# Southern City Gate / Budapest South Gate

## District heating and cooling integrated to a large scale city development

**Ákos Murin, QPLAN Kft.**

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# Introduction – the project and why it is interesting

A complete remodeling is planned in the southern part of Budapest – the name of the project is Southern City Gate / Budapest South Gate.

As it is a complex city development, various aspects of the area are designed. One of these is district heating and cooling – in which we have a small part.

He we'd like to show some parts of this project, including the district heating and cooling.

Although heat pumps are exciting alone as well – especially for the experts who design them, it is a much greater challenge to properly integrate them with the consumers, especially if it is not a technology with stable temperatures and heat loads, but a dynamically changing environment – and that is exactly why we think that this project is interesting.

# Introduction – the project and why it is interesting

When supplying heat and cold energy to the buildings, it should be borne in mind that according to TNM Decree 7/2006 (V.24.) 25% of the total energy performance of the building must come from renewable energy, which in connection with heating in most cases means that min. 40% renewables should be ensured in the peak heating performance provided that no other renewable resources are used in the buildings (solar panel, direct cooling, etc.).

# Introduction – the project and why it is interesting

The structure of this presentation is, that after a general introduction, we will first present the project's general aspects and after that will focus step-by-step towards the district heating and cooling. At the end if I have the time, I'll show some more nice aspects of the project.

Notes:

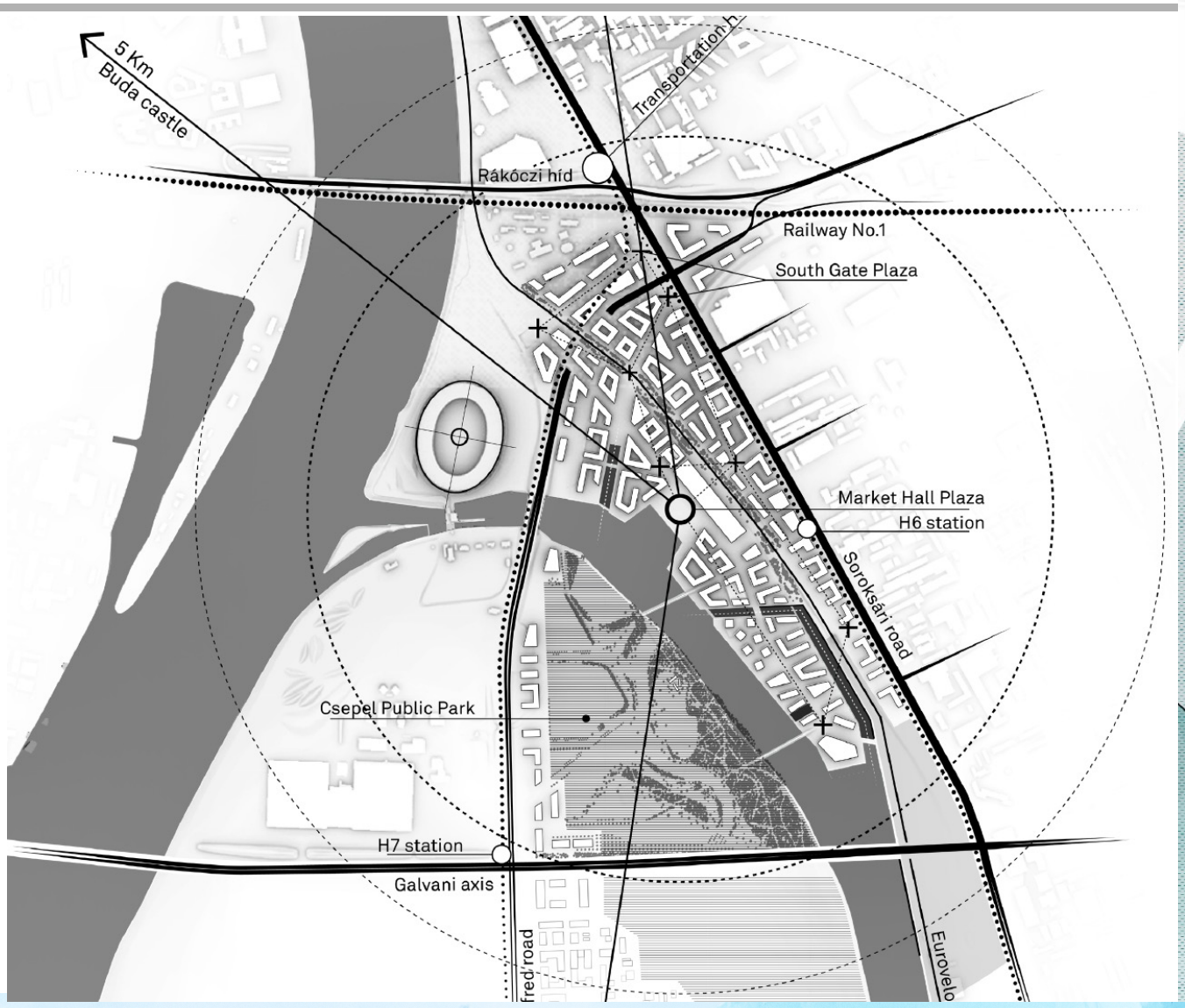
- Many of the details will not fit into the time frame allocated for the presenter but might be revisited by anyone interested.
- I am really excited about this project, so I've included many aspects, especially the environment related parts.

# Introduction - area

# Introduction – the area

The next slides show the general area, for which the complex plans are prepared.

# Introduction - area

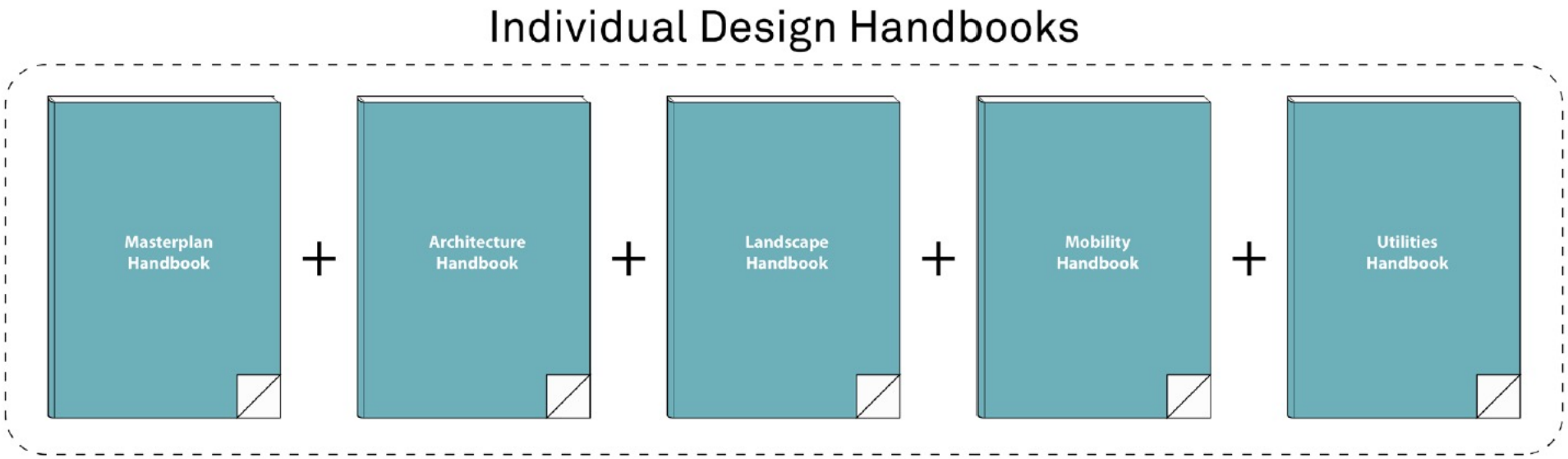



# Introduction - area

1 Wholesale Market Hall
2 Wholesale Market Hall plaza
3 public swimming pool
4 green spine / linear park
5 floating platform
6 green plaza
7 pedestrian bridge
8 new artificial canal
9 park pavilion
10 wooded area
11 wetland
12 urban gardens
13 sport facilities
14 club house
15 Ráckevei (Soroksári)-Duná channel
16 cultural center
17 rowing course start area
18 old train station
19 Athletic Arena main entrance
20 South Gate plaza
21 Athletic Arena
22 Warm up fields
23 Ráckevei (Soroksári)-Duná bridge
24 Kvassay flyover
25 Kvassay bridge
26 new Danube bridge
27 Kvassay dam
28 Rákóczi Bridge
29 Müpa Budapest
30 National Theatre
H7 speed train station
H6 speed train station
No.1 railway line
dock

# Complex design

A wonderful aspect of this project is, that many / all aspects are thought after and designed not just with functionality, but with the environment in mind as well.



# Complex design

City and Water

the New Budapest Parks

South Gate Urban Landscape

# Complex design – green aspects


1. Green plaza
2. Park Pavillion
3. Sport Facilities
4. Club House
5. Wooded Area
6. Forest Deck Path
7. Biotope / Wetland
8. Clearing
9. Storm water swales / Trench
10. Urban Gardens
11. Urban boulevard
12. Pedestrian bridge

# Execution Phases

There are nine planned execution phases – these will be presented in the following slides briefly.

Please note, that not all phases are heat-pump relevant, nevertheless they have their own slides in order to keep the numbering consistent.

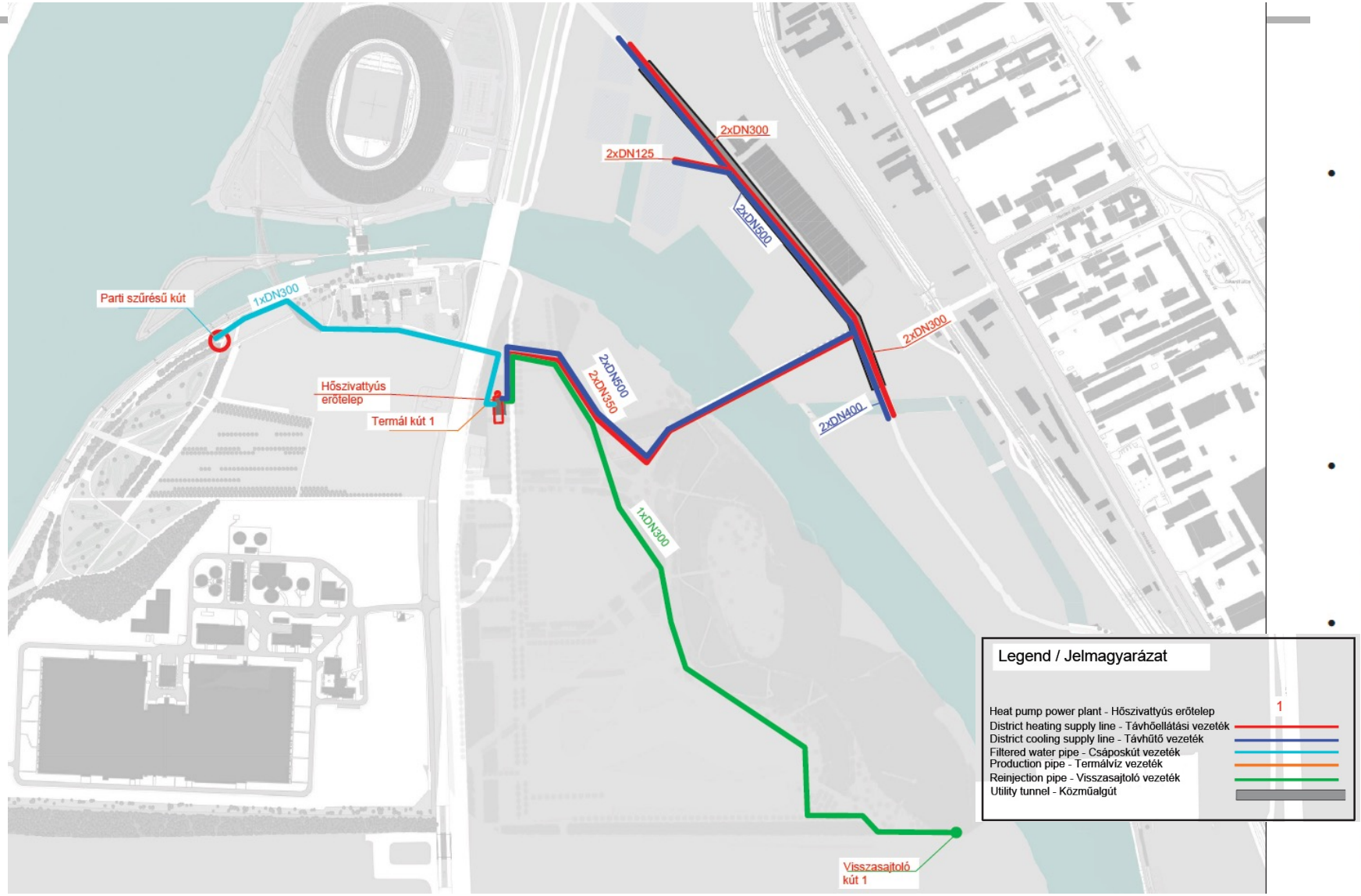
These drawings only show the final result of a complex analysis.

For cooling operation, river-bank filtered cold water is used for direct cooling as well as the heat sink of the heat pump.

For heating purposes, the heat pump uses thermal wells as heat source and these thermal wells are used for direct heating as well.

In a later phase optionally treater wastewater is used as well as heat source / sink for the heat pump.

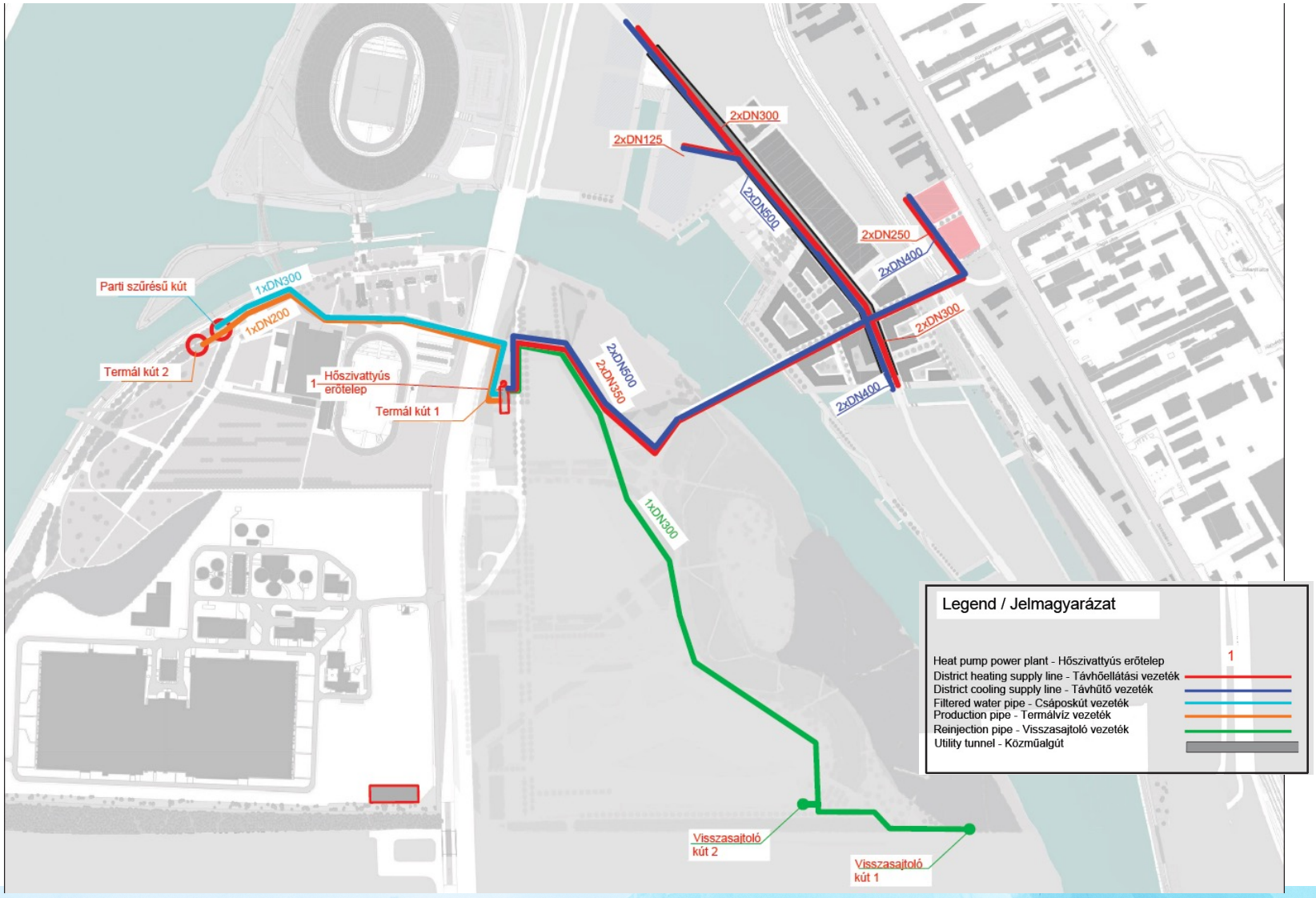
# Project data – Phase 1




**Phase 1**

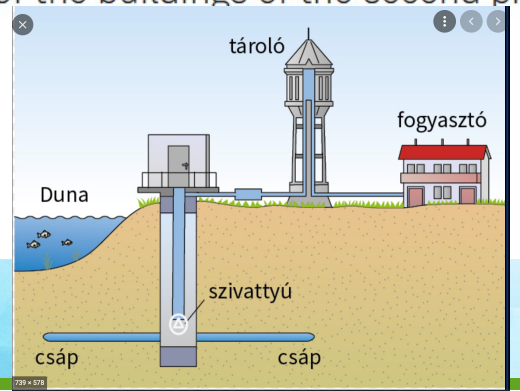
- The bank-filtered well should be built on the designated place with appropriate gallery pipe up to 5000 m3/d water intake, the DN300 KPE pressure pipe up to the heat pump power center.
- The thermal well, thermal water well should be built on the designated place (preliminarily next to the power center) with pressure pipe connection up to the power center and the injection well on the designated place with DN300 PP injection pipe between the power center and the injection well.
- The heat pump power center with the final first and second phase compressor park, heat exchangers, pumps and electric connection should be built.
- The island and bridge sections of the heating and cooling network belonging to the first and second phases should be built, as well as the relevant part of the distribution network with final diameters. The feeding cable of the bank-filtered well and of the thermal well should be built from the engine room.

