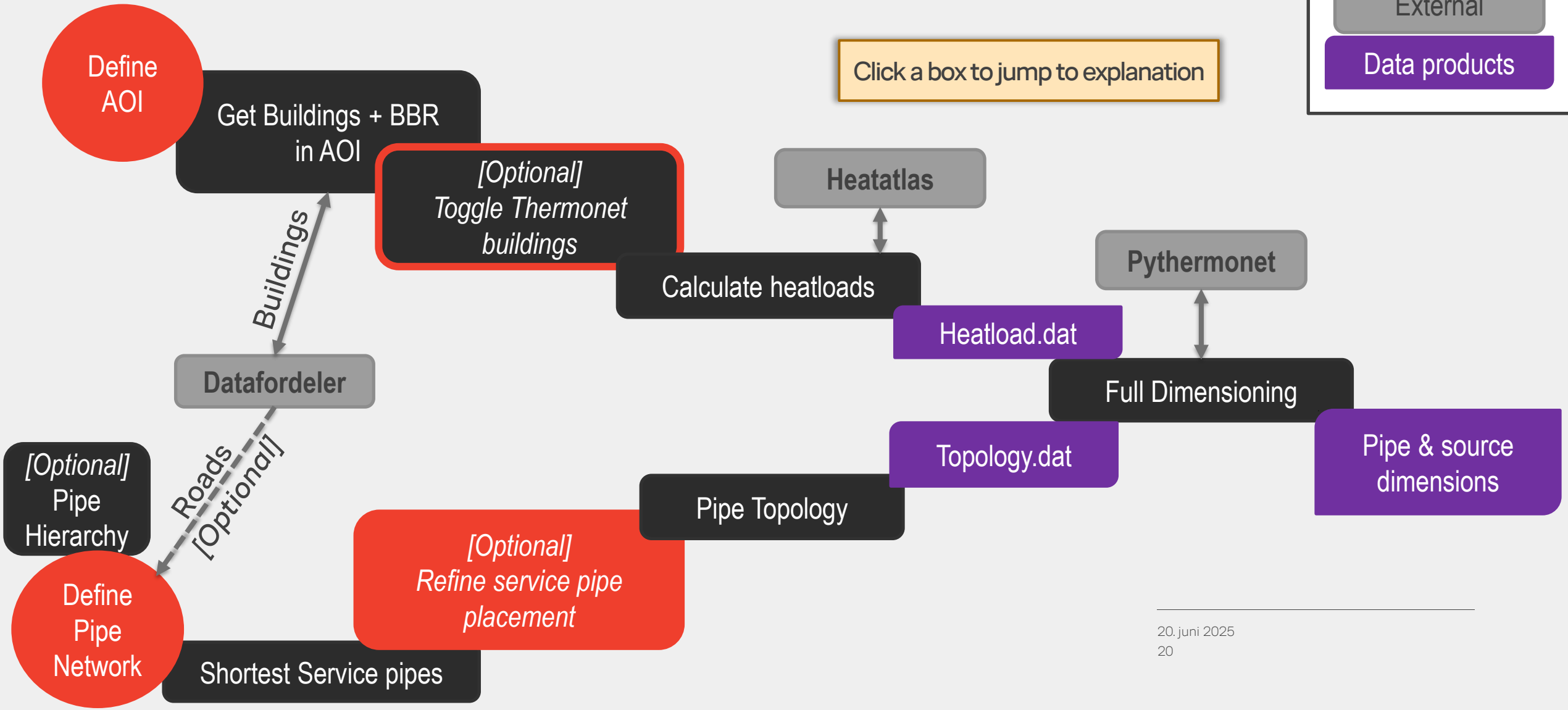
Part B / QThermonet v. 0.1 work flow



Part B / QThermonet v. 0.1 work flow



Part B / QThermonet v. 0.1 work flow

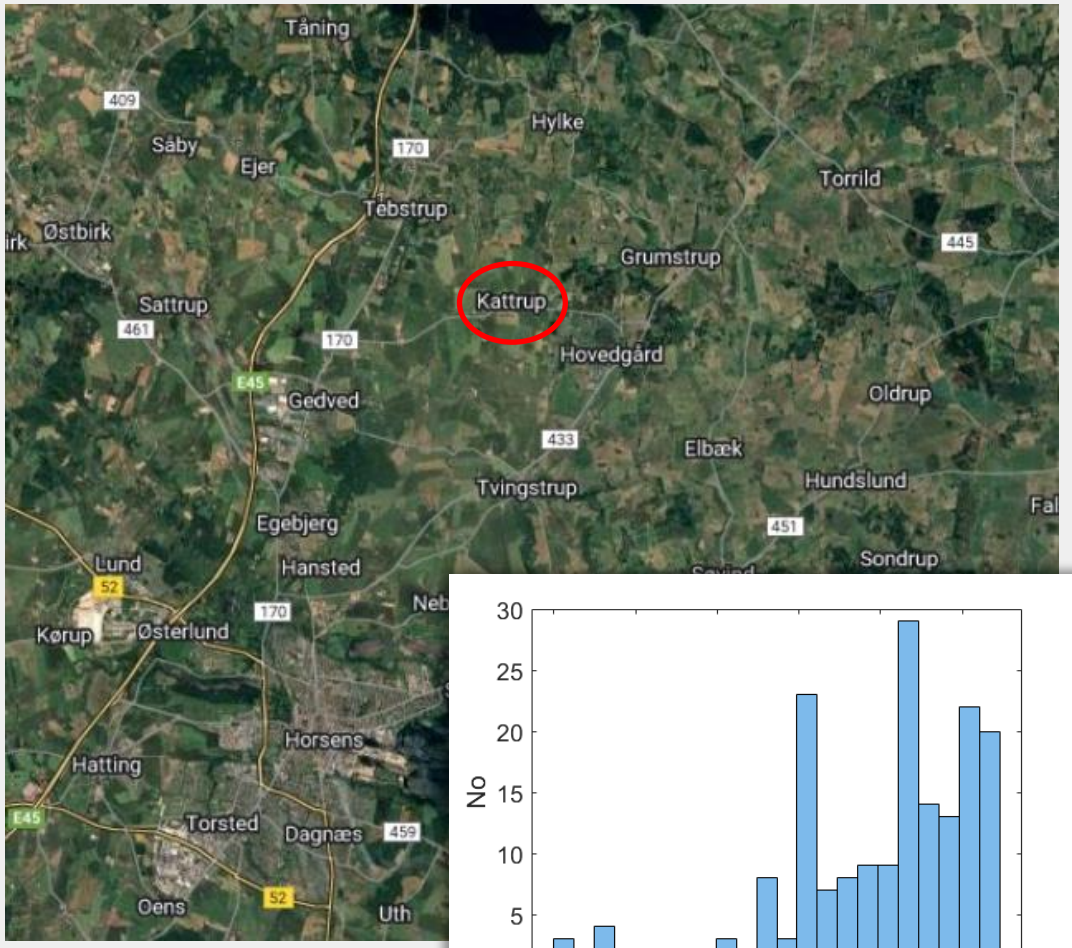


Part B / Test case setting

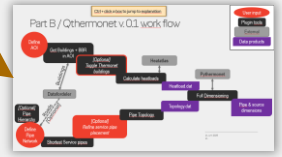
The test case area that we will work with in this tutorial is located in the village of Kattrup, Horsens Kommune, Denmark. In Kattrup, most buildings are currently heated by natural gas or oil. Buldings are from 1751-2021.

According to the climate plan for Horsens Kommune, Kattrup could be a potential candidate for thermonet or individual heatpumps in the future (*Varmeplan Horsens Kommune*).*

**Varmeplan 2023-2030 – for Horsens Kommune, last revised 08.06.23, not legally binding.*

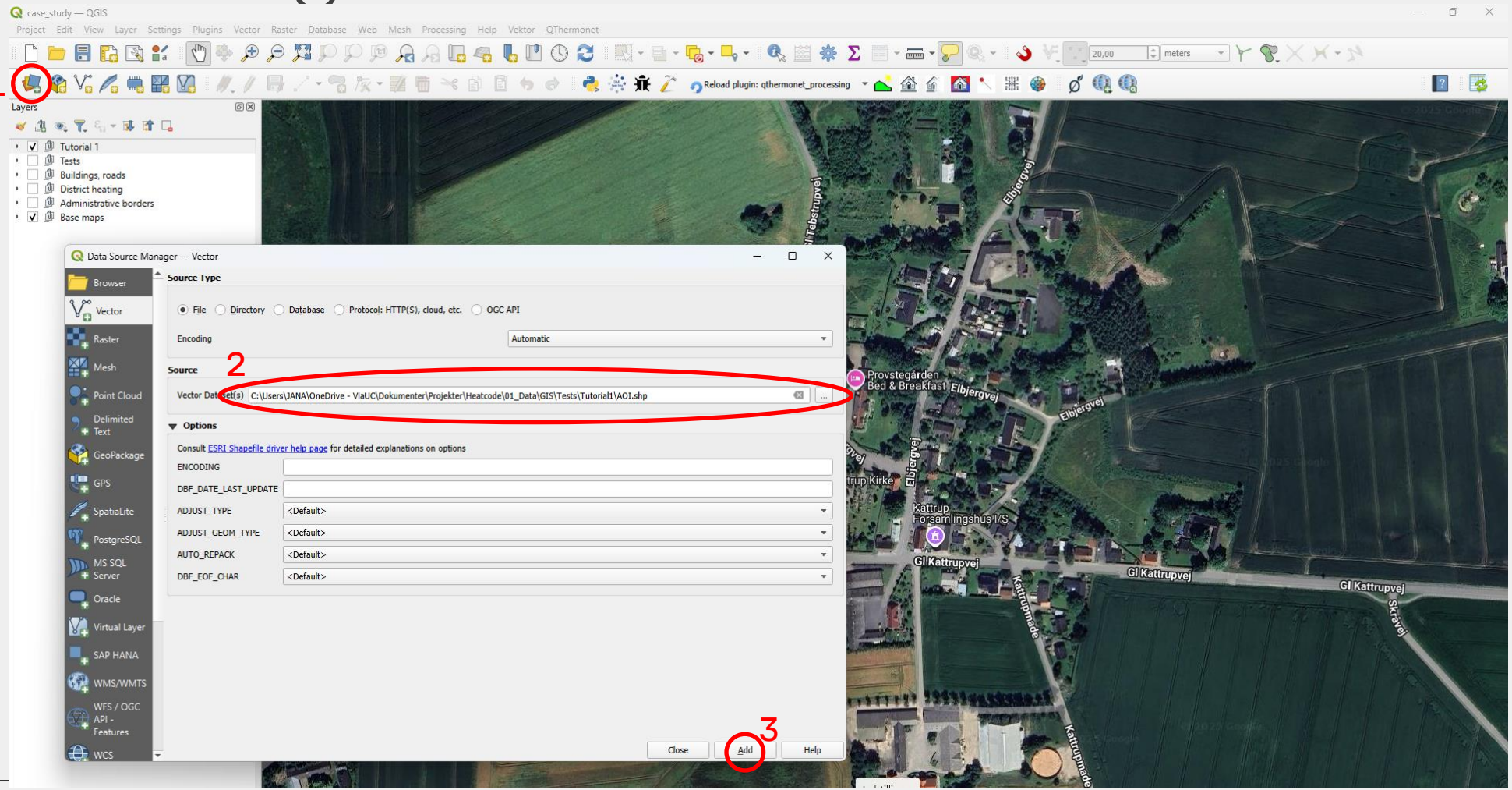


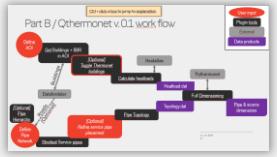
Click to return to overview



Part B1 / Buildings and heat loads 1

We define the area of interest (AOI) for a potential thermonet in the eastern part of Kattrup using a single polygon in a shapefile/geojson file.





