"Seeing is believing"

Combining Cooling & Heating to Provide Heat for a Low