# Project data – Phase 2

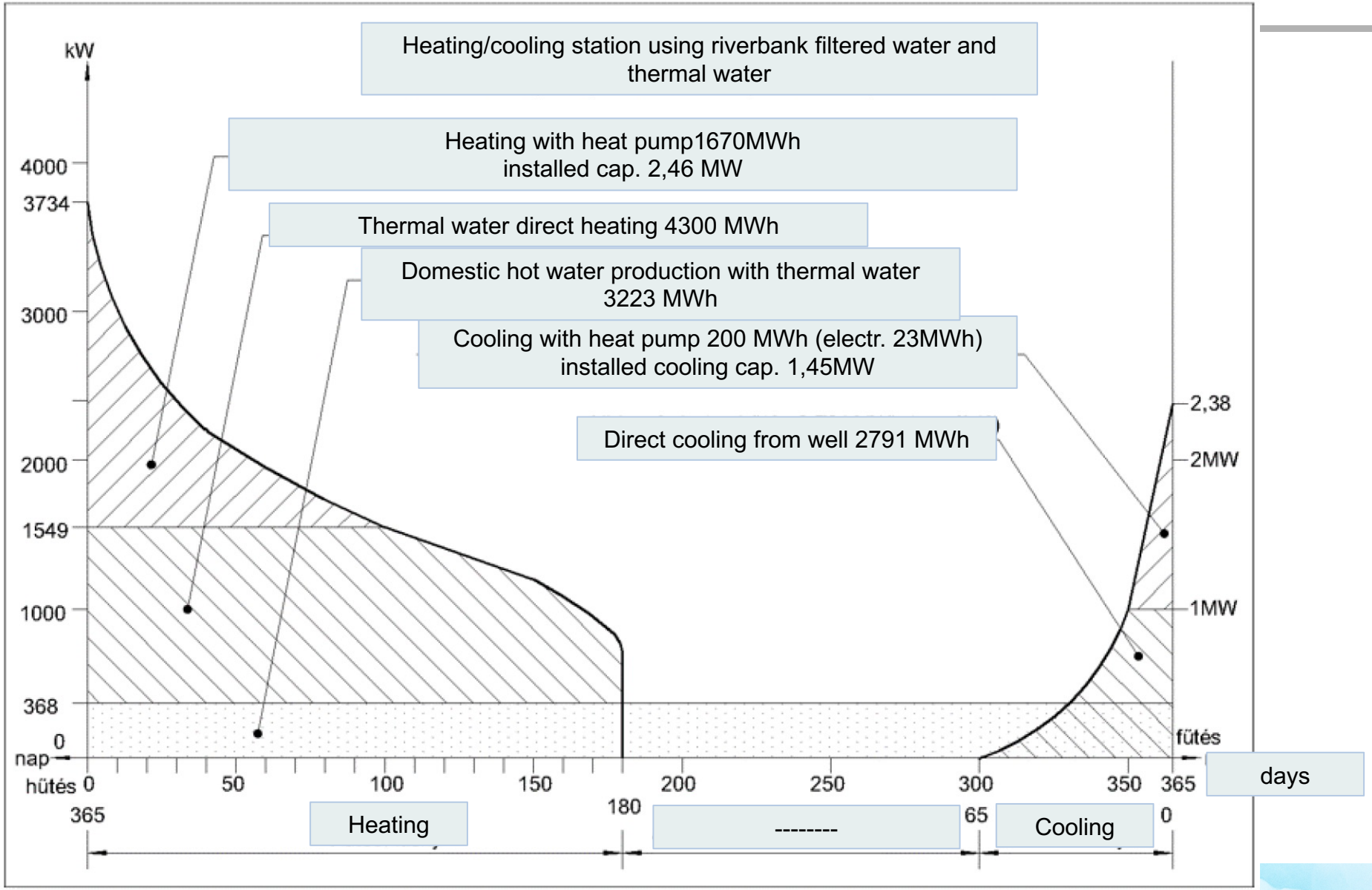



## Scheduling Phase 2

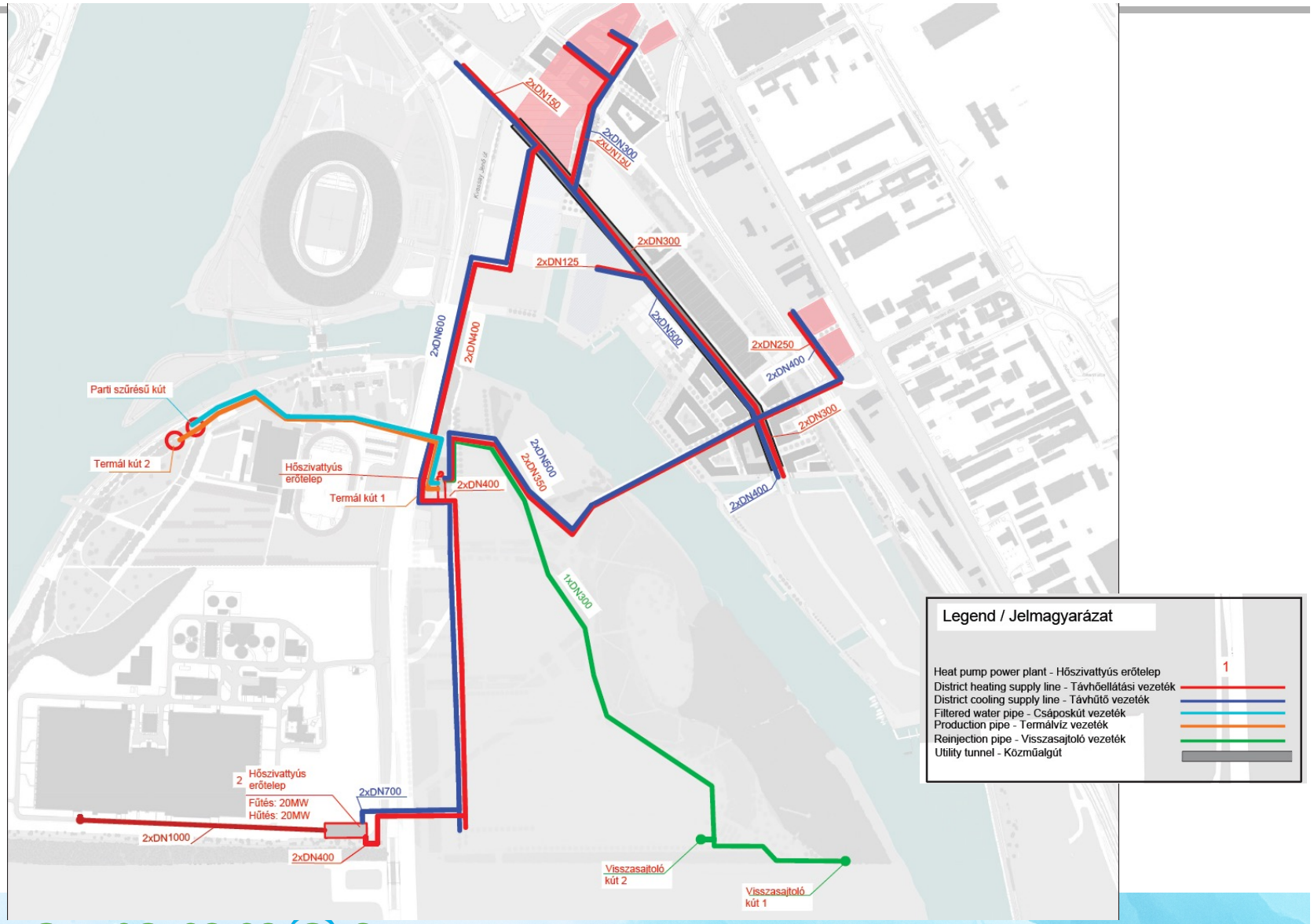
- Water production of the bank-filtered well must be increased to 10.000 m3/d by building a new gallery pipe (this can also be built in the first phase).
- The second thermal well no. 2 should be built according to the preliminary location next to the bank-filtered well.
- Pressure pipe between the well and the power plant and the feeding cable of the well to be built.
- Injection well no. 2 to be built connected to the common pipe of injection well no. 1. The heat pump block of the power plant to be supplemented by the necessary heat exchangers and pumps (the compressors are made in the first phase). The heating and cooling network will be extended by the connecting pipes of the buildings of the second phase.



# Project data – Phase 1-2



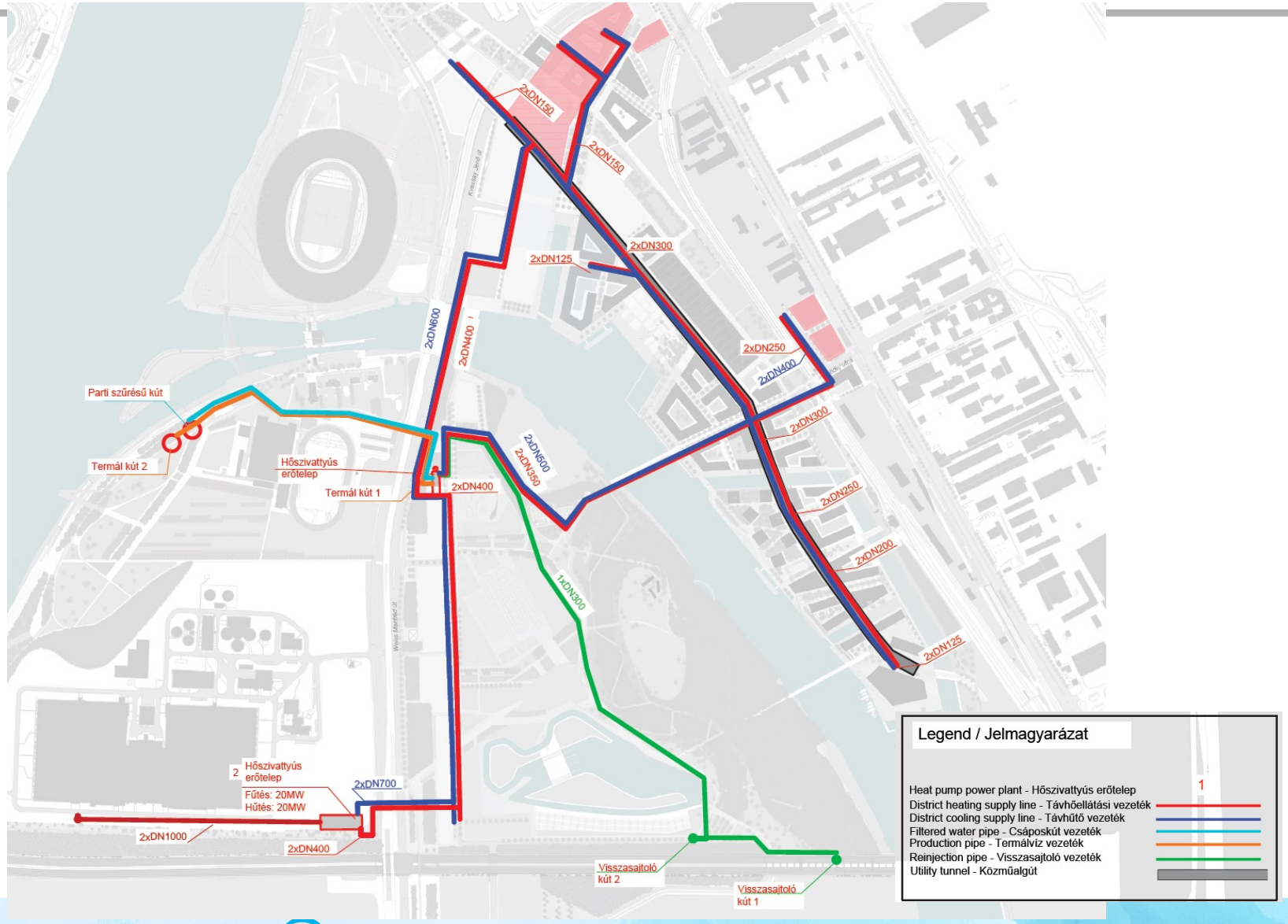
# Project data – Phase 3




## Scheduling Phase 3

- In the third phase the heat pump power plant on the territory of wastewater treatment plant no. 2 must be made. The treated wastewater pumping station shall be constructed and the power plant shall be connected to the pumping unit with a 2xDN1000 connecting cable pair. The power plant building is to be built with a half capacity machine line, with two pcs of separating heat exchangers, 3 pcs circulating pumps, 2 pcs separating heat exchangers, 4 pcs compressors with the attached heat exchangers, gas engines and hot water boiler. The complete electrical feeding cable with the adjoining receiving part (10 kV) with 2 pcs of 10/04 kV transformers and the necessary 0,4 kV electric cabinets. The gas connection pipeline of 3-6 bar pressure is to be built with natural gas receiving part and gas pressure regulator (the regulator is shared with the wastewater treatment plant).
- The island, Kvassay bridge and Pest side sections of the trunk pipeline of the heating and cooling network should be started and should be connected to distributing network of Phase 3.

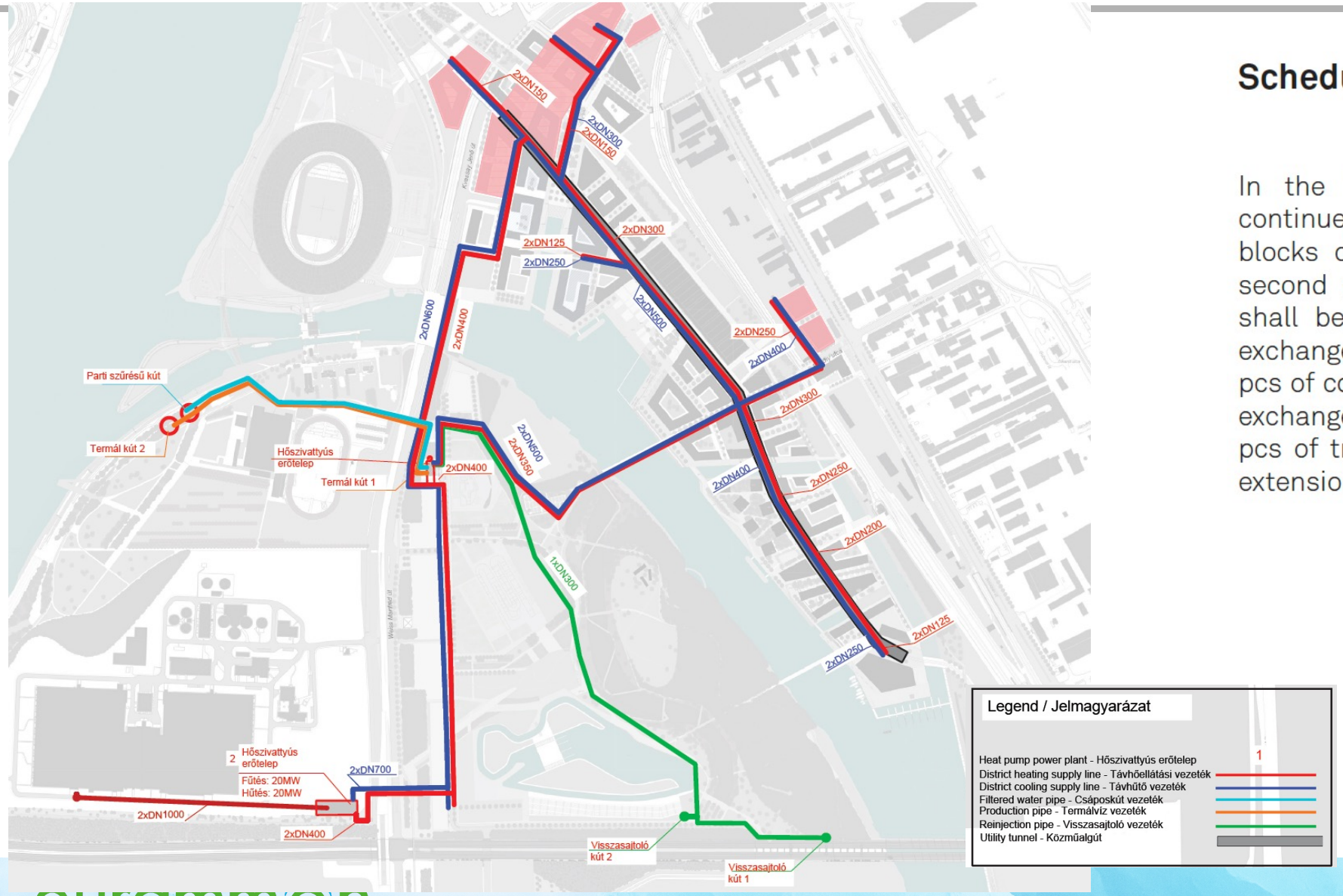
# Project data – Phase 4




## Scheduling Phase 4

In the fourth phase the distribution heating and cooling network shall be extended according to the newly built blocks of houses.