Part B1 / Buildings and heat loads 1

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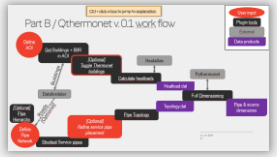
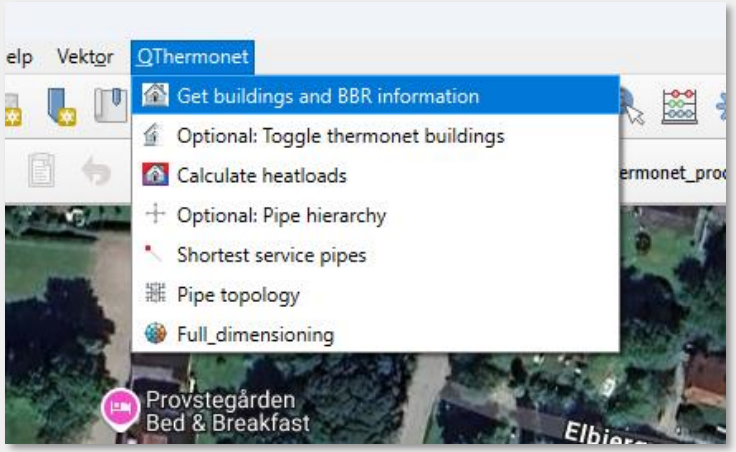
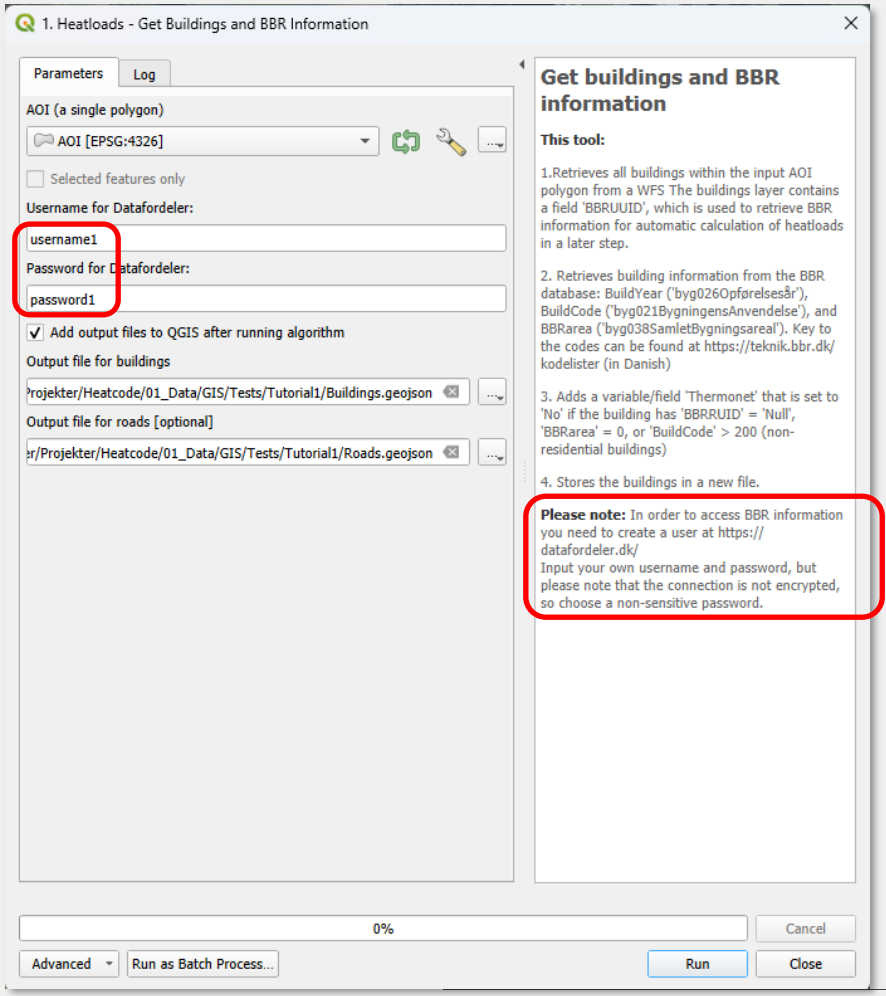


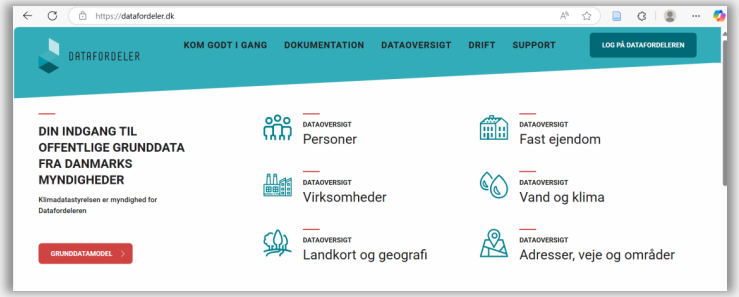
Part B1 / Buildings and heat loads 2

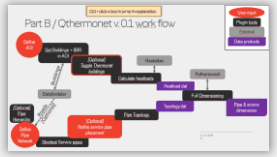
Using the first tool in the QThermonet plugin: "*Get Buildings and BBR information*" we retrieve the buildings (and roads) within our AOI and the BBR information of the buildings (Total Area, Building Code, Construction Year).





Running the tool requires a username and password for datafordeler.dk ([Instructions to set up a user](#))



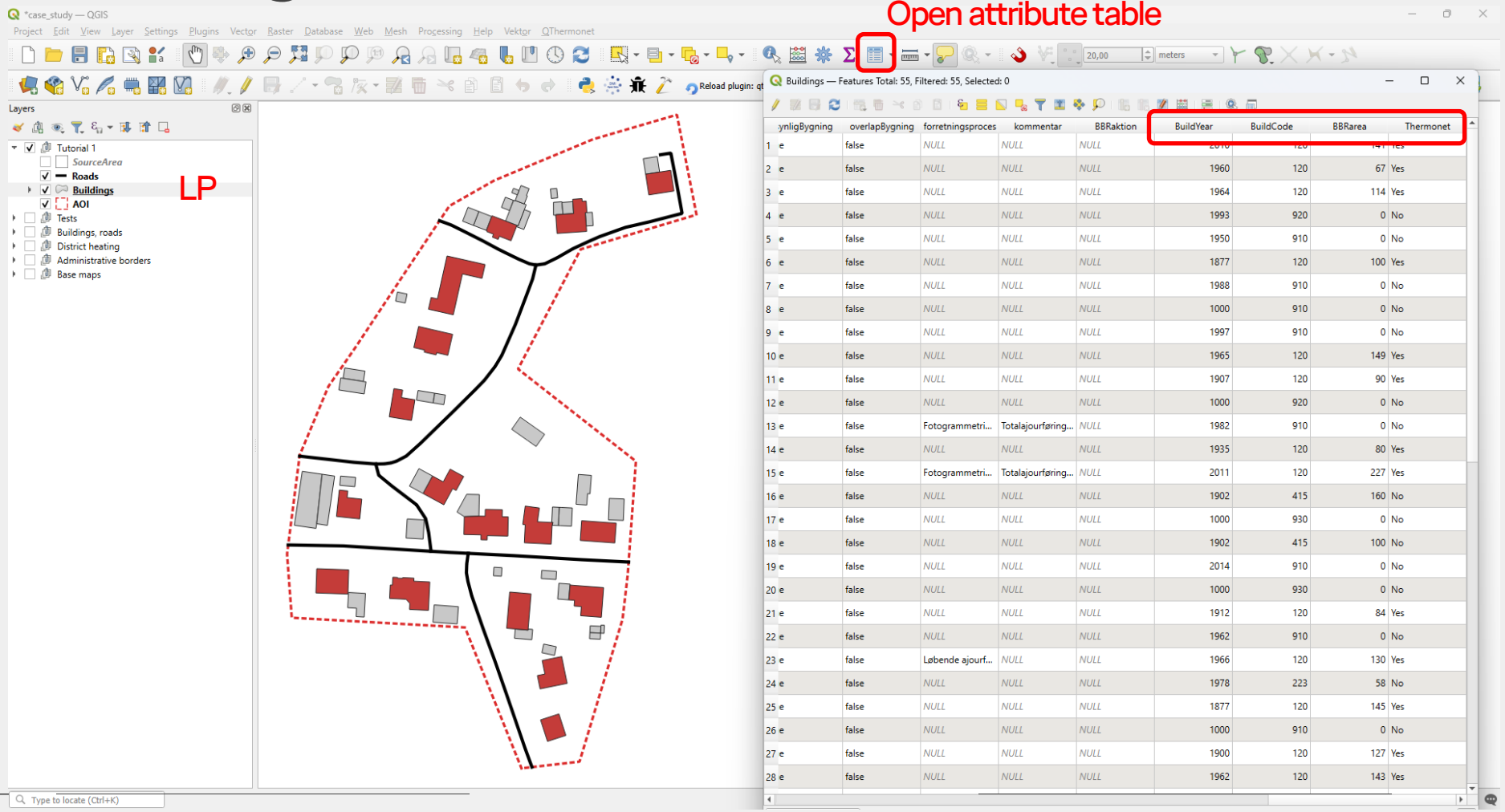


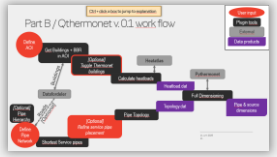
Part B1 / Buildings and heat loads 2

After running the tool, buildings (+ optionally roads) within the AOI are loaded into the layers panel (LP) of QGIS.

The 'Buildings' table can be inspected using the 'Open attribute table'.