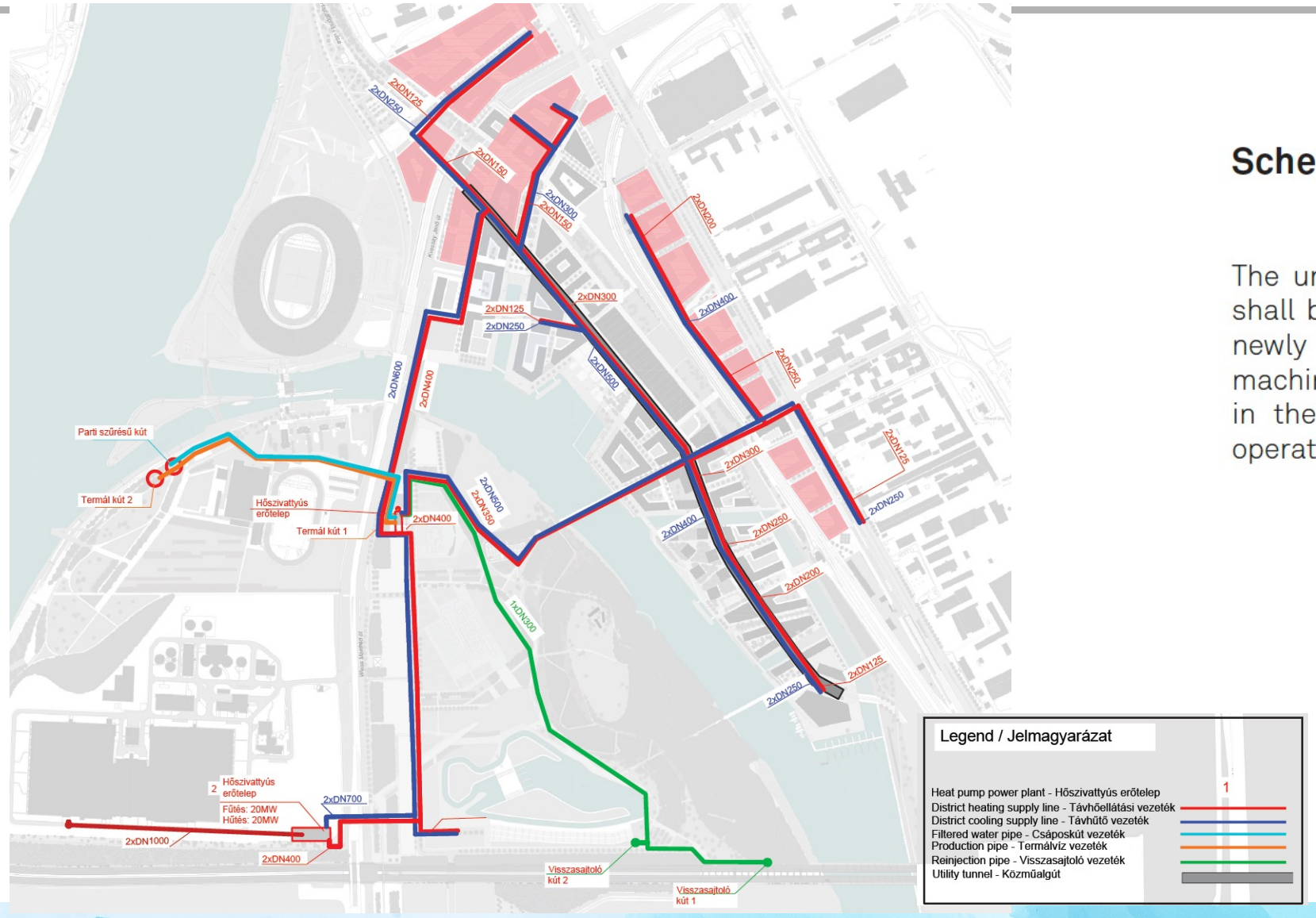
# Project data – Phase 5




## Scheduling Phase 5

In the fifth phase extension shall be continued according to the newly built blocks of houses. The installation of the second machine line of the power plant shall be prepared (1 pc separating heat exchanger, 1-1 pc of circulating pump, 4 pcs of compressors with the adjoining heat exchanger, gas engine, hot water boiler, 2 pcs of transformer extensions with 0,4 kV extension).

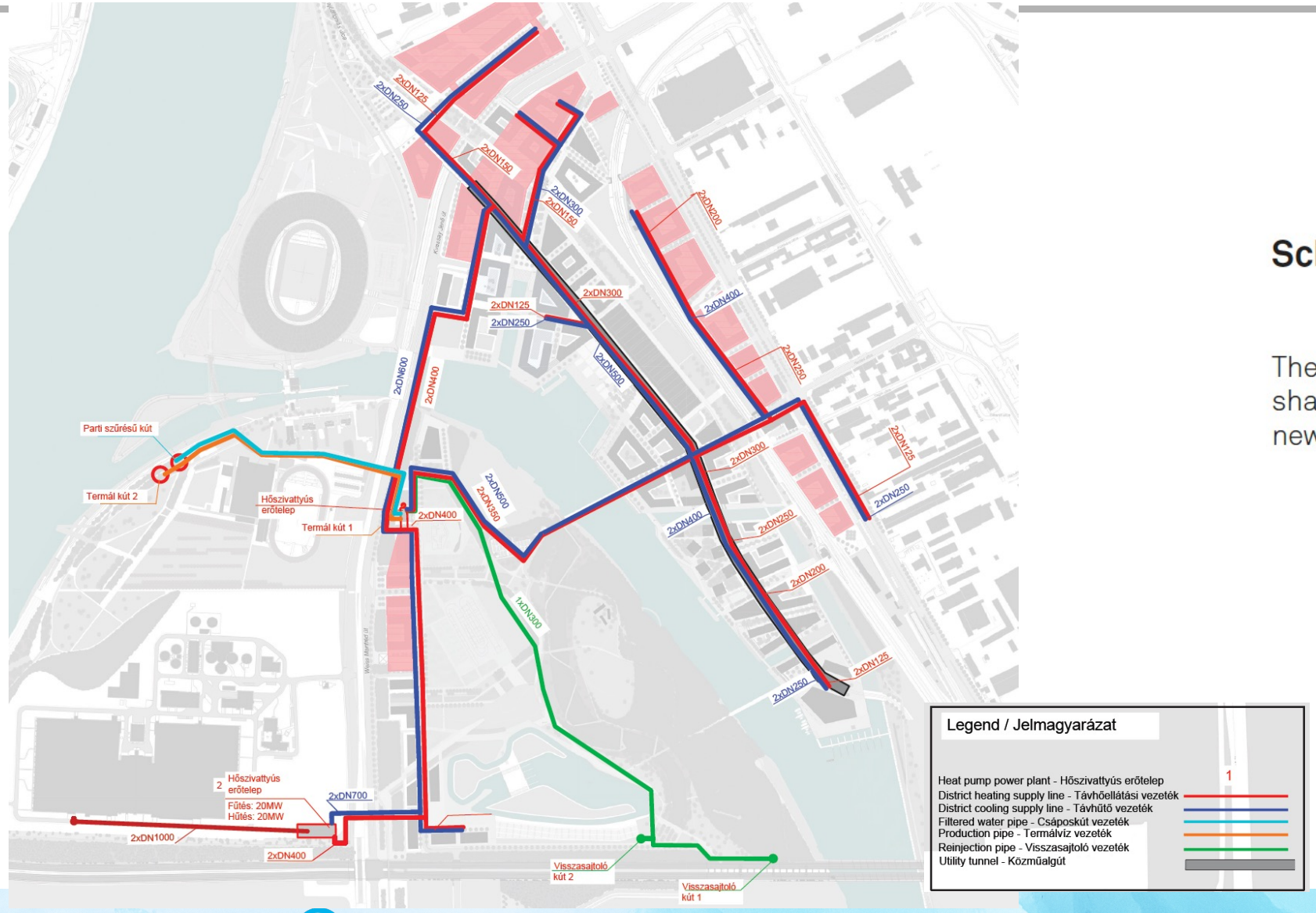
# Project data – Phase 6




## Scheduling Phase 6

The urban trunk and distribution network shall be extended further according to the newly built blocks of houses. The second machine line of the power plant prepared in the previous phase shall be put into operation.

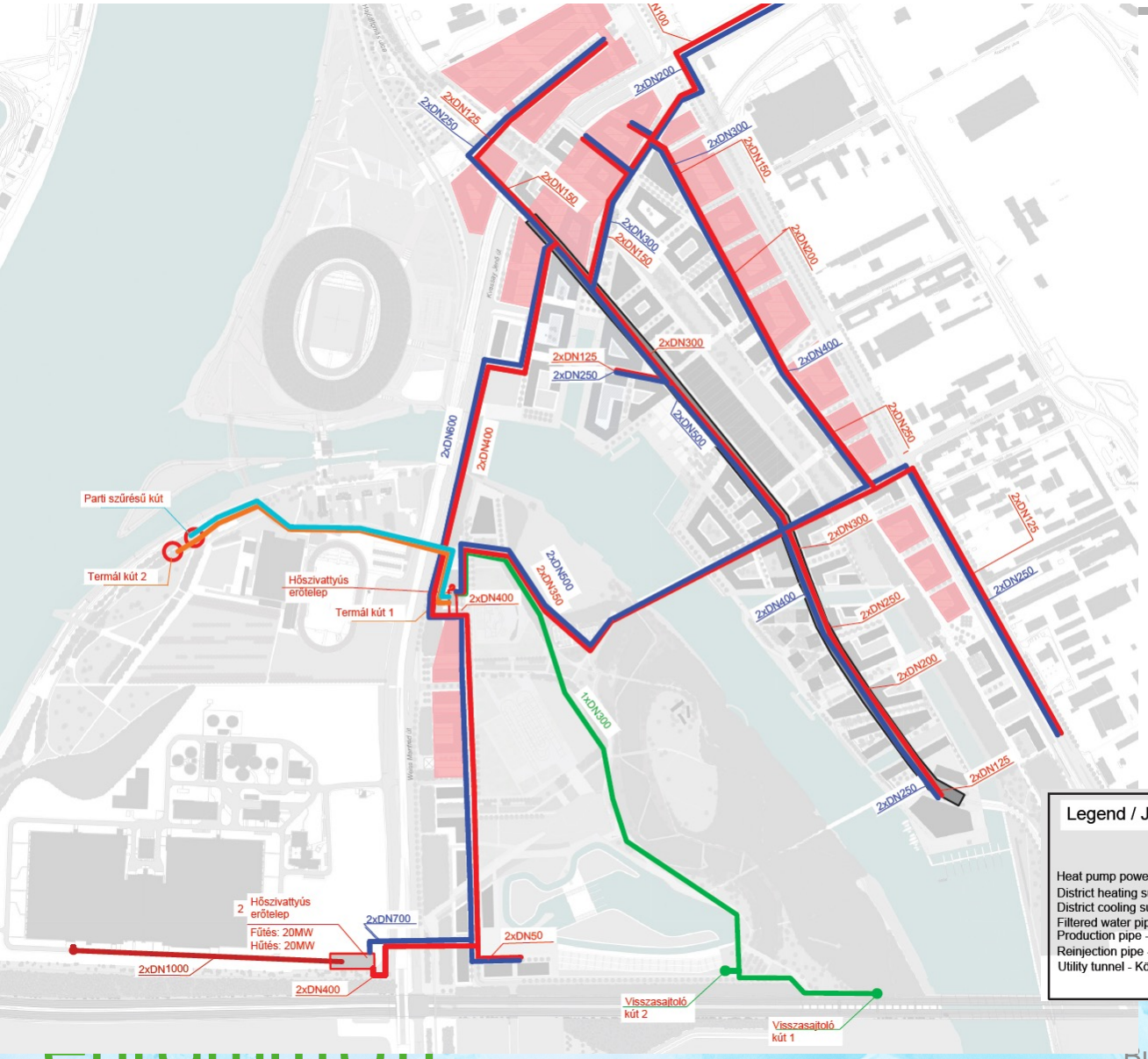
# Project data – Phase 7




## Scheduling Phase 7

The urban trunk and distribution network shall be extended further according to the newly built blocks of houses.

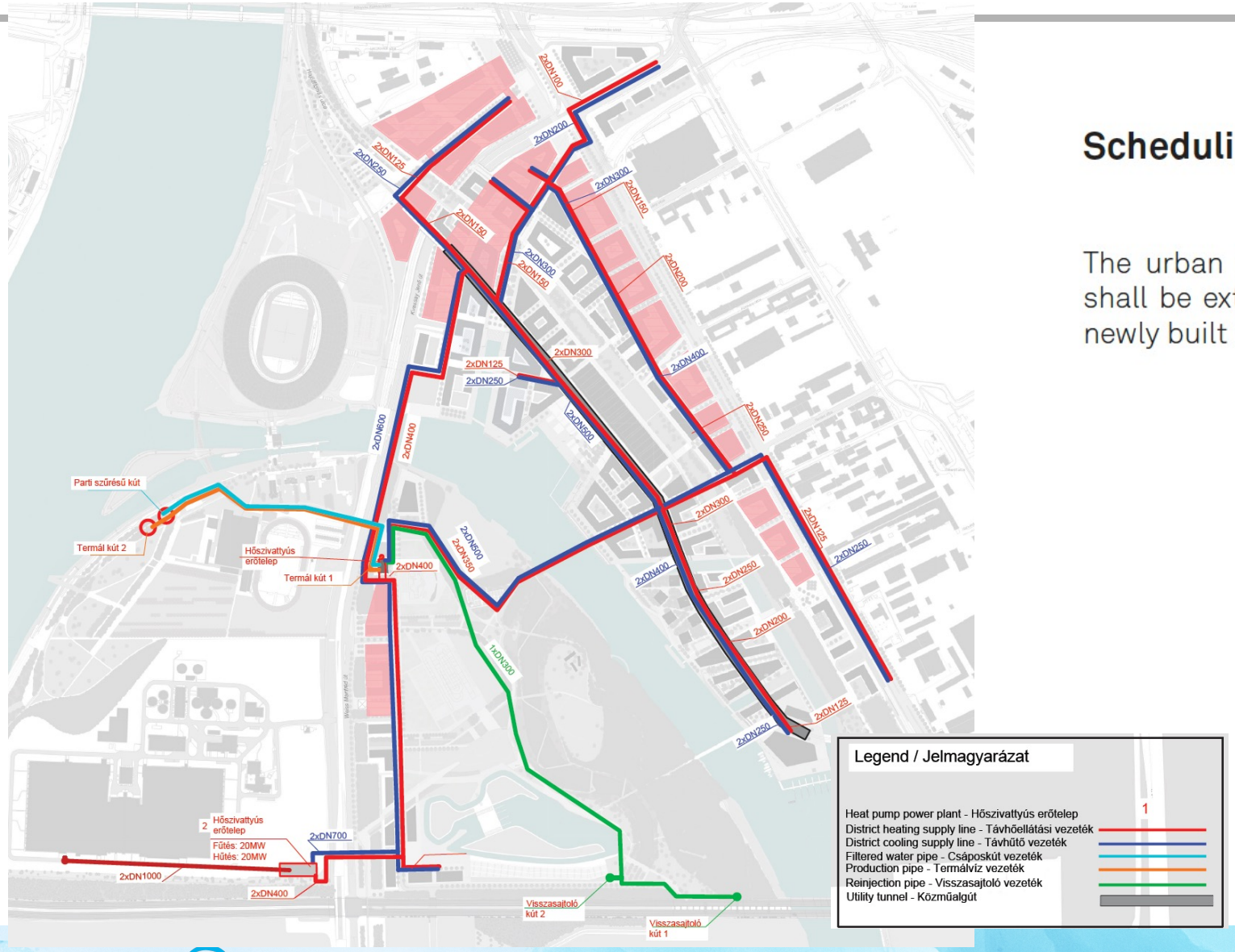
# Project data – Phase 8




## Scheduling Phase 8

The urban trunk and distribution network shall be extended further according to the newly built blocks of houses.

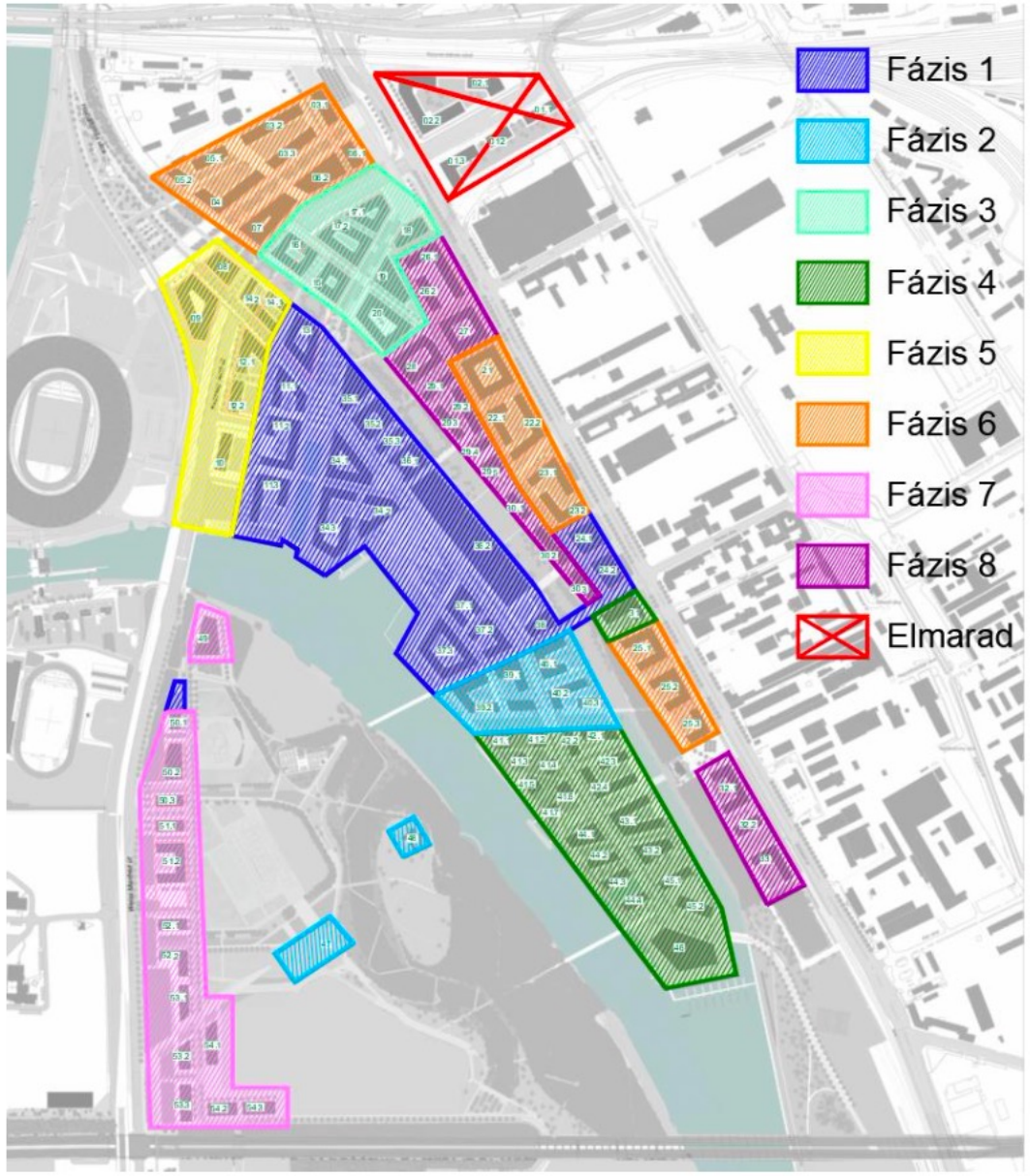
# Project data – Phase 9




## Scheduling Phase 9

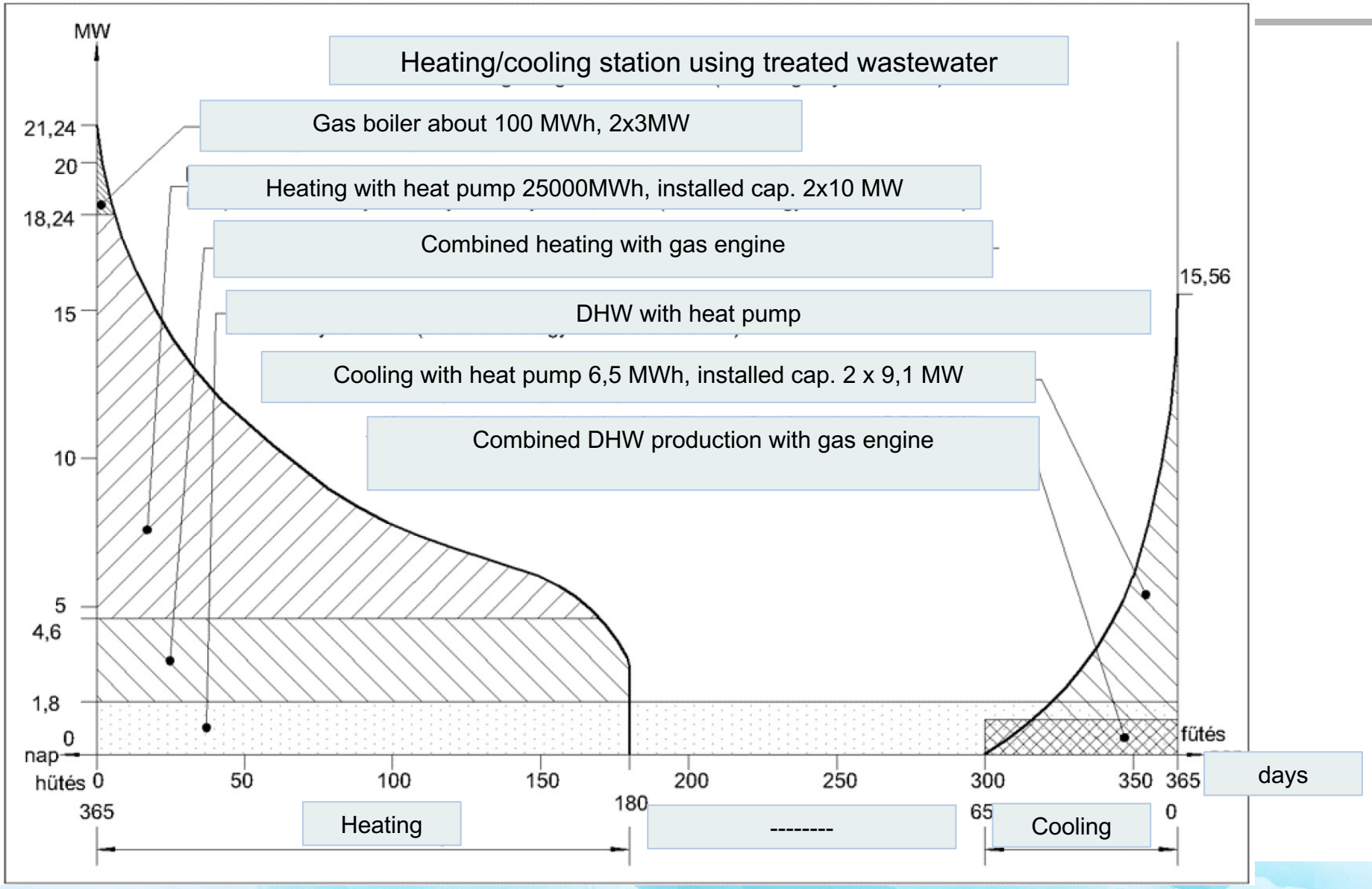
The urban trunk and distribution network shall be extended further according to the newly built blocks of houses.

# Project data – Phase 9



# Project data – Phase 3-9 – an earlier version

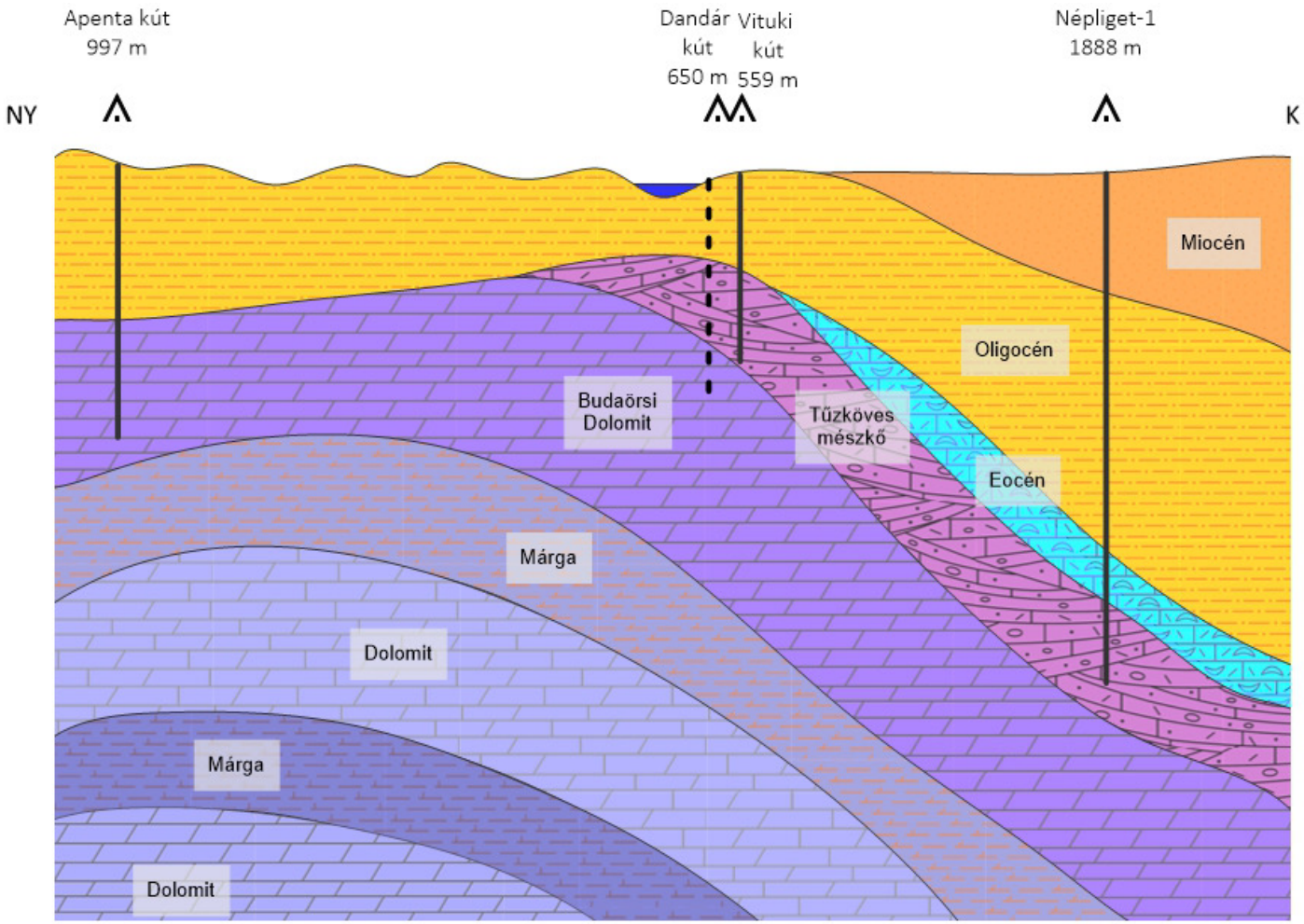
Note: I have no final energy diagram for the last phases. This diagram shown the usage, but the suppliers are not final.



# Project data – Used heat sources

- bank-filtered well water of relatively constant temperature of 10-12°C with high yield capacity that can be used for direct cooling and also for cooling and heating, when connected to the heat pump
- thermal water of 55-57 °C temperature, under the development area between 650 - and 1500 m depth continuous thermal water layer can be found, based on the data of the existing wells the water yield of one well – with conservative estimate – is about 90 m3/h. Max. 2 wells can be drilled in the area. When using for energetic purposes the cooled water shall be pressed back to the original layer. The well water can be directly used for heating through a heat exchanger. The temperature of the cooled water can be increased to the initial temperature with a heat pump.

# Project data – Used heat sources



# Project data – Other possibilities considered

The Budapest Central Wastewater Treatment Plant is operating on the Southern border of the development area. After purification it discharges large volume of treated sewage water into the Danube at 14-24 °C. This wastewater is suitable for operating a heat pump operated cooling-heating heat plant. From the point of view of heat pumps, the 200-300.000 $m^3$/day water quantity can practically be regarded an unlimited heat source.

Later during the optimization process Phase 9 has been removed, wastewater usage has been eliminated with increased bank filtered river water and thermal water usage. Nevertheless, this option remains on the table for later expansion, since the usable heat content of the treated wastewater flow is almost an order larger, than the current requirement.

# Project data – Other possibilities considered, but not recommended

- **Danube water**. In winter the water temperature is so low that it cannot be cooled further by the heat pump equipment, because the water freezes, thus water can only be used for cooling up to max. +6-7 °C. Besides, there are other problems with the use of the Danube water, since Danube water is muddy, the heat exchanger needs to be cleaned frequently, algae and shellfish proliferate in the pipeline connecting the water with the Danube and this causes frequent malfunctioning. The bank-filtered well water that can be further utilized after leaving the cooling system is much more favorable than the continued use as grey water.

# Project data – Other possibilities considered, but not recommended

- It is not advisable to use the untreated **wastewater as heat source** in the area, because the Budapest Central Wastewater Treatment Plant is close to the building site, thus wastewater is available here in treated form, which makes utilization easier; on the other hand the cooling of wastewater before treatment negatively affects the treatment technology, thus obtaining permit for such solution would also be difficult.
- The disadvantage **of heating and cooling energy obtained from the air** is that heating energy obtainable from the air results very low level of energy utilization compared to the primary (electric) energy and this value becomes even worse with the reduction of the outside air temperature.
- There are several reasons why the **absorption cooling systems** cannot be used, but the most important is that there is no relatively high temperature waste heat on the site that could be used for operating the absorption cooling machine, since this kind of cooling is very uneconomical with any type of traditional heating media (district heating, gas).

# Project data – Other possibilities considered, but not used

- In Hungary the conditions are not available for the large-scale use of **fuel cells.**
- The use of **natural gas** for heating was ab ovo excluded, since the basic principle in the design of new city quarters has been for a long time that dual channel energy supply systems should be established, either electricity and gas supply, or electricity and district heating services. In the present case, decision was made in favour of the electricity, local district heating and cold energy supply.
- The **use of wind energy** is first of all an urban architectural issue, installation of windmills simply does not fit into the environment.
- The use of **solar collectors** can primarily contribute to the domestic hot water consumption, but this can be regarded settled with the thermal water and planned heat pump systems, thus their use is not justified. This is all the more true as the collector takes space on the roof from the more efficient solar panel.

# Project data – Other possibilities considered, but not used

- Heat and cold energy supply operated by **soil probe** was also excluded from the possible solutions, since the supply of the built up area would require the drilling of 5-6000 pcs of probes (5-6 kW per probe),  the establishment of soil probes alone would mean an investment cost of 5-6 billion HUF. In spite of the above it may happen that if the planned cooling-heating system is not built in time, still the soil probe solution should be used at the first buildings.

# Project data – green aspects

| Subject | Unit \ Phase # | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | SUM |
|---|---|---|---|---|---|---|---|---|---|---|
| Built area [$m^2$] | $m^2$ | 321 100 | 39 200 | 101 400 | 113 100 | 54 900 | 178 200 | 93 100 | 140 200 | 1 041 200 |
| Domestic hot water yearly | MWh/a | 7 411,20 | 1 798,00 | 2 314,20 | 2 918,80 | 1 682,30 | 1 102,90 | 160,9 | 2 748,00 | 20 136,30 |
| Domestic hot water peak | MW | 1,8 | 0,47 | 0,52 | 0,66 | 0,51 | 0,2 | 0 | 0,61 | 4,76 |
| | | | | | | | | | | |
| Heating and DHW yearly sum: | MWh/a | 22 846,20 | 3 718,00 | 7 294,20 | 8 003,80 | 4 427,30 | 9 822,90 | 4 815,90 | 9 108,00 | 70 036,30 |
| Heating and DHW peak: | MW | 9,56 | 1,43 | 3,08 | 3,15 | 1,89 | 4,9 | 2,58 | 3,72 | 30,3 |
| Yearly cooling demand | MWh/a | 2 813,03 | 288,2 | 899,73 | 724,09 | 419,8 | 1 947,24 | 1 159,25 | 837,22 | 9 088,55 |
| Peak cooling demand | MW | 6,57 | 0,71 | 2,13 | 1,81 | 1,03 | 4,42 | 2,58 | 2,17 | 21,41 |

# The heat pump - some overview

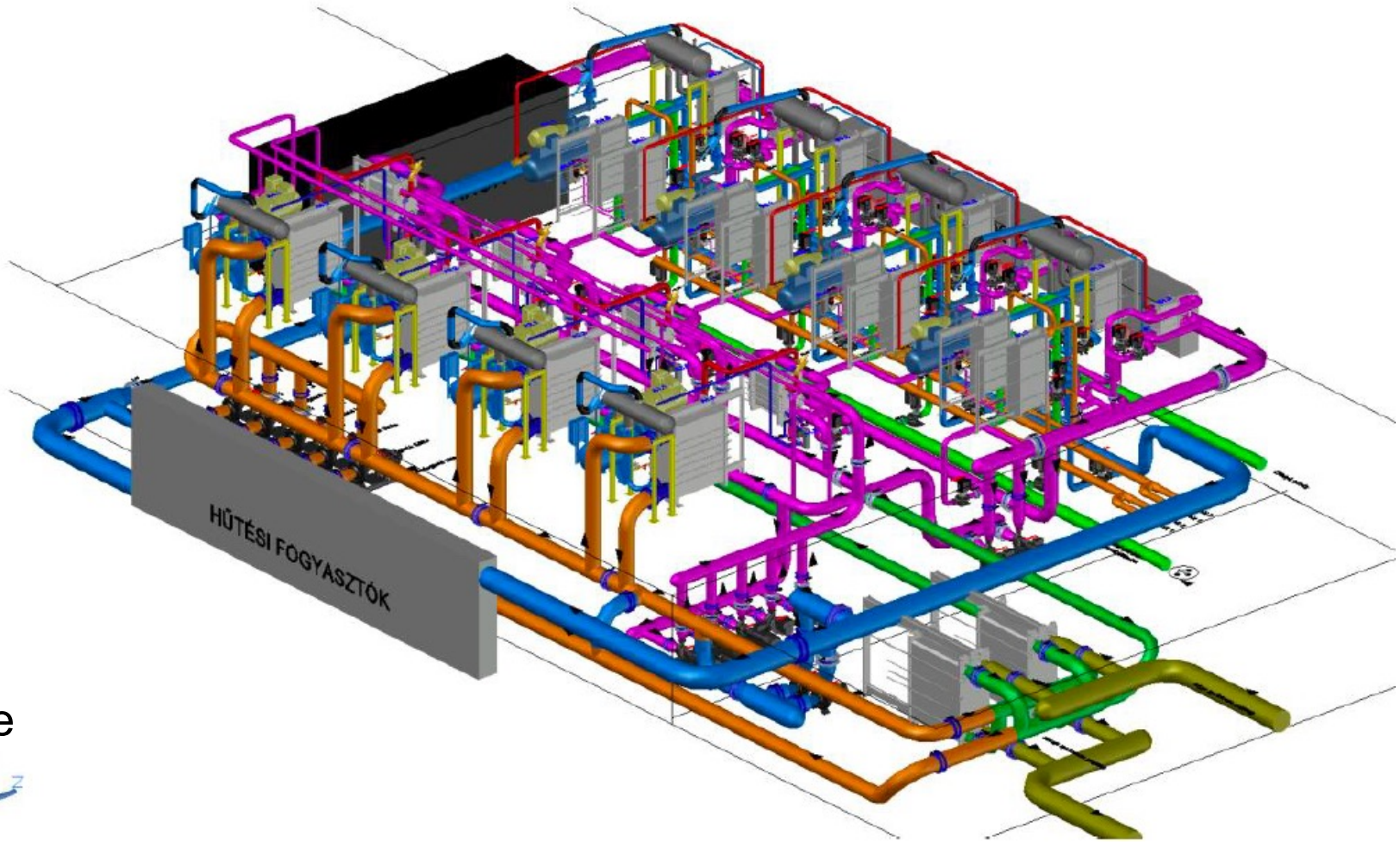
One units is sized for 2,5MW heating and 2,5MW cooling - including the free cooling / heating component.