The attribute table contains the data retrieved from datafordelen + three columns from the BBR database + a column called 'Thermonet'





Part B1 / Buildings and heat loads 2

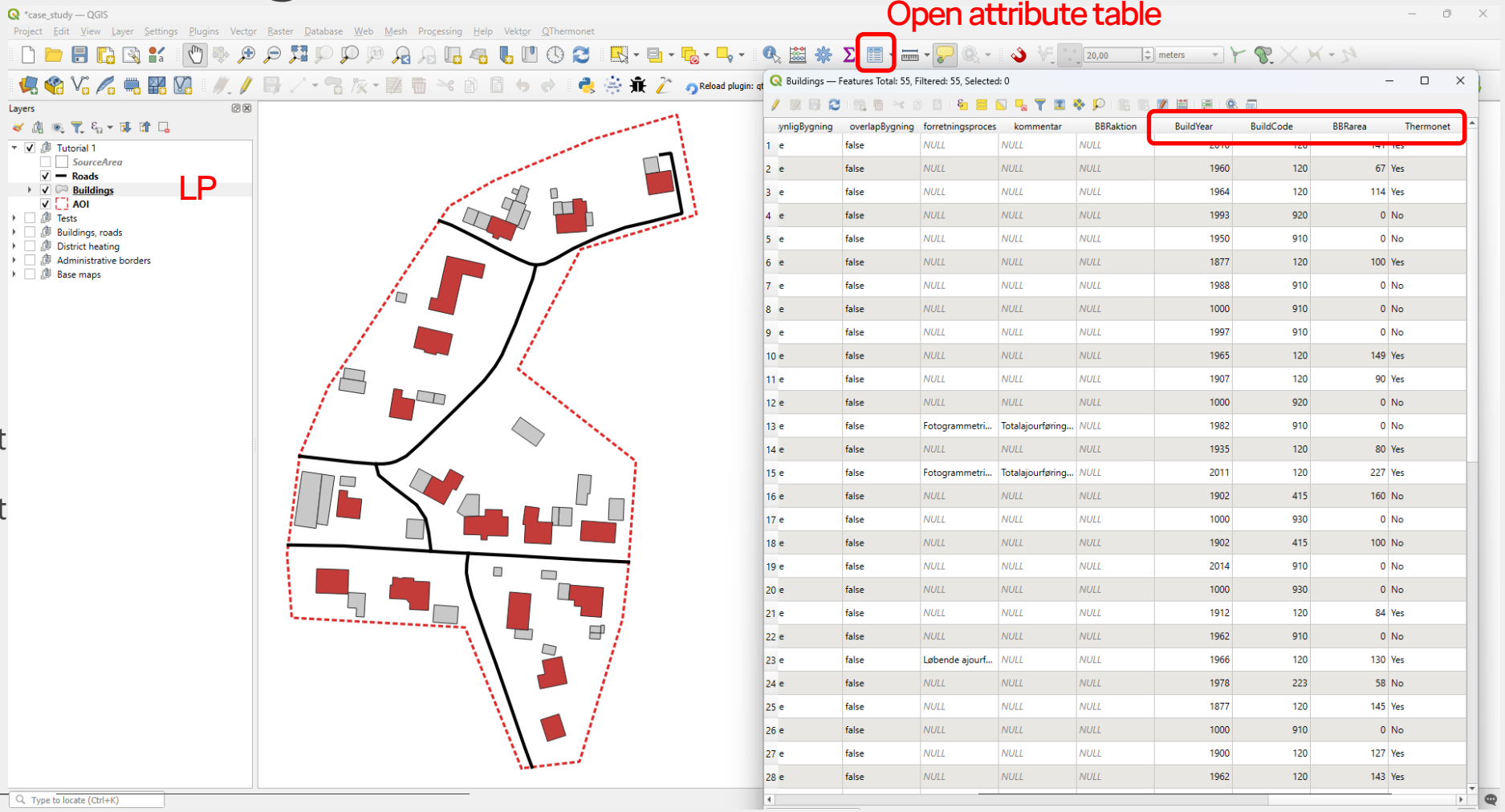
BuildYear: Construction year of the building.

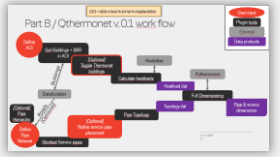
BuildCode: Type of building (residential/industry etc), see codelist here (in Danish): [Kodelister - BBR Teknik]

BBRarea: Total area of the building (including potential multiple floors)

Thermonet: This column controls whether a building is included in the heat load calculation and connected to the thermonet or not. A building is by default included (set to 'Yes') if it has a BBRUUID, an area >0, and a BuildCode < 200 (residential).

Buildings in red on the map have Thermonet = 'Yes'



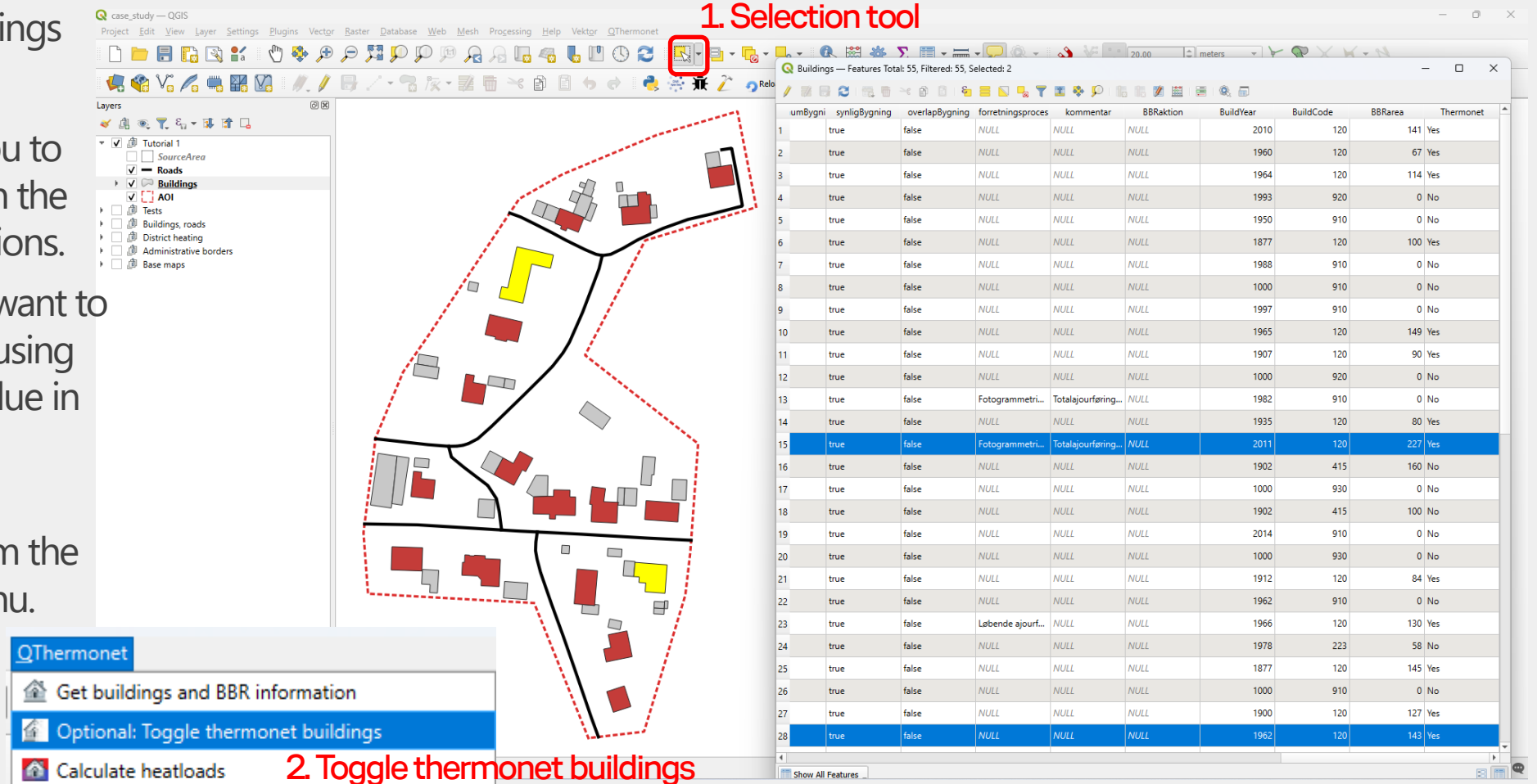


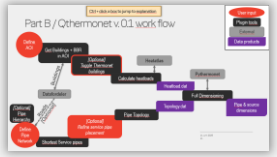
Part B1 / Buildings and heat loads 3

Optional: Toggle thermonet buildings

This is a helper tool that allows you to easily include/exclude buildings in the heat load and thermonet calculations.

1. Select the buildings that you want to toggle on/off the thermonet using the selection tool (they turn blue in the attribute table).
2. Open the 'Optional: Toggle thermonet buildings' tool from the QThermonet drop-down menu.