Thermal water is 57°C 180m$^3$/h and riverbank filtered water comes at 9..13°C 860m$^3$/h.

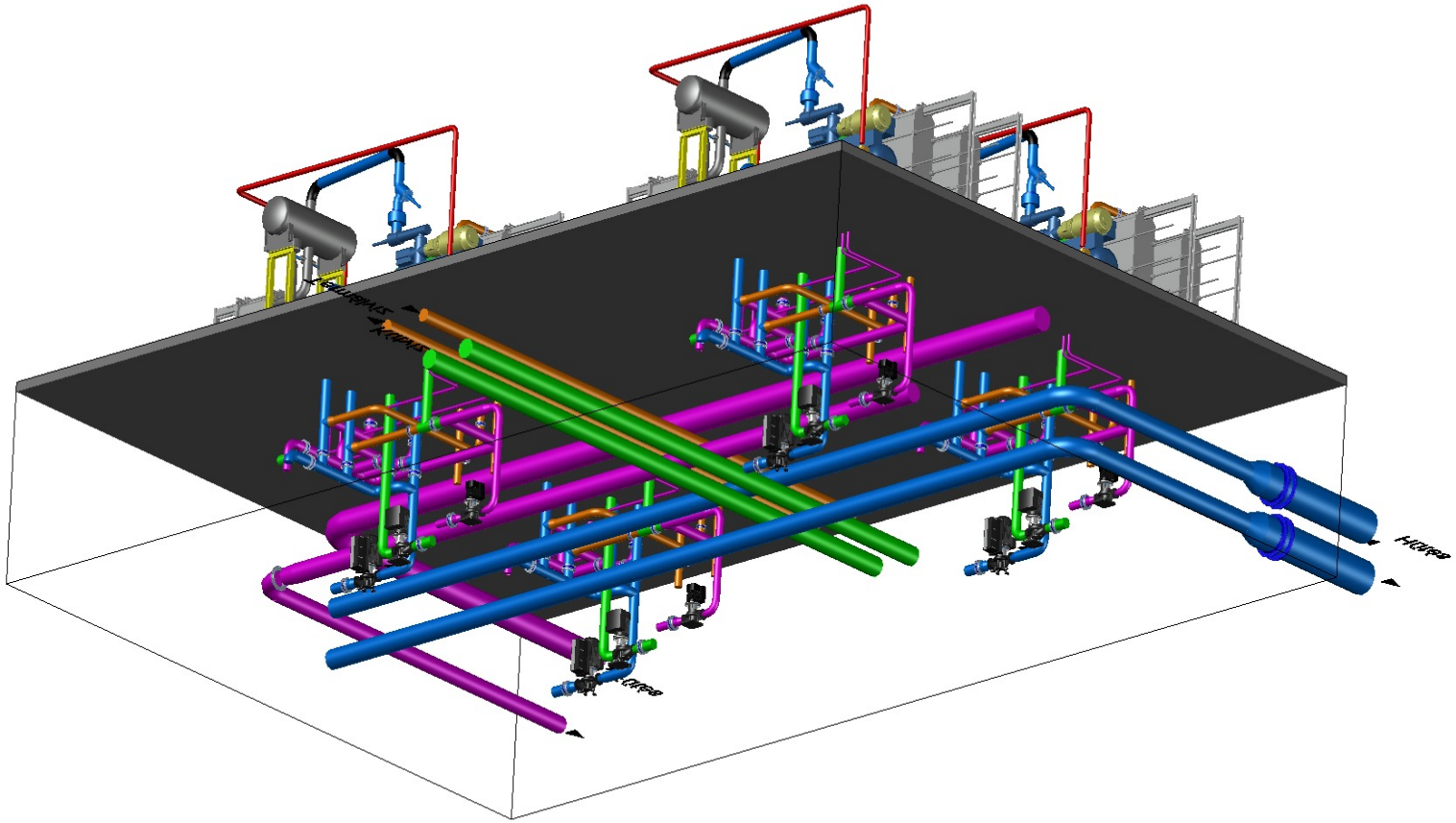
Heating is designed for 80/40°C, cooling is for 5..7/17°C.

Either heating or cooling mode.

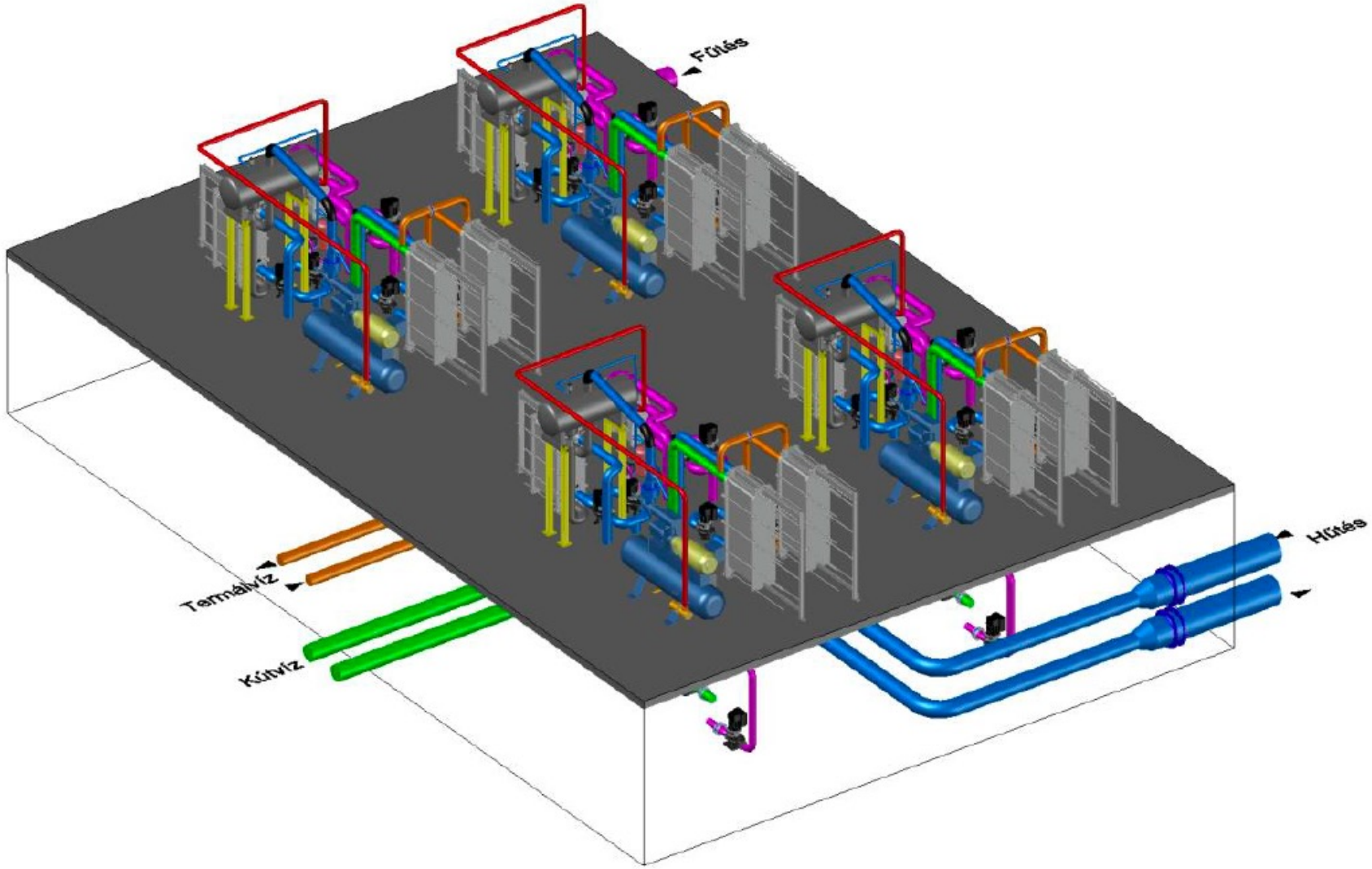
… and the refrigerant is of course AMMONIA.



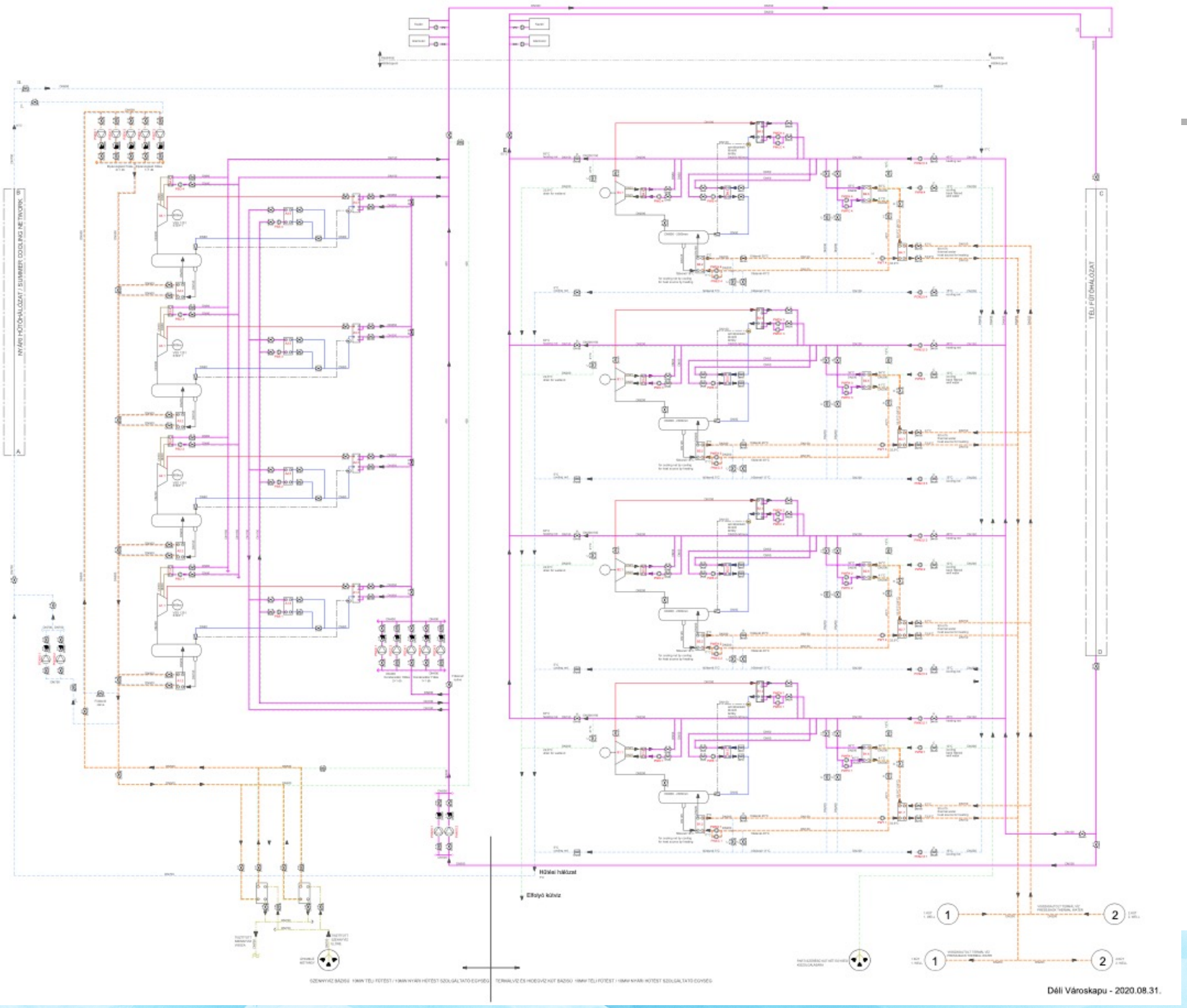
# The heat pump - some overview



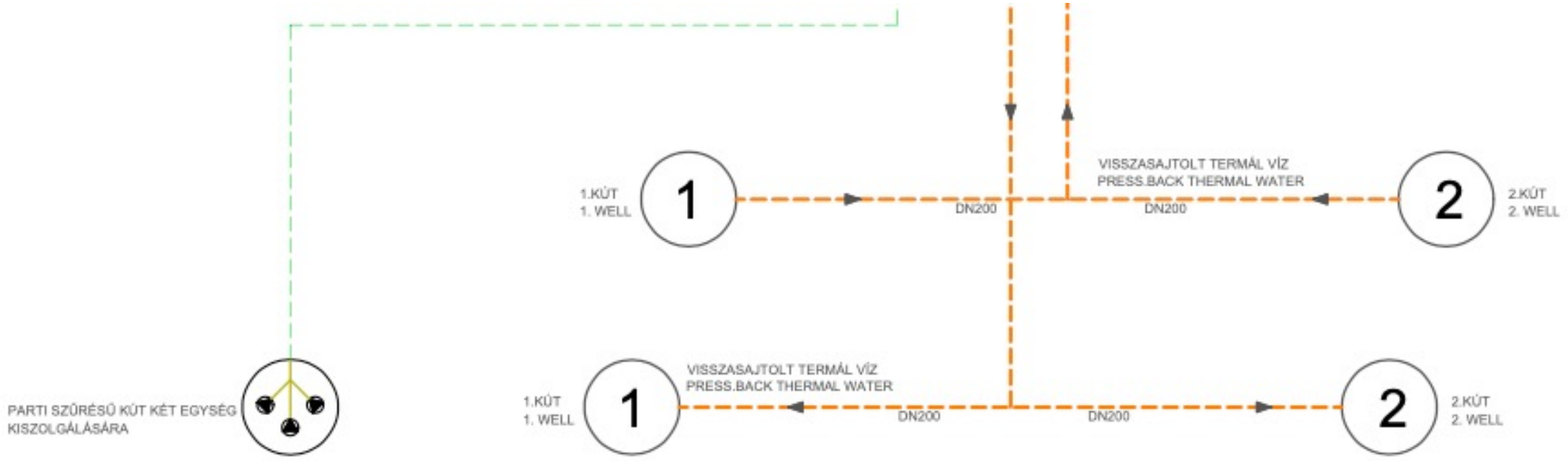
# The heat pump - some overview



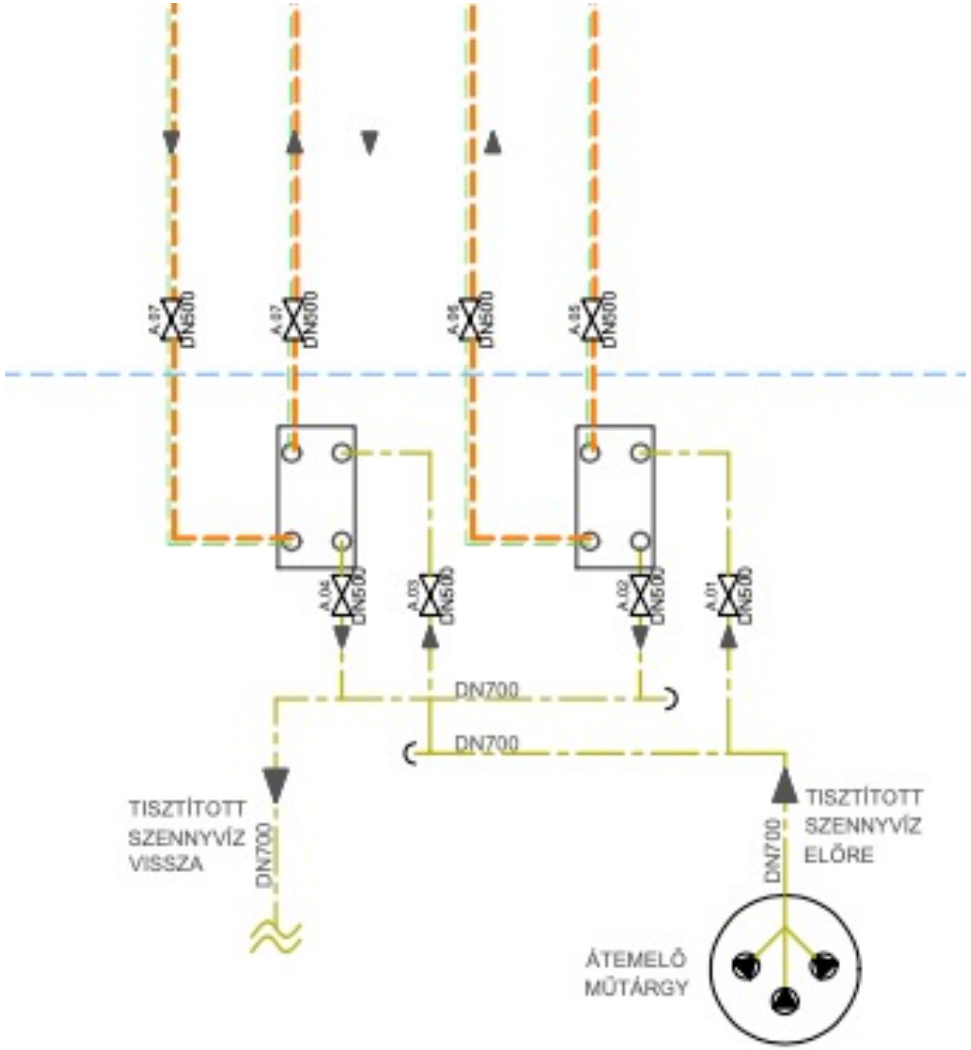
# The heat pump



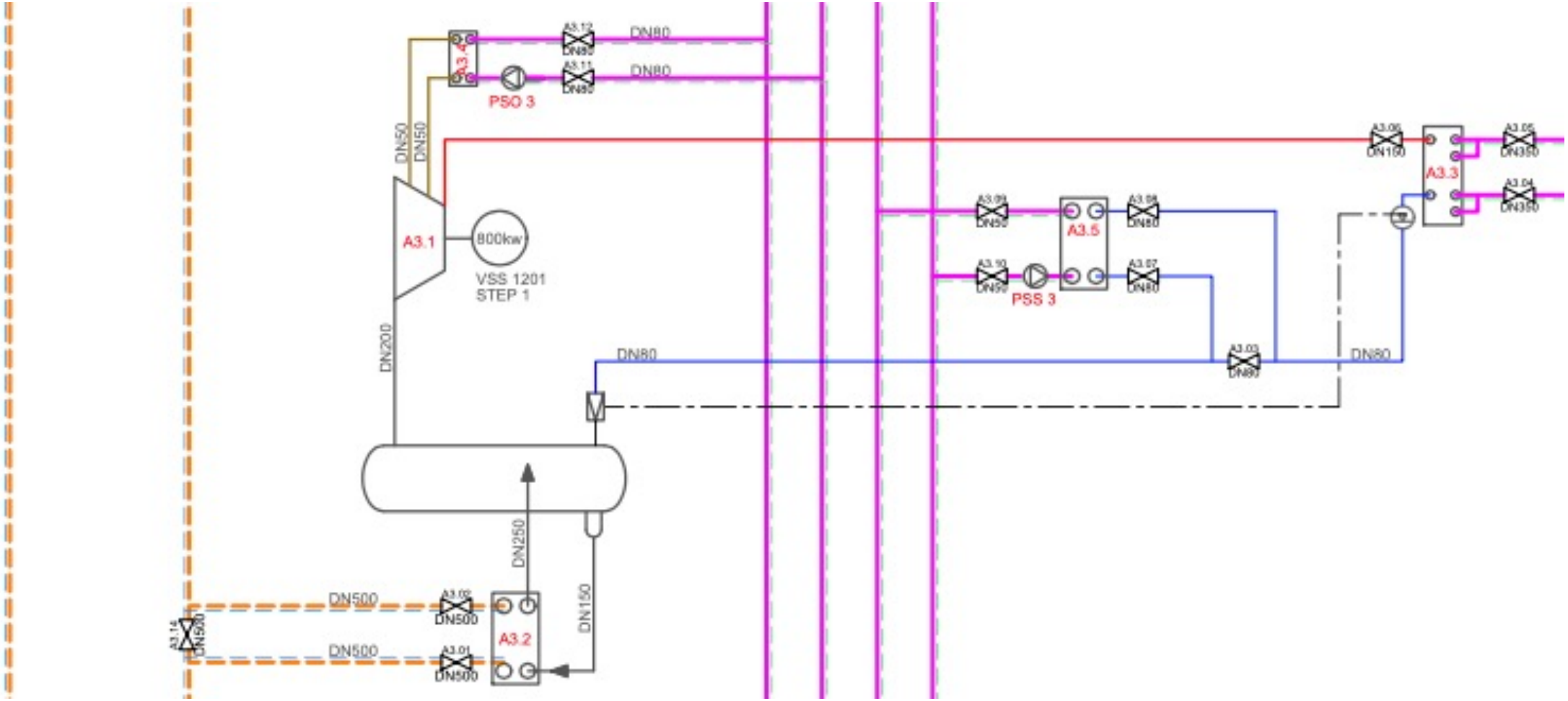
# The heat pump - some overview



# The heat pump - some overview



# The heat pump - some overview



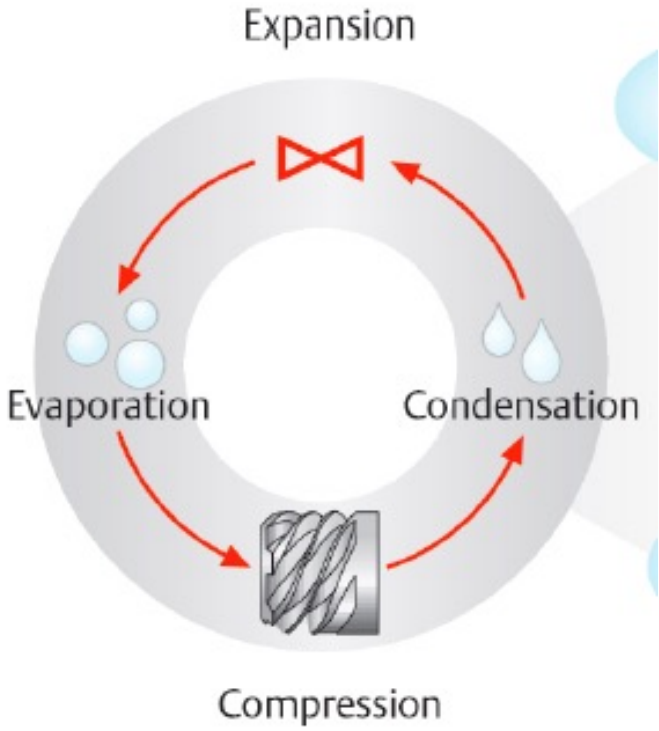
# The heat pump - some overview

The heat pump refrigeration cycle is quite simple.

Chilled water return line is cooled with river water 17/13°C, then 13/5..7°C with heat pump evaporator in cooling mode. After the free cooling PHX the river water cools the condensers, then the oil coolers.

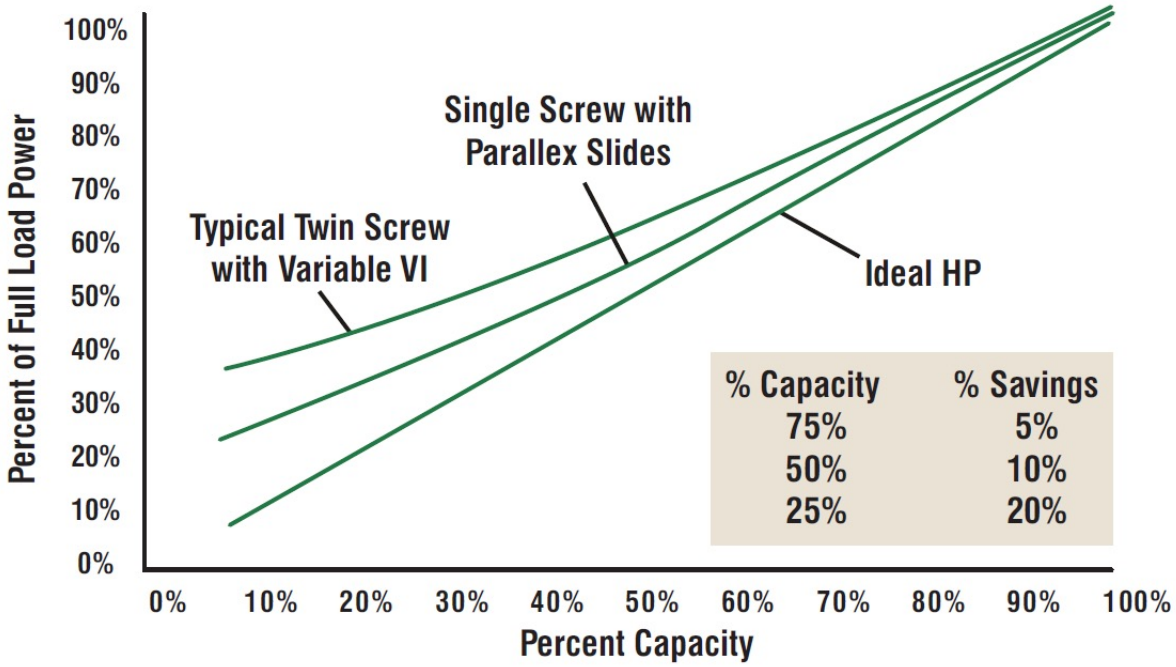
In heating mode the 40°C return line is heated through a PHX to 55°C by the thermal water and after that to 65°C first by the condenser and then by the oil cooler PHX. The thermal water circuit uses an additional decoupling PHX and circuit because of the higher salt / mineral content.

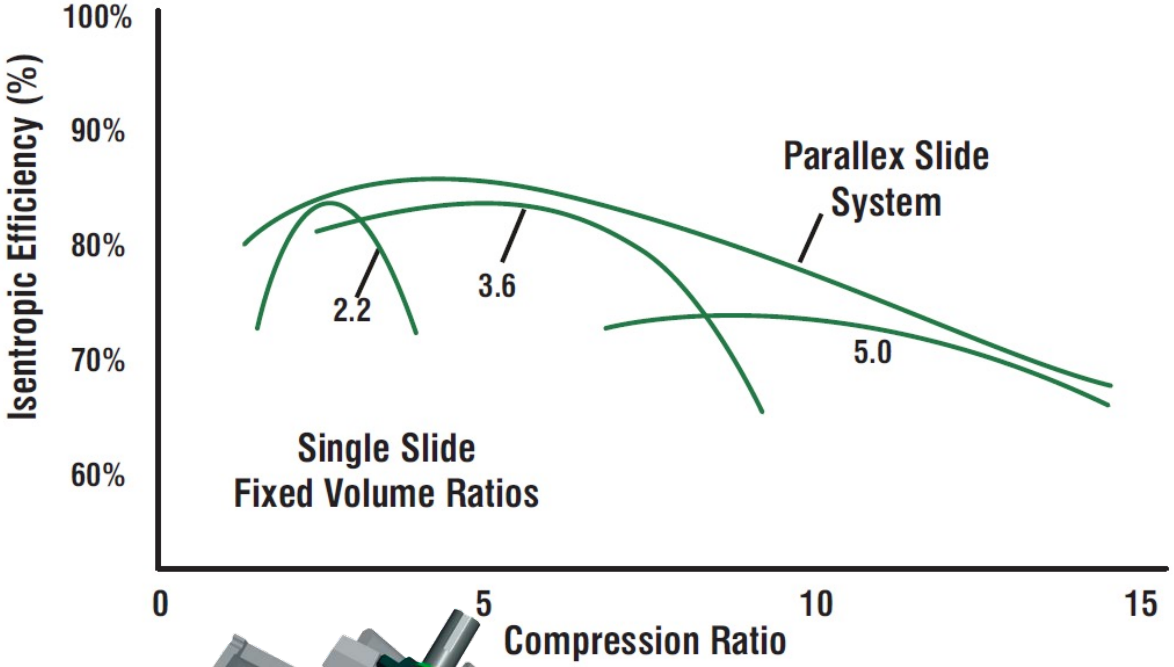
In this way the combined COP.heating = 12,7 and COP.cooling=15,6.

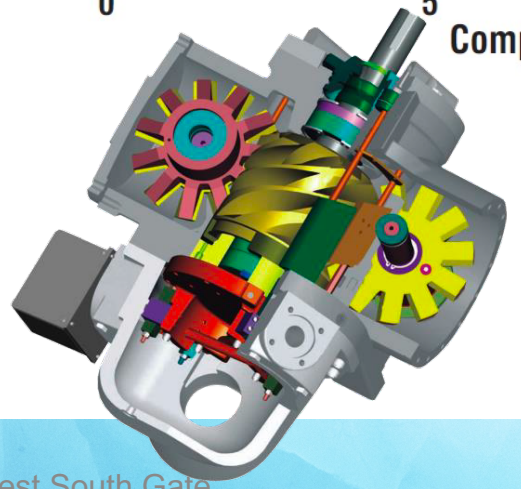


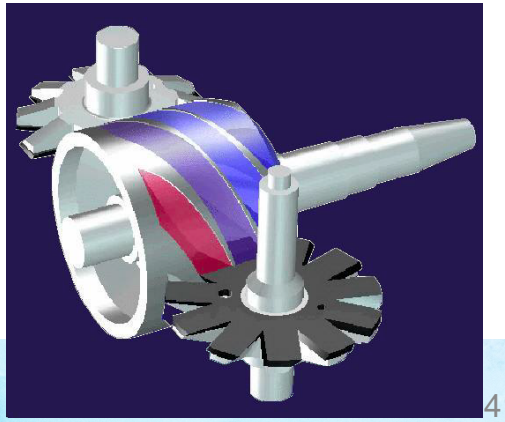
# The heat pump - compressors

We recommend the single screw compressors for this application especially, because of the increased part load efficiency, long life and low vibration.