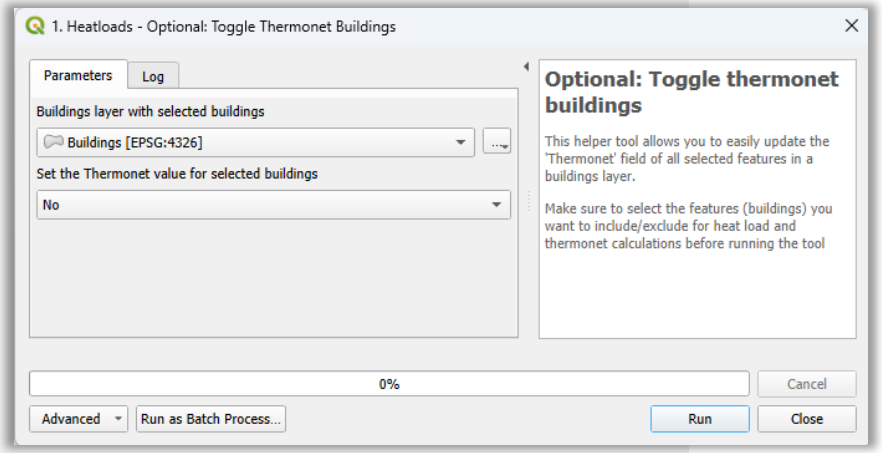


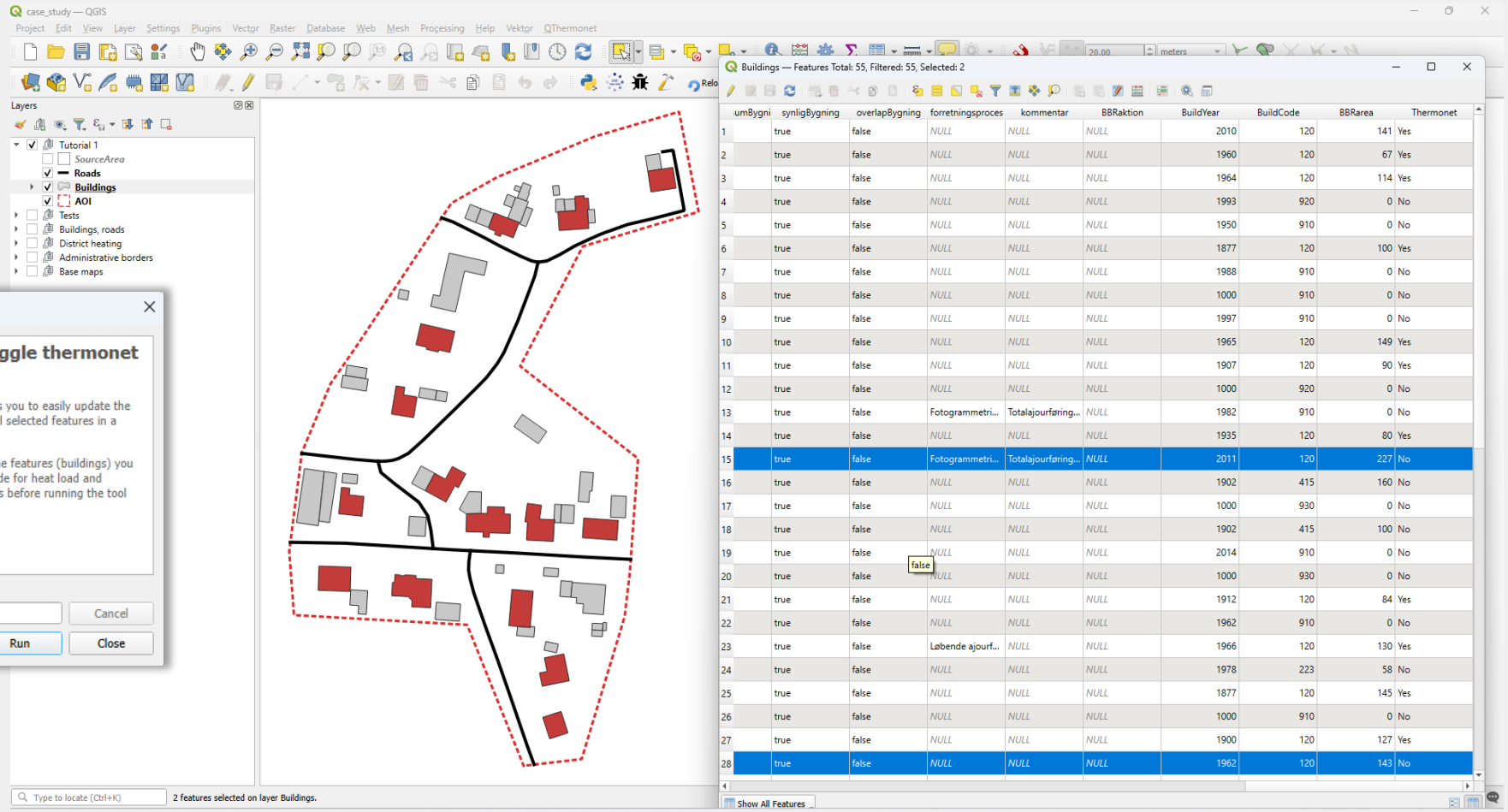


Part B1 / Buildings and heat loads 3

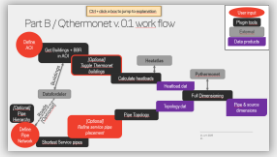
Optional: Toggle thermonet buildings

3. Run the tool to toggle off the selected buildings (sets 'Thermonet' to 'No').





Alternative: Update the attribute table directly.

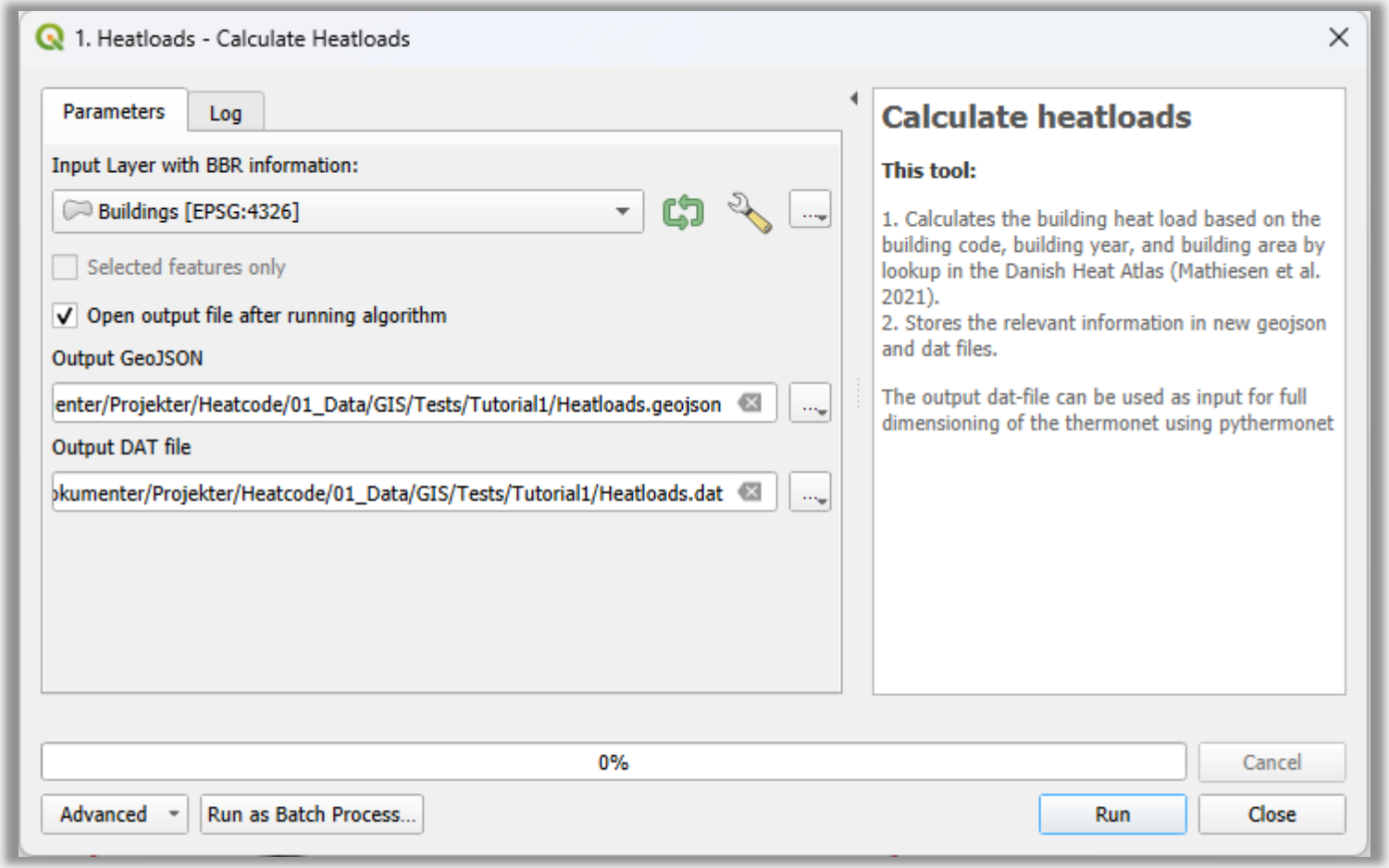


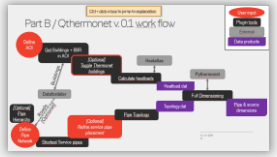
Part B1 / Buildings and heat loads 4

Calculate Heatloads

This tool calculates annual, winter, and maximum daily heatload for a building based on the BBR information.

Creates the heatload input file (.dat) for running pythermonet dimensioning





Part B1 / Buildings and heat loads 4

Calculate Heatloads

- The tool looks up the annual heat load (kWh/m2) for each building in the thermonet based on table look-up in the Danish Heat Atlas (2019)
- Multiplies by building area to get total load.
- For now, multiplies by a fixed factor to get winter/peak daily heat load:

Multiplication factors:

Winter heat load = 1.6 x annual heat load

Daily heat load = 3.2 x winter heat load

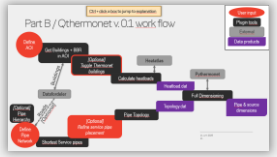
Specifikt årligt varmeforbrug i kWh/m² for forskellige bygningsanvendelseskoder samt alderskategorier.

Construction year

Building Codes

Anvendelse	<1850	1850-1930	1931-1950	1951-1960	1961-1972	1973-1978	1979-1998	1999-2006	2007<
110	137	156	173	179	138	126	115	106	82
120	152	185	197	163	123	110	97	82	65
121	152	185	197	163	123	110	97	82	65
130	170	180	192	172	130	112	80	69	67
131	170	180	192	172	130	112	80	69	67
132	170	180	192	172	130	112	80	69	67
140	143	139	144	148	117	116	84	76	68
150	182	177	164	141	128	180	122	111	86
160	249	206	171	186	153	143	125	112	82
185	142	172	196	155	151	131	106	74	83
190	142	172	196	155	151	131	106	74	83
210	215	244	235	190	198	192	157	166	148
211	0	0	0	0	0	0	0	0	0
212	0	0	0	0	0	0	0	0	0

Mathiesen, B. V., Lund, H., Nielsen, S., Sorknæs, P., Moreno, D., & Thellufsen, J. Z. (2021). *Varmeplan Danmark 2021 - Baggrundsrapport*. Aalborg Universitet.



Part B1 / Buildings and heat loads 4

Calculate Heatloads

Note: for now, the cooling loads are set to 0

Heatloads.dat

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Heat_pump_ID	Yearly_heating_load_(W)	Winter_heating_load_(W)	Daily_heating_load_(W)	Year_COP	Winter_COP	Hour_COP	dT_HP_Heating	Yearly_cooling_load_(W)	Summer_cooling_load_(W)	Daily_cooling_load_(W)	EER	dT_HP_Cooling
1038035605	1046	1673	5354	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038035696	1246	1993	6378	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038035704	1600	2559	8189	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038035713	2110	3377	10806	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038035720	2091	3345	10704	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038035794	1899	3039	9725	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1038037287	1798	2877	9206	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1081328666	1773	2836	9075	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1081356087	1824	2919	9341	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1081363287	3060	4896	15667	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1081376105	2680	4288	13722	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1081382535	2258	3613	11562	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1090189622	1604	2566	8211	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1102801346	2279	3647	11670	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0
1210916157	1333	2133	6826	3.3	3.4	3.0	3.0	0	0	0	0.0	0.0

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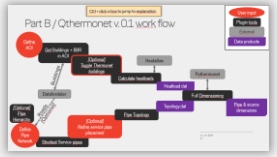


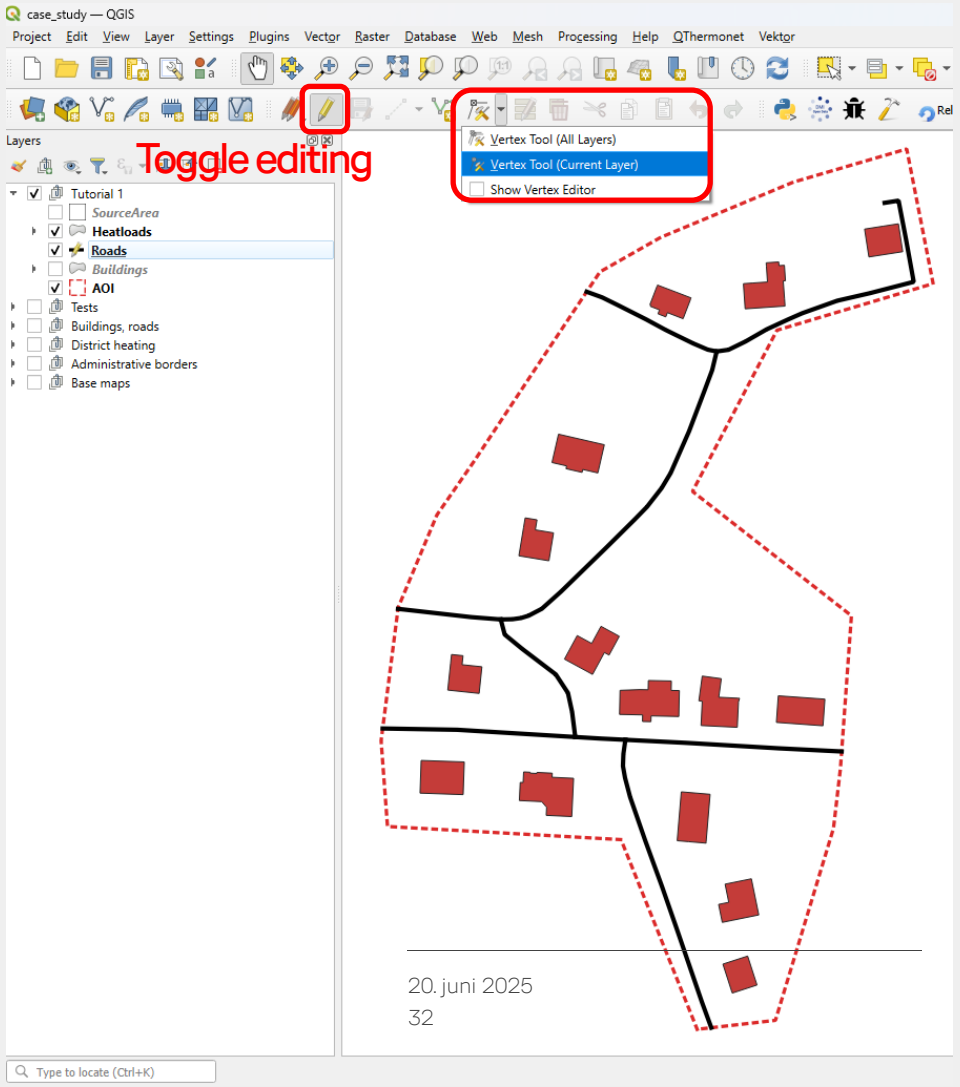
Part B2 / Thermonet pipe layout 1

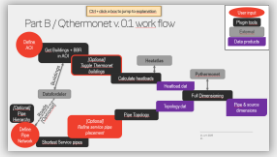
Define pipe network

In this step we will modify the roads network retrieved from the tool "Get buildings and BBR information" to define the main pipe network for our thermonet.

Please note that the pipe network needs to have a **tree structure** (i.e. no loops) in order to work.

To modify the network click the 'Toggle editing' button in QGIS and use the 'Vertex Tool (current layer)'.





Part B2 / Thermonet pipe layout 1

Define pipe network

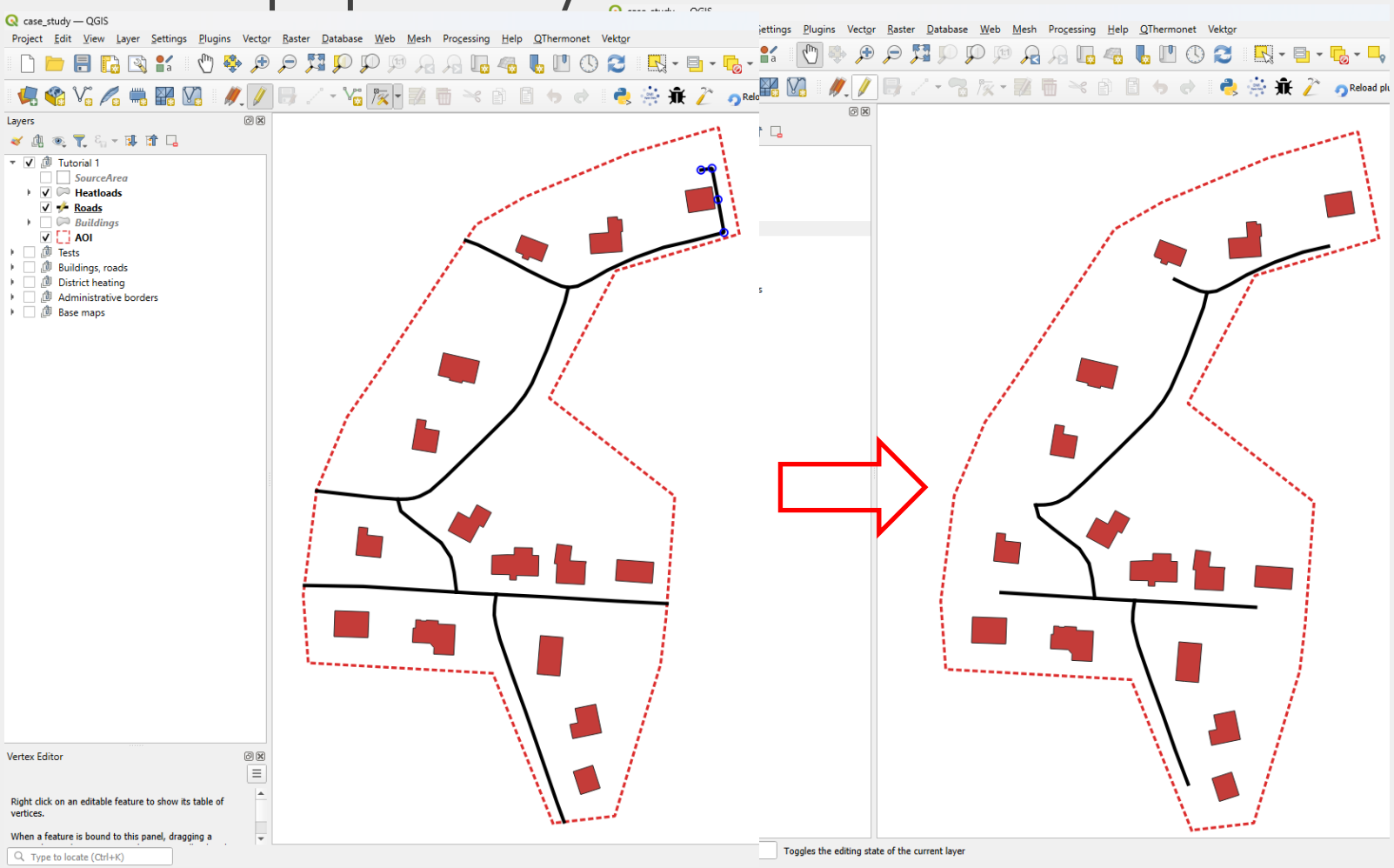
With the vertex tool selected, you can click, drag or delete vertices of the road network.

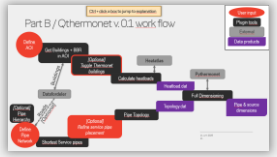
Remove unnecessary road segments to create your main pipe network.

Don't connect the houses to the network yet!

Save your edits and toggle off the layer by clicking the button again.

Note: Your pipe network does not need to follow existing road network, you can draw your own network e.g. in places where it would be cheaper to dig.

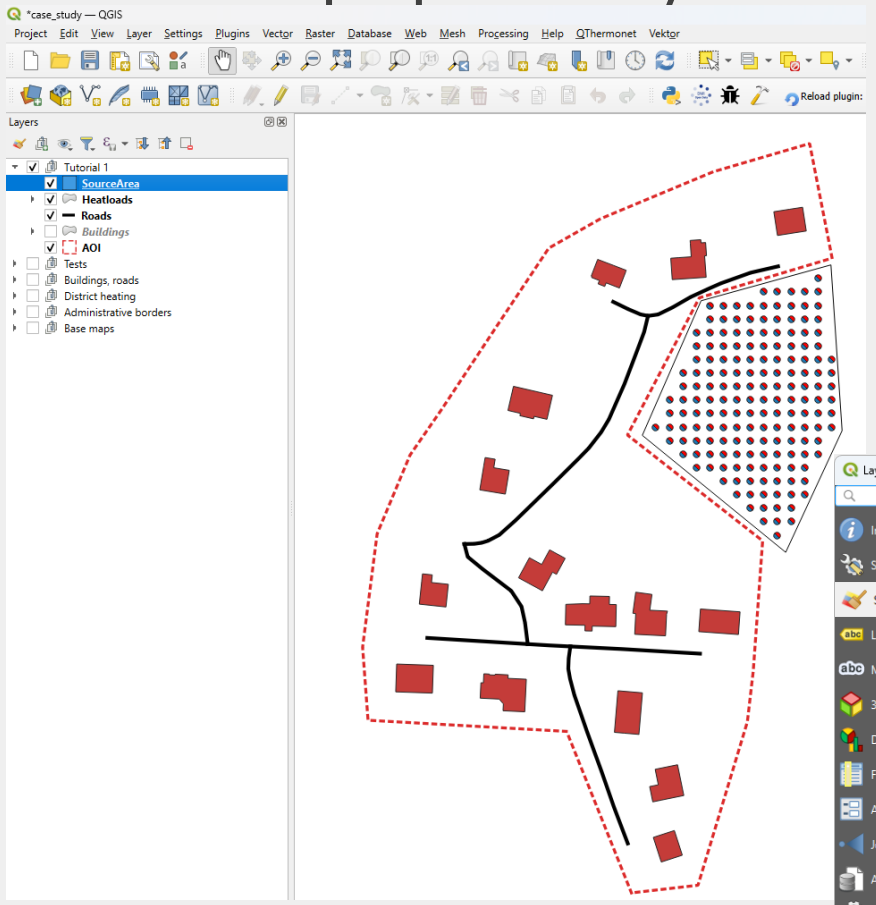


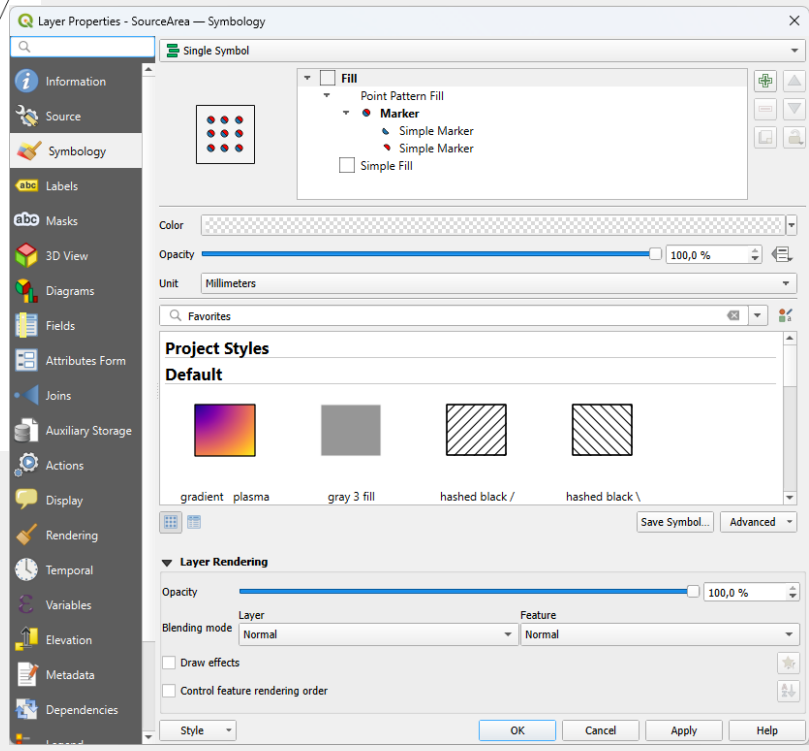


Part B2 / Thermonet pipe layout 2

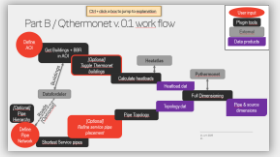
Pipe Hierarchy

- To define the pipes hierarchy (main/periferal pipes) you need to decide on the location of your source area (location of borefield or horizontal heat exchangers).
- Load the 'SourceArea.shp' file into QGIS using the data source manager like you did for the AOI (link). The source area is defined as a single polygon.
- *Optional:* set the style of the layer by double-clicking the layer and changing the 'symbology'.



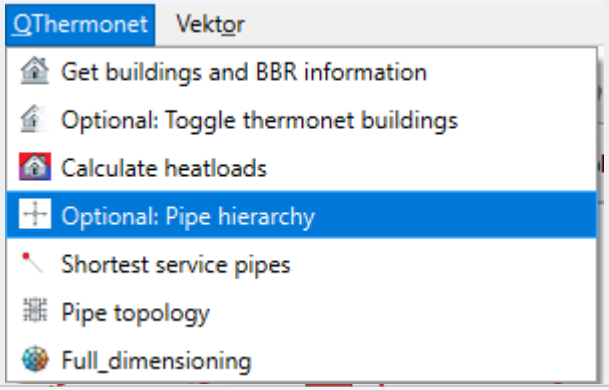


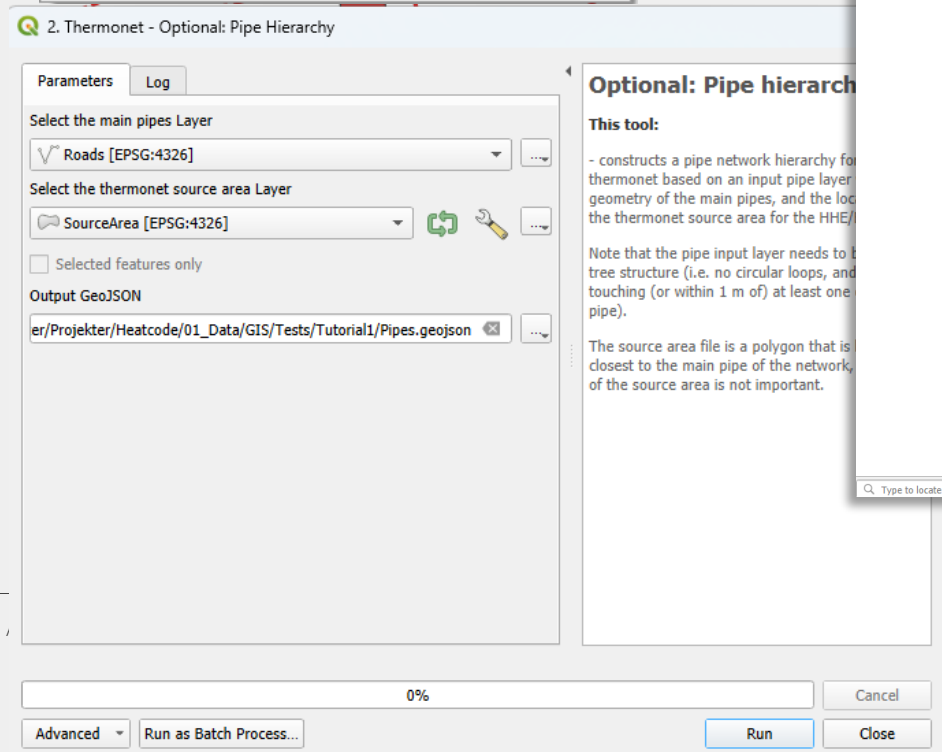
Part B2 / Thermonet pipe layout 2

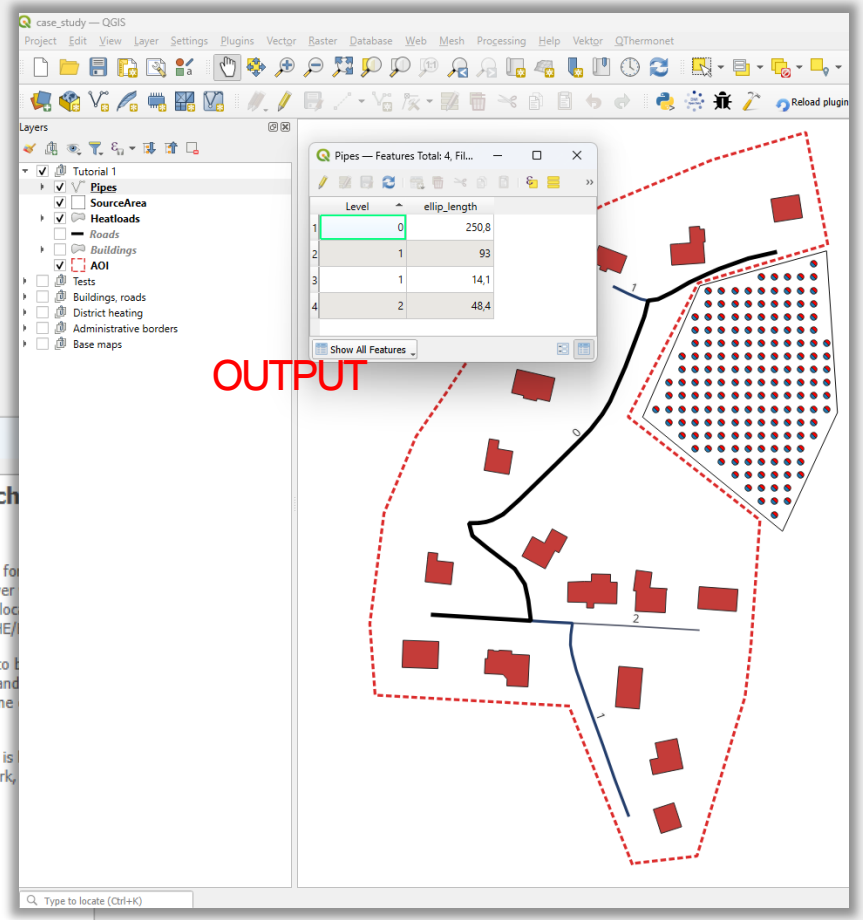


Pipe Hierarchy

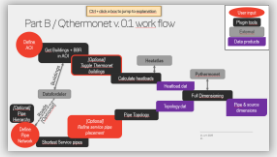
- Next, run the 'Optional: Pipe hierarchy' tool from the Qthermonet plugin menu.
- The tool creates a new output layer ('Pipes') that contains a field 'Level'
- The highest level ("0") is assigned to the main pipe closest to the sourceArea, branching pipes are assigned gradually lower levels ("+1")
- *Note: Alternatively the pipe level field can be added and populated manually in the attribute table of the roads file*







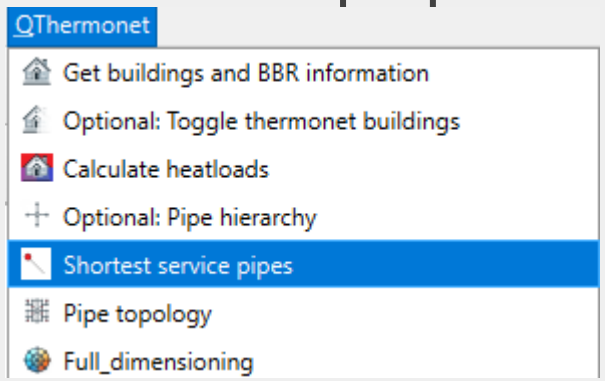
Part B2 / Thermonet pipe layout 3

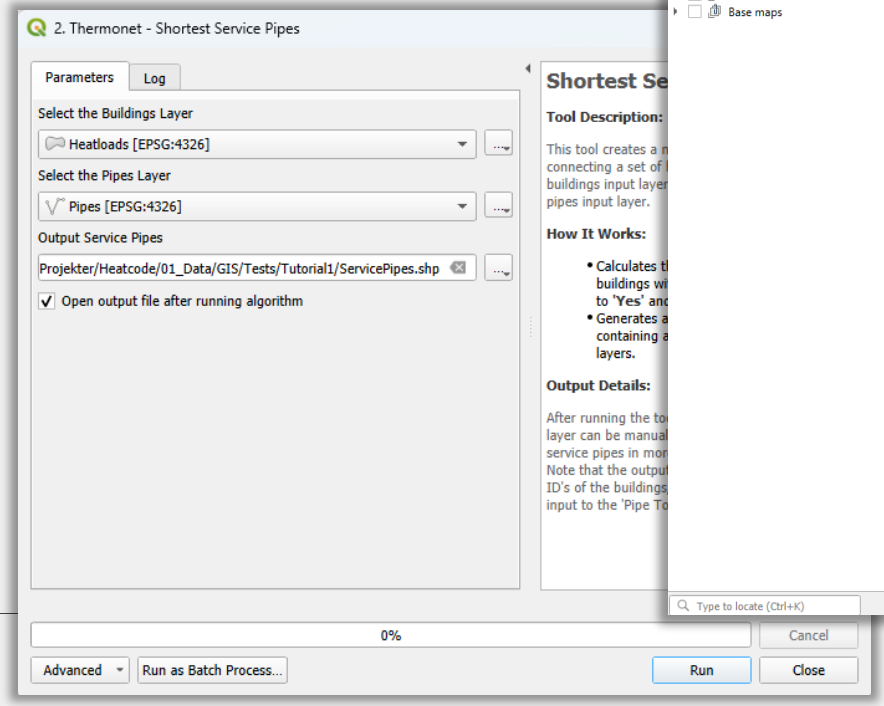


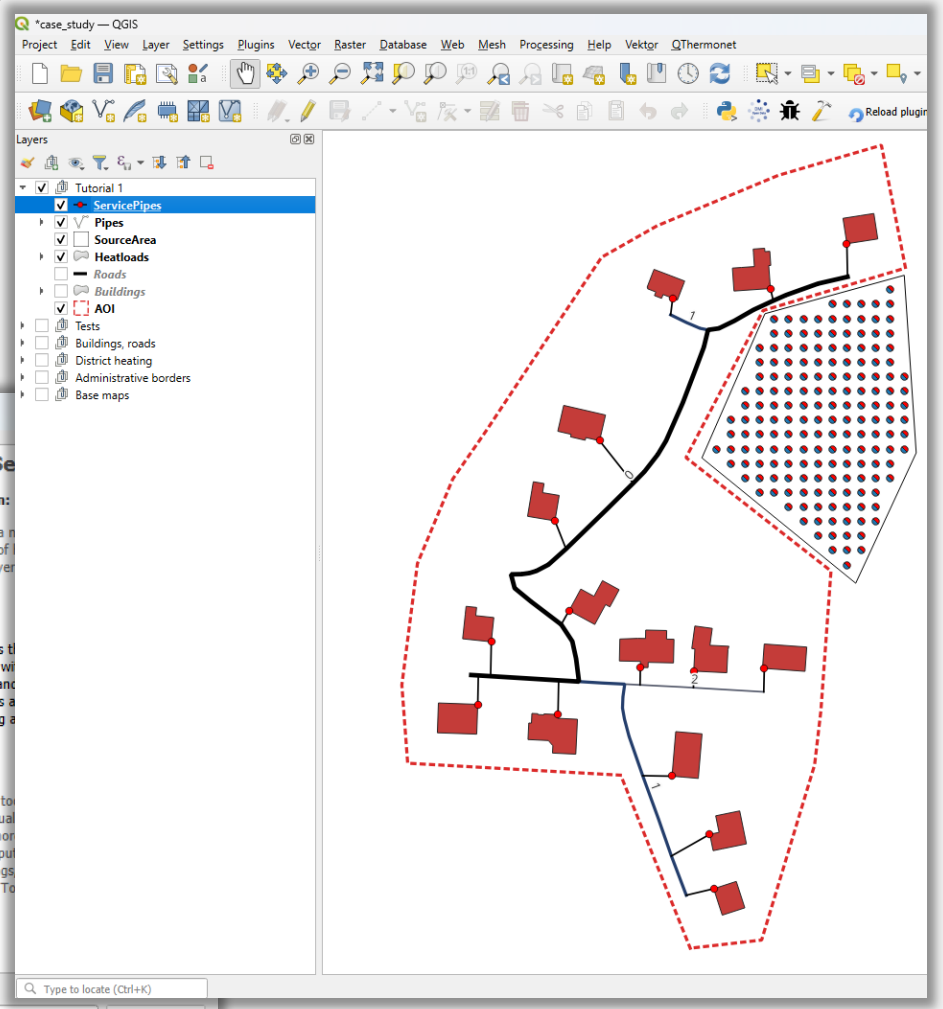
Shortest service pipes

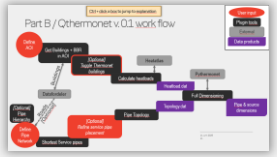
Now the main pipe network is complete, and it is time to combine the houses/ heatpumps to the network with service pipes.

- The tool 'Shortest service pipes' will create a new layer with service pipes connecting each house with the closest pipe segment.
- The output ServicePipes layer contains one line segment for each service pipe illustrated with a red dot at the location of the heatpump and a black line connecting to the main pipe network.
- Optional: The exact location of the service pipe can be refined by setting the ServicePipes layer in 'Toggle editing' mode and using the 'Vertex tool (current layer)' as was done for the main pipes layer (link)









Part B2 / Thermonet pipe layout 3

Shortest service pipes

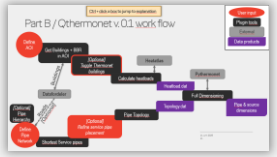
Note that the attribute table of the shortest service pipes layer contain the information from both the heatpumps/houses (BBR, heatloads, heatpump ID (id.lokalId) and the main pipe network (Level).

They therefore tie together the information from step B1 and B2 in this tutorial and provide the link between the thermonet and the heatload.

ServicePipes — Features Total: 15, Filtered: 15, Selected: 0

	id.lokalId	BBRUUID	Thermonet	BuildYear	BuildCode	BBRarea	YrHeatLoad	WiHeatLoad	DyHeatLoad	ellip_leng	Level
1	1038035605	51470dc8-234b...	Yes	2010	120	141	1046	1673	5354	250,8	0
2	1038035704	fd22b5df-899e-...	Yes	1964	120	114	1600	2559	8189	250,8	0
3	1038035720	a8d1ab6e-ab8a...	Yes	1965	120	149	2091	3345	10704	250,8	0
4	1038035794	a54d4ee1-7a4b...	Yes	1907	120	90	1899	3039	9725	250,8	0
5	1038037287	06b8614e-6b3a...	Yes	1935	120	80	1798	2877	9206	250,8	0
6	1081328666	60b99ac4-001f-...	Yes	1912	120	84	1773	2836	9075	250,8	0
7	1081376105	f373a98d-ec53-...	Yes	1900	120	127	2680	4288	13722	250,8	0
8	1102801346	2fdd2ca3-7621...	Yes	1877	120	108	2279	3647	11670	250,8	0
9	1038035696	65398663-c62b...	Yes	1960	120	67	1246	1993	6378	93,0	1
10	1081356087	a6352e9f-2619-...	Yes	1966	120	130	1824	2919	9341	93,0	1
11	1090189622	8e6e9de3-0da6...	Yes	1880	120	76	1604	2566	8211	14,1	1
12	1210916157	e571f5ad-b8ca-...	Yes	1962	120	95	1333	2133	6826	93,0	1
13	1038035713	bc8f1dea-3cd1-...	Yes	1877	120	100	2110	3377	10806	48,4	2
14	1081363287	96a92f8a-4eb2-...	Yes	1877	120	145	3060	4896	15667	48,4	2
15	1081382535	3b842d62-c414...	Yes	1877	120	107	2258	3613	11562	48,4	2

Show All Features

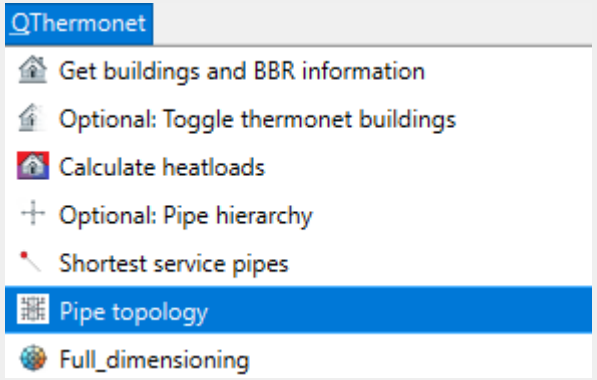


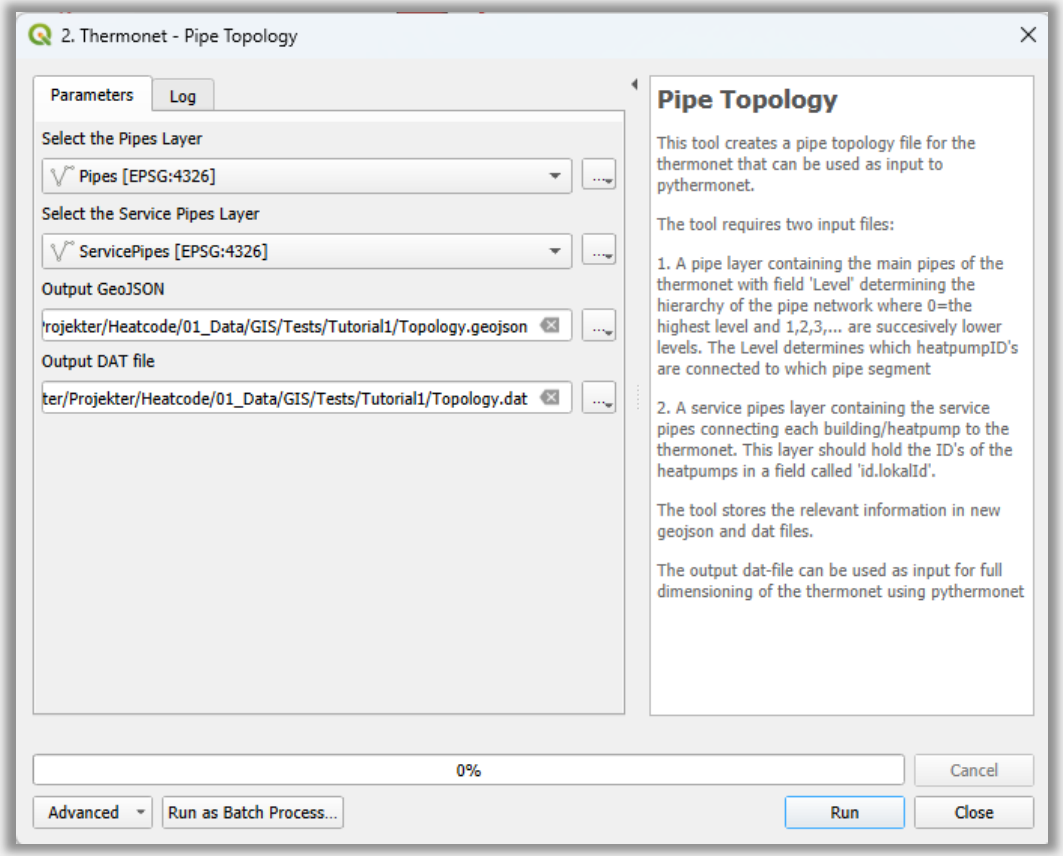
Part B2 / Thermonet pipe layout 4

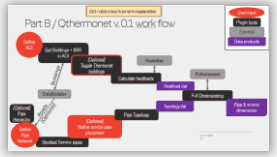
Pipe Topology

The pipe topology tool combines the pipe network and the service pipe network (that contains the handles/IDs of the heatpumps).

The tool generates the Topology.dat file which is a required input for the thermonet dimensioning.







Part B2 / Thermonet pipe layout 4

Pipe Topology

Output of the pipe topology tool.

*Note: for now, the SDR is set to 17 and the pressure loss to 180*Trace_length by default.*

Topology.dat

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Section SDR	Trace_(m)	Number_of_traces	Max_pressure_loss_(Pa)	HP_ID_vector
Service_pipe_1	17	18.79	1	3383	1038035605
Service_pipe_2	17	9.79	1	1761	1038035696
Service_pipe_3	17	10.04	1	1807	1038035704
Service_pipe_4	17	8.15	1	1466	1038035713
Service_pipe_5	17	11.88	1	2139	1038035720
Service_pipe_6	17	11.93	1	2147	1038035794
Service_pipe_7	17	10.47	1	1884	1038037287
Service_pipe_8	17	11.49	1	2068	1081328666
Service_pipe_9	17	10.18	1	1833	1081356087
Service_pipe_10	17	6.06	1	1091	1081363287
Service_pipe_11	17	5.56	1	1002	1081376105
Service_pipe_12	17	5.76	1	1036	1081382535
Service_pipe_13	17	5.80	1	1043	1090189622
Service_pipe_14	17	4.33	1	780	1102801346
Service_pipe_15	17	15.33	1	2759	1210916157
Pipe_branch_1	17	48.40	1	8712	1038035713, 1081363287, 1081382535
Pipe_branch_2	17	93.00	1	16740	1038035696, 1038035713, 1081356087, 1081363287, 1081382535, 1210916157
Pipe_branch_3	17	14.07	1	2532	1090189622
Pipe_branch_4	17	250.81	1	45146	1038035605, 1038035696, 1038035704, 1038035713, 1038035720, 1038035794, 1038037287, 1081328666, 1081356087, 1081363287, 1081376105, 1081382535, 1090189622, 1102801346, 1210916157

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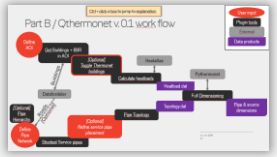
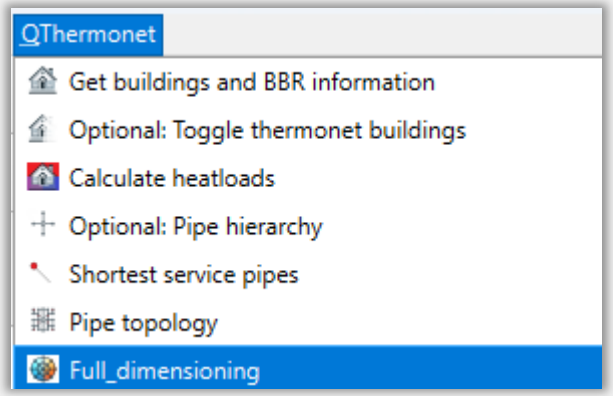


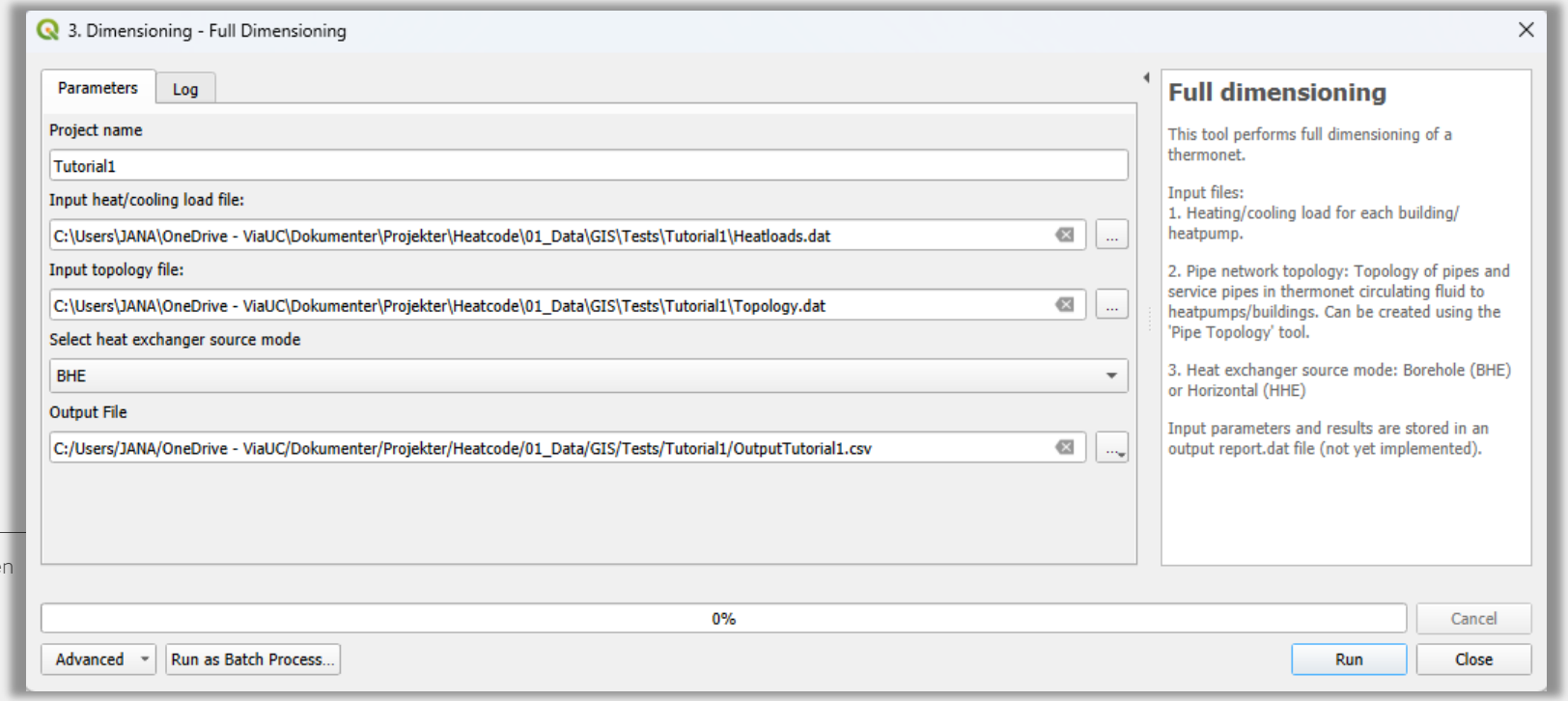
Part B3 / Full dimensioning 1

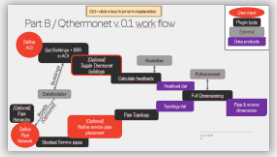
To perform thermonet dimensioning open the Full_dimensioning tool

- Input the Heatloads.dat file created in part B1, and the Topoplogy.dat file created in Part B2.
- Select either Borehole Heat Exchanger (BHE) or Horizontal Heat Exchanger (HHE) source mode.

Note: The output file is not currently used – output is written to the Python Console in QGIS.





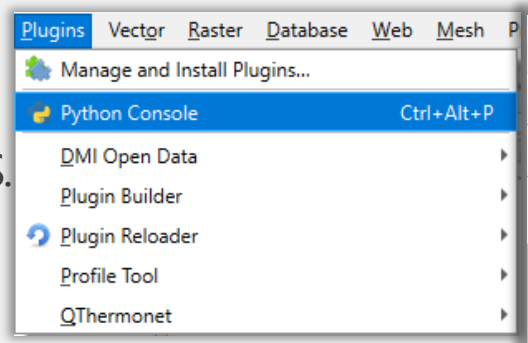


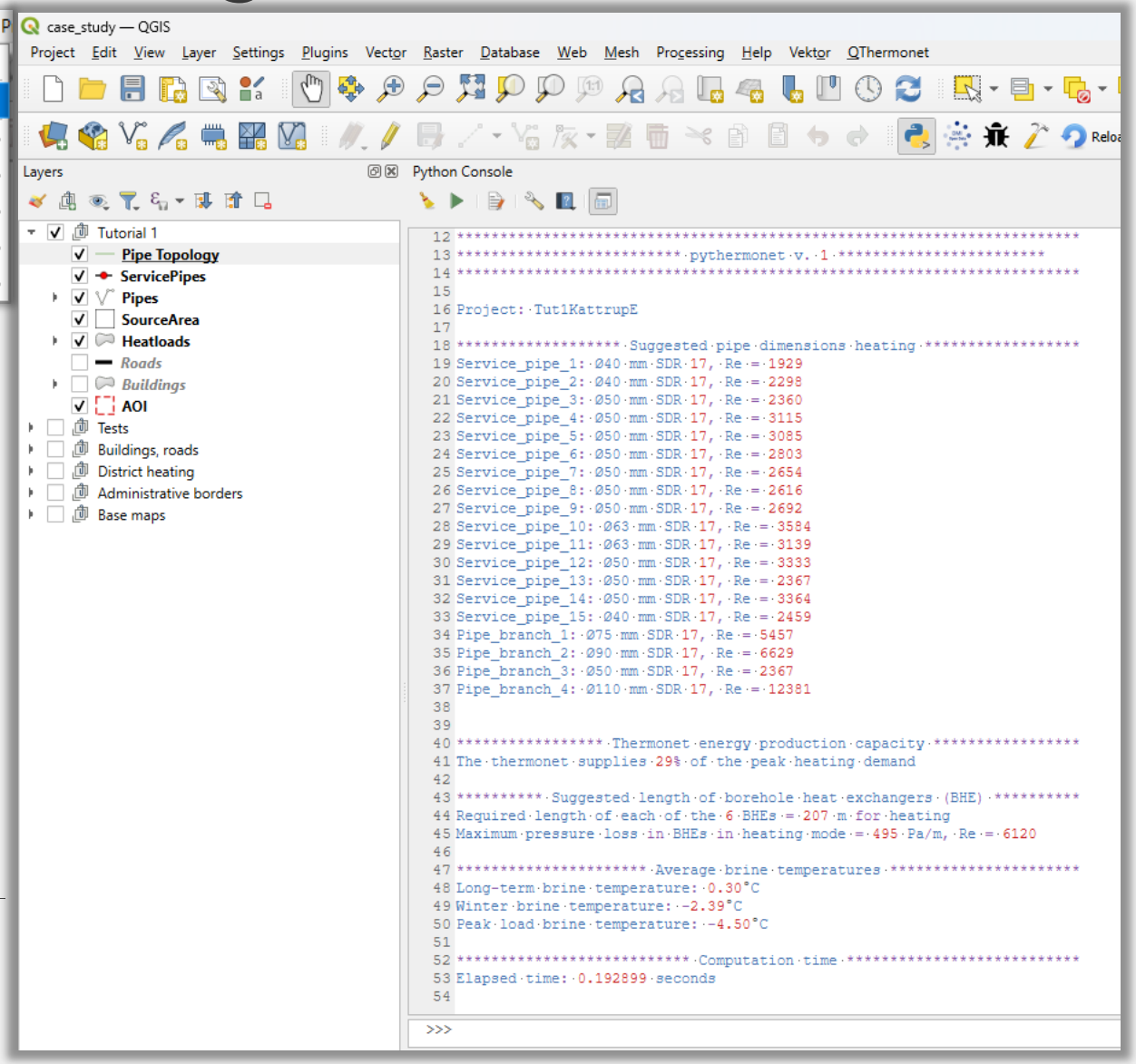
Part B3 / Full dimensioning 2

After running the tool, the output is written to the Python Console in QGIS.

The output contains:

1. The suggested pipe dimensions for heating.
2. The percent of total peak demand covered by the pipe network constituting the thermonet (without source area)
3. The dimensions of the thermonet source (BHE/HHE pipe length)
4. Average brine temperatures
5. Computation time





Plugin development plans

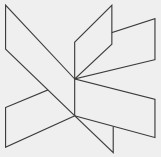
- Write output to a file - including the parameters + assumptions used in the thermonet dimensioning.
- Tailor (separate) json output to Modelica/Alessandro…
- More advanced input handling to allow setting more of the dimensioning parameters directly from QGIS.
- Optimize code (documentation, speed)
- Enable more sophisticated handling of winter/daily and total heatload calculations (EnergyPlus?)
- Easy adjustment of building parameters for individual buildings
- Coupling with GEUS database/tool for calculation of thermal resistivity (calibrated with TRT results).
- Enable multiple heat sources (e.g. waste heat / LEG-DHC), seasonal demand/supply, balancing thermonet
- Enable different configurations (Now: tree structure, single borefield)
- Link to GHEDesigner for automatic /optimized borehole locations within borefield
- Educational/display of existing thermonets
- …

Bring ideas to life
VIA University College

If you need any assistance, please contact:

jana@via.dk

Bring ideas to life
VIA University College



QThermonet

A thermonet dimensioning tool for QGIS