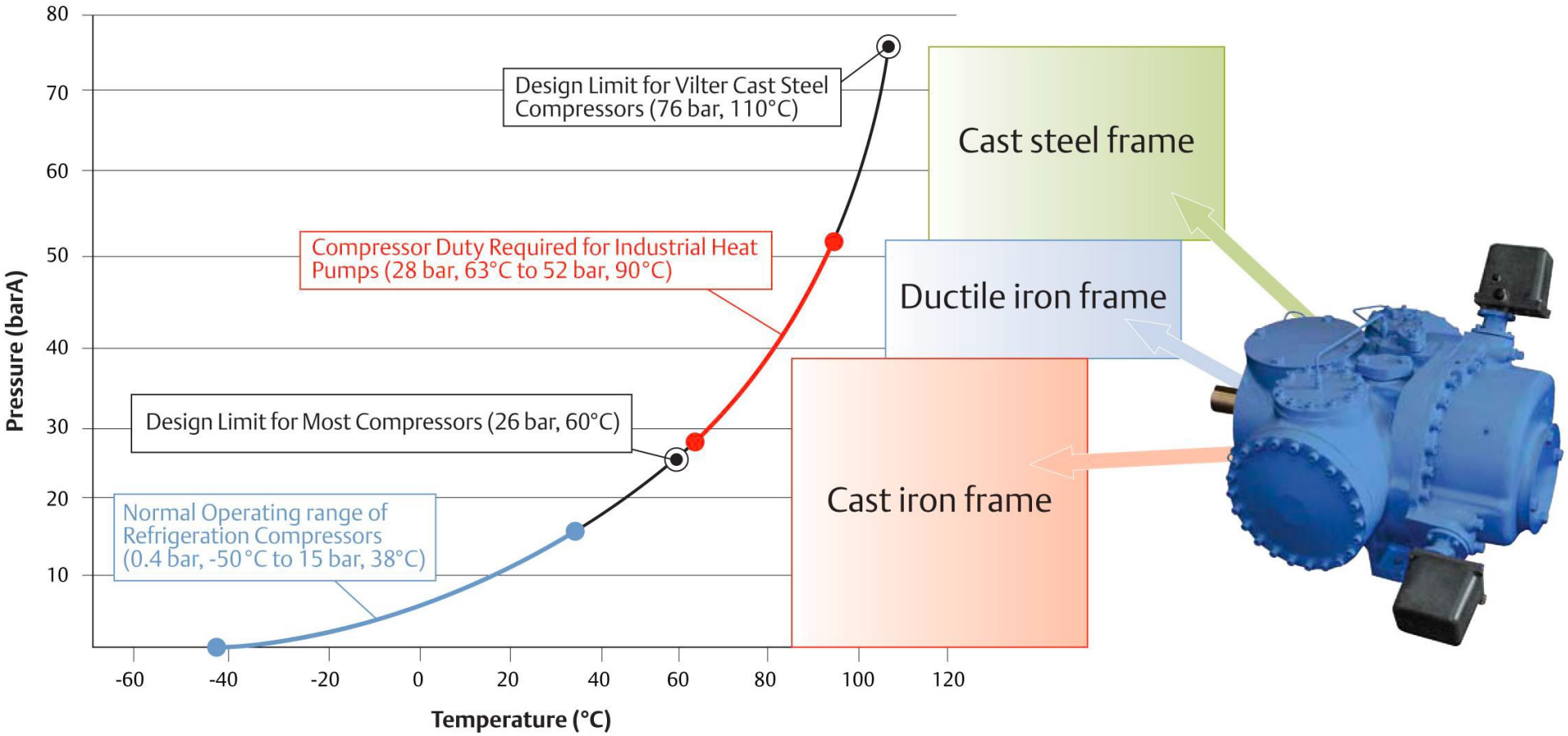



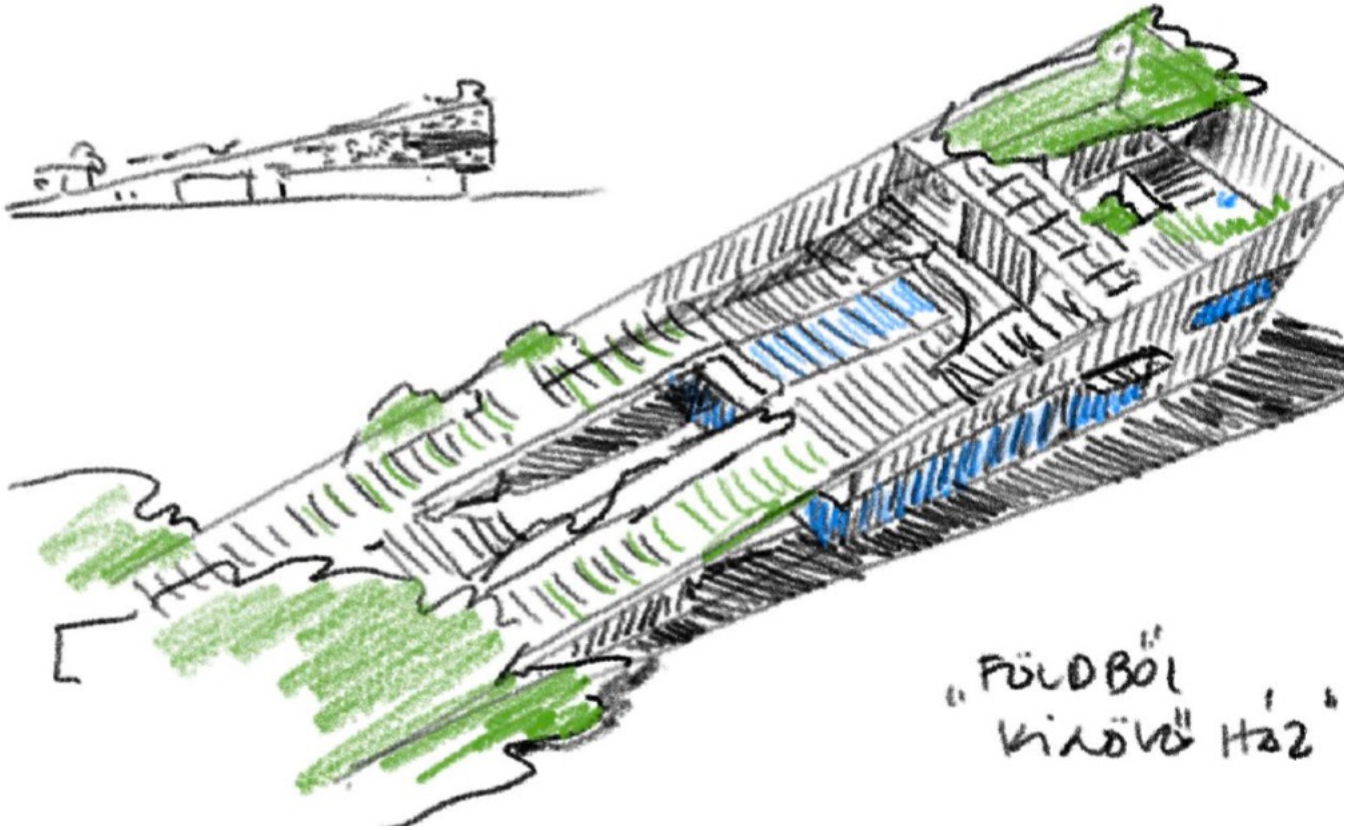


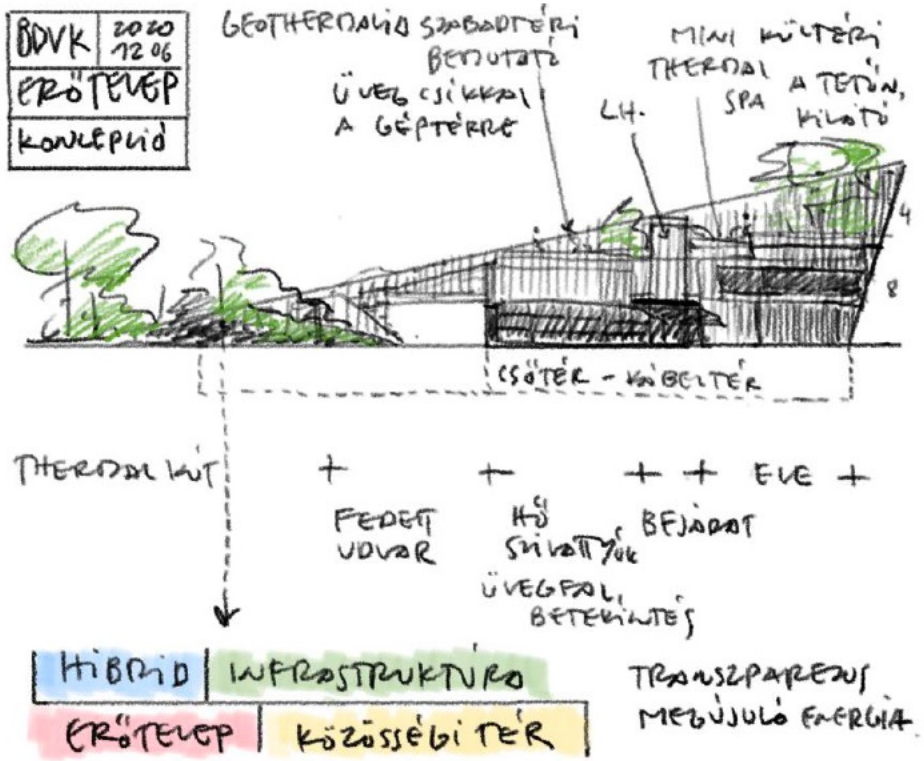
# The heat pump - compressors

At some point during the optimization process higher heat pump generated hot water was also on the table, however due to the available thermal water and low percentage of high load requirement during the year, this version has been eliminated – obviously increasing the COP and decreasing complexity as well. Nevertheless, the possibility remains available.

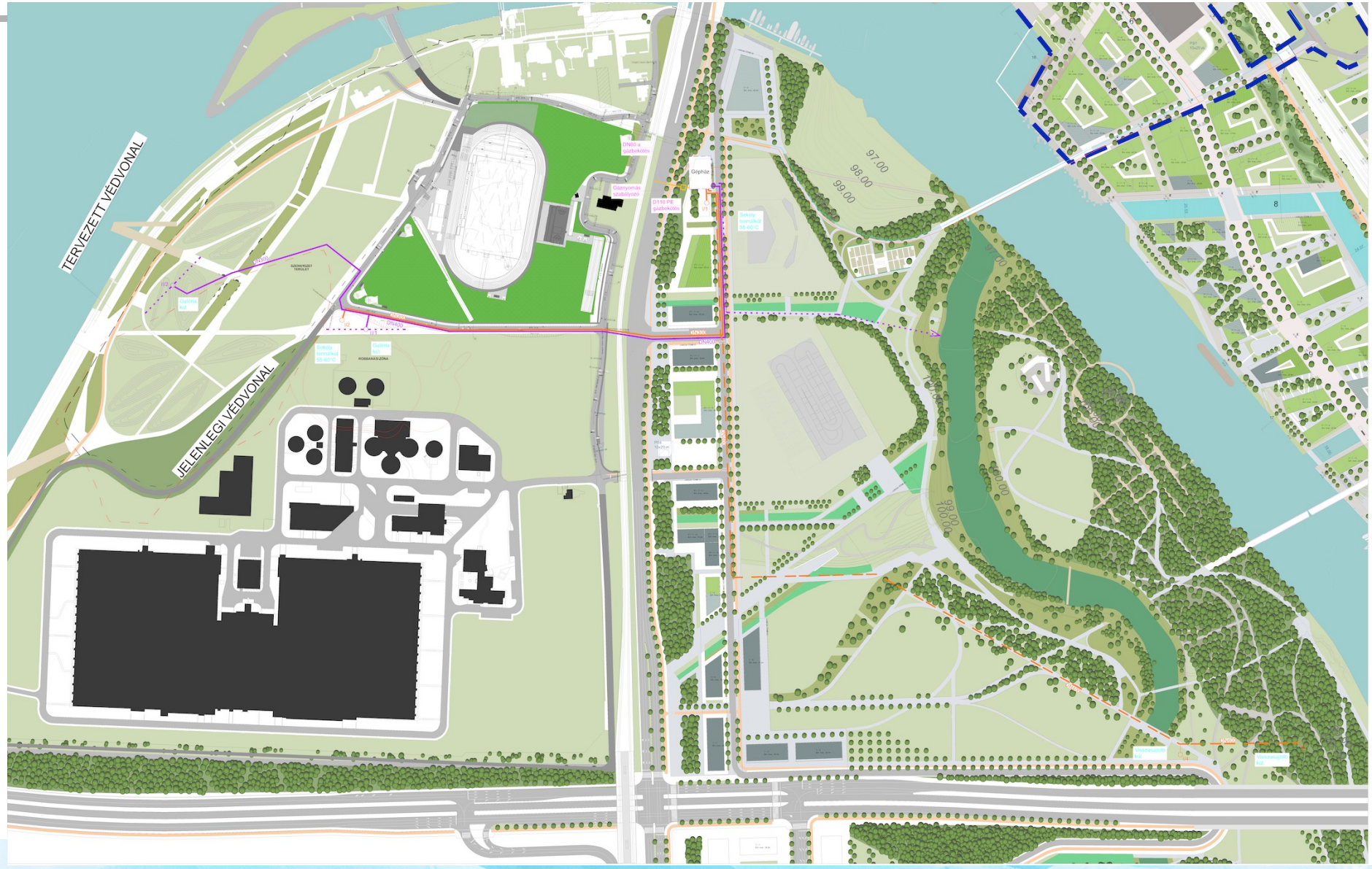


# The heat pump

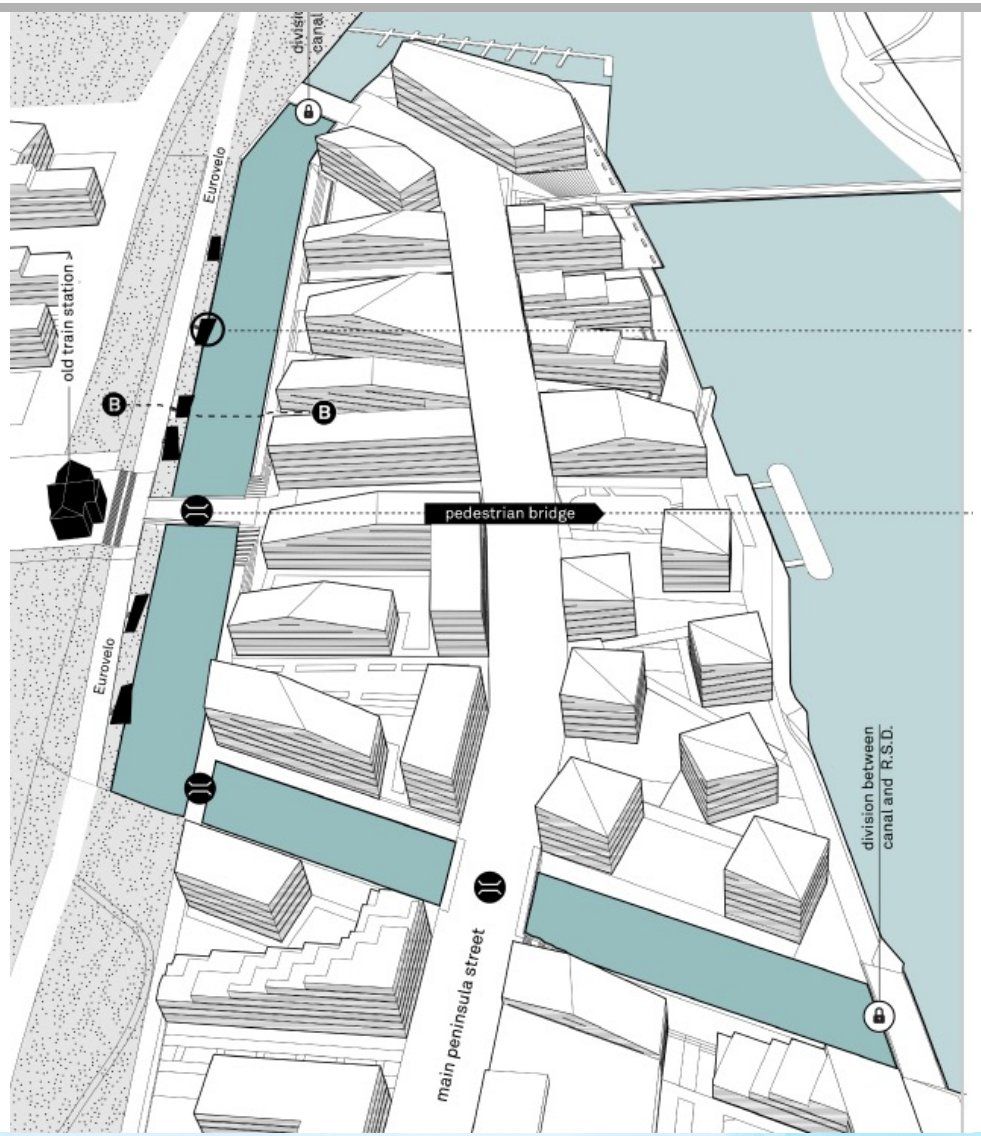


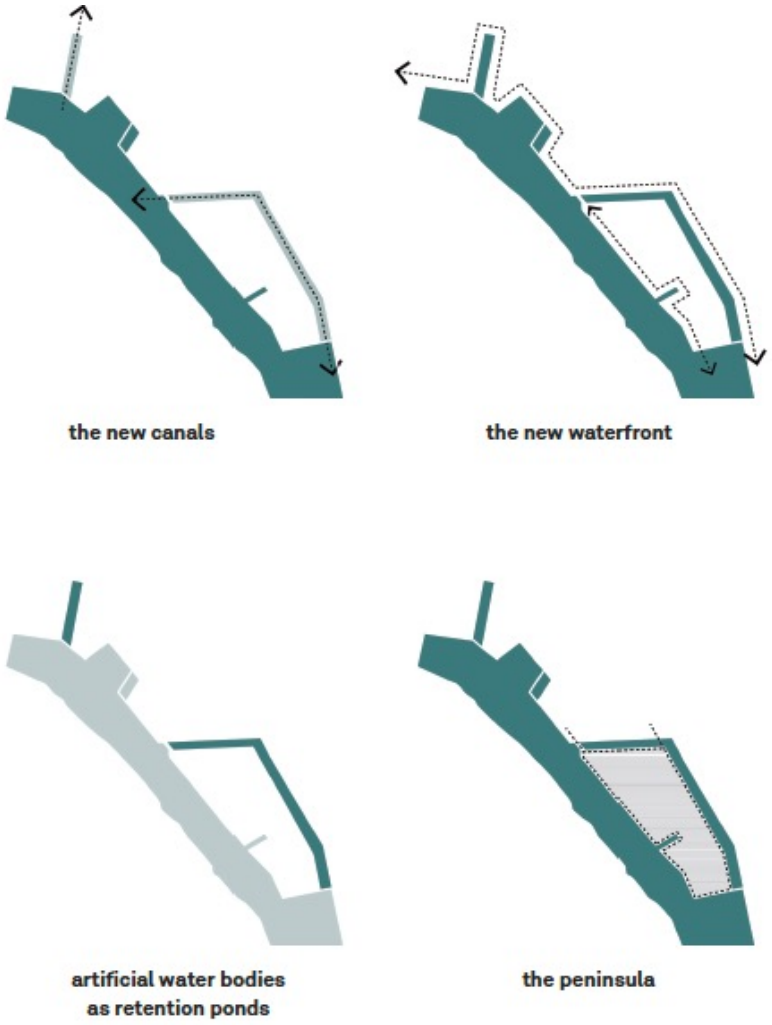



# Some nice pictures



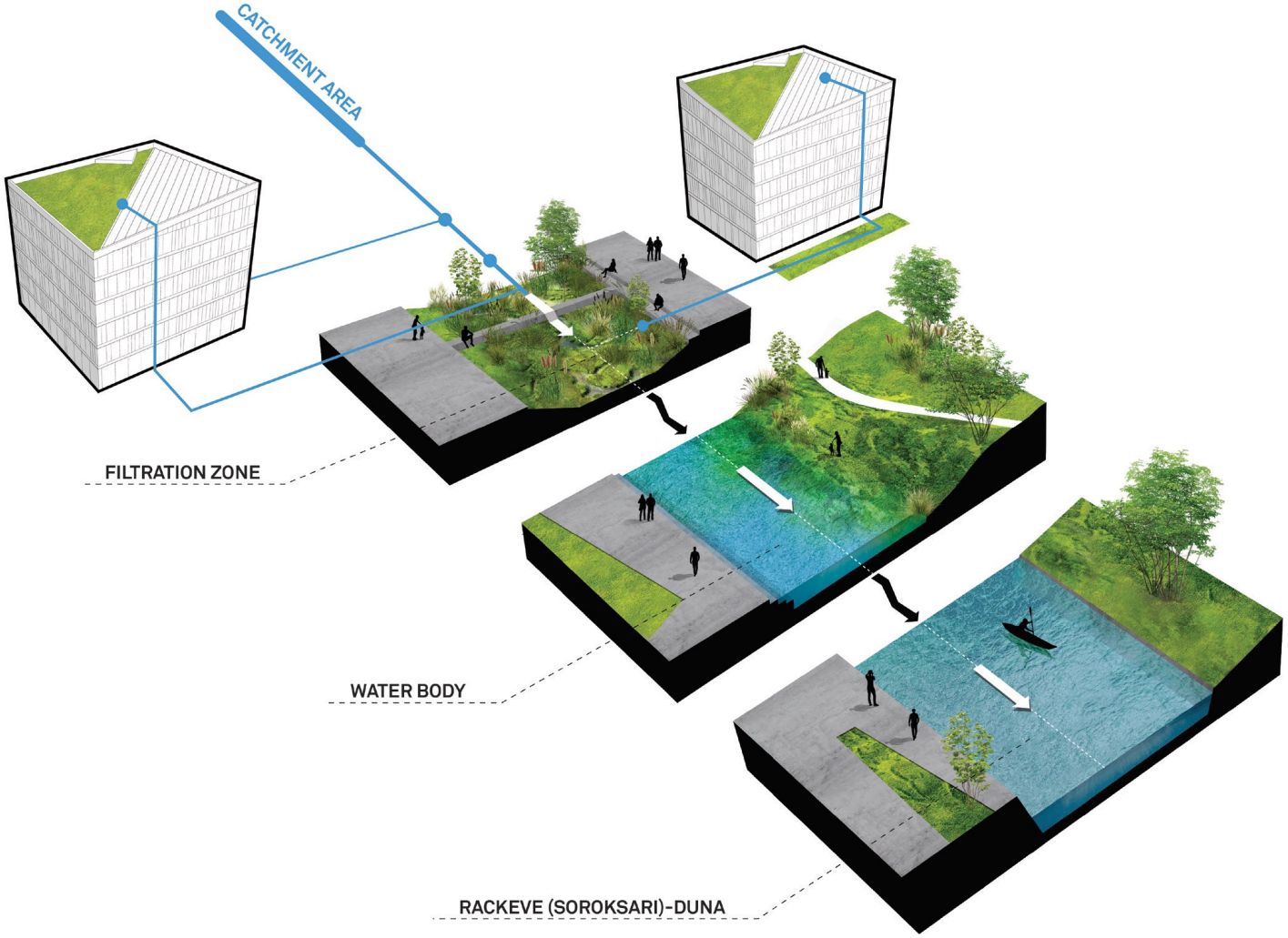
# Some nice pictures – water



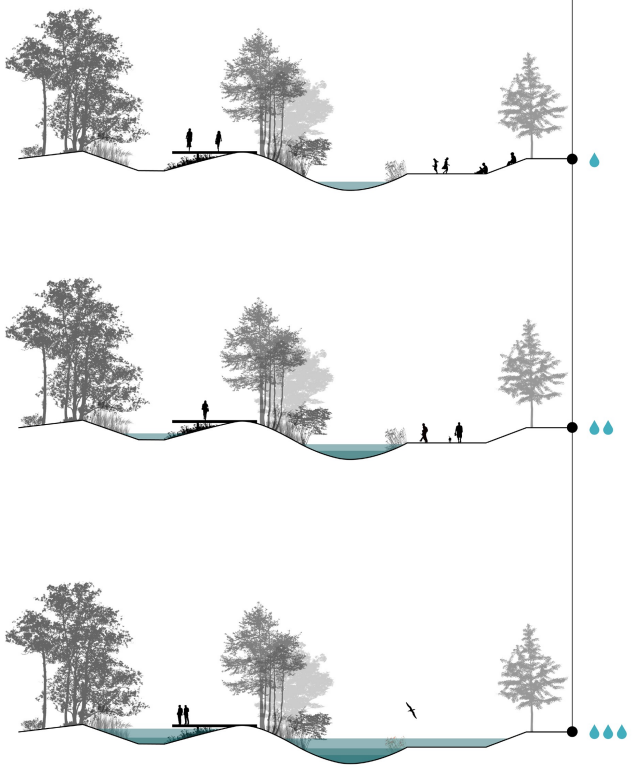
# Some nice pictures

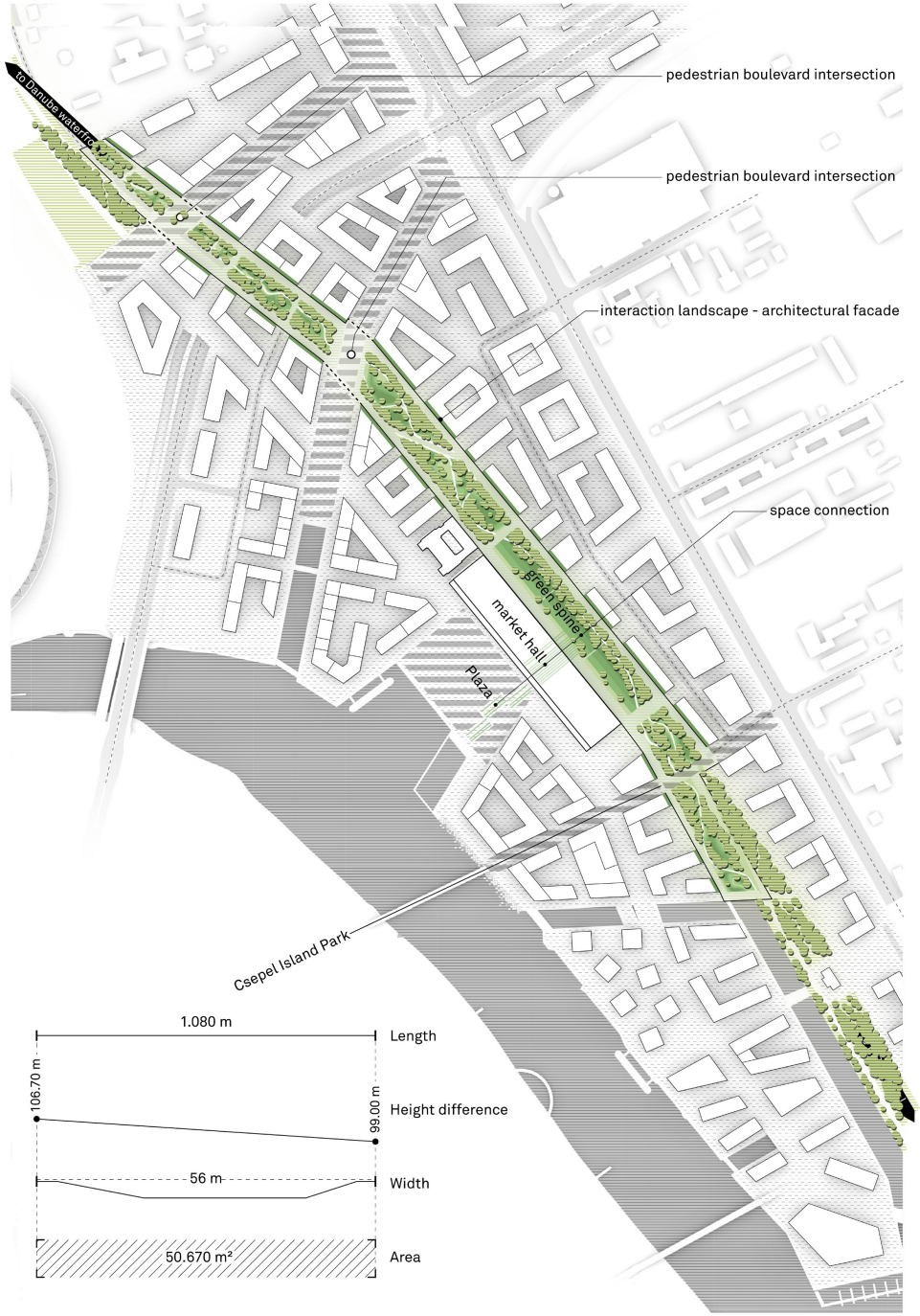
Nicely designed open channel water management / rainwater treatment.



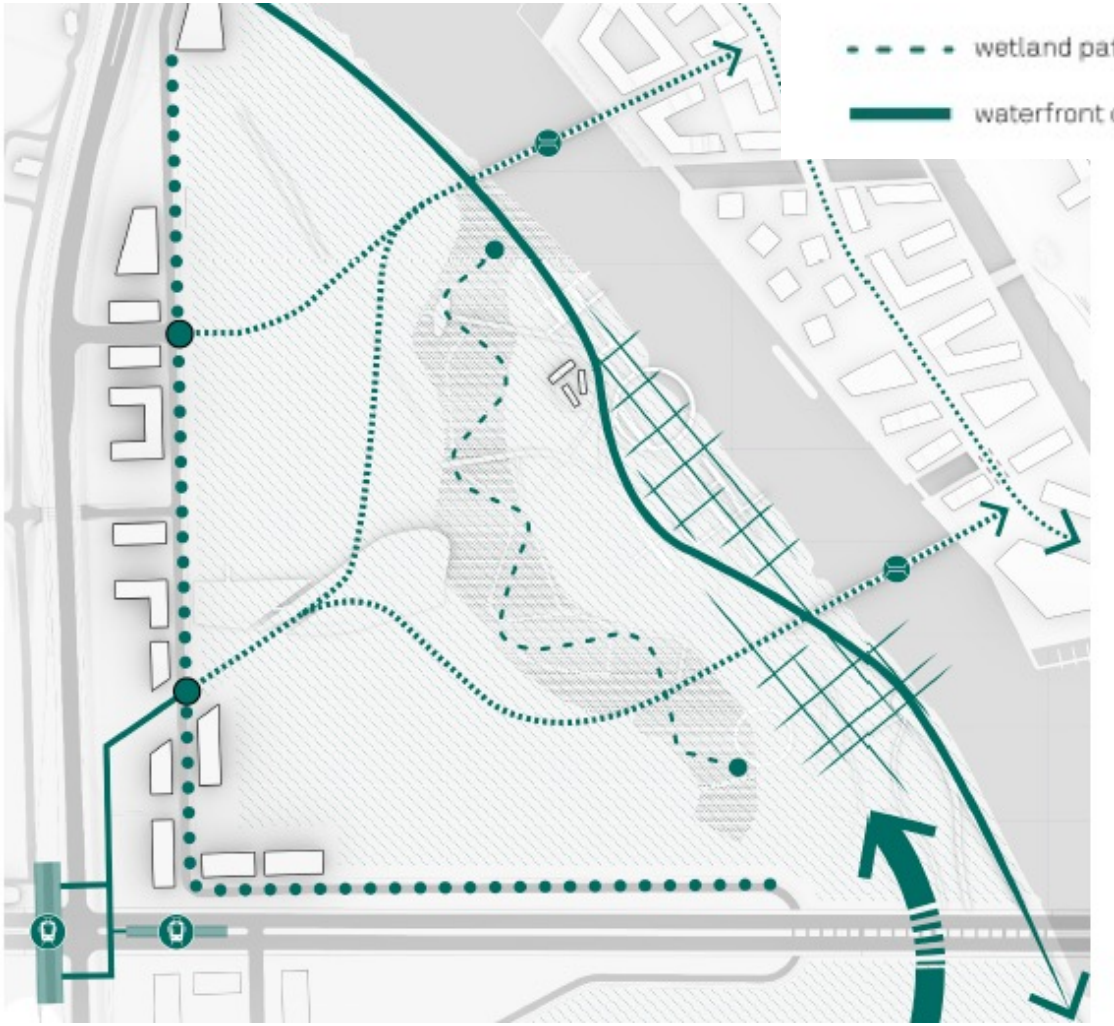
# Some nice pictures – green spine

The landscape has to be modelled in order to create a sequence of different ambients and different functions. The designer has to coordinate the design of the vegetated area, the space for relax and outdoor activities, paths and spacial connections. With an accurate soil modeling the green spine will be able to collect the stormwater coming from the catchment areas. Depending on the soil shape a temporary water landscape will food the green spine, generating a "landscape in movement".

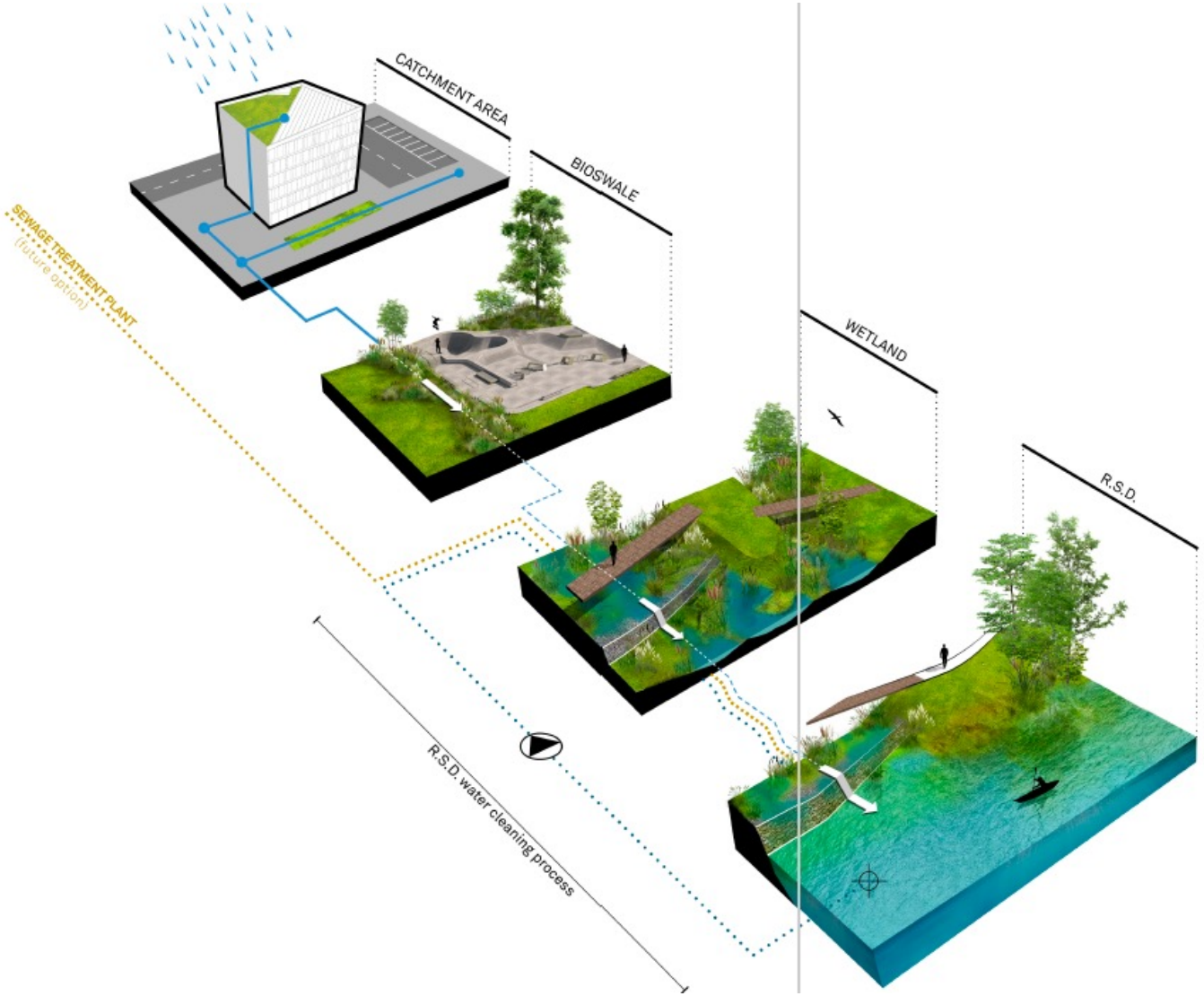




# Some nice pictures – same concept on the Csepel island side




# Some nice pictures – rainwater again



# Some nice pictures

# The End - Thank You for your attention !!!

Many thanks to BFK and FÖMTERV for the pictures!

# The End - Thank You for your attention !!!

**eurammon e. V. is always available as a sparring partner for questions on refrigeration with natural refrigerants.**

Contact:

Dr. Karin Jahn | Lyoner Straße 18 | 60528 Frankfurt | Germany

Phone: +49 (0)69 6603-1277 | E-Mail: karin.jahn@eurammon.com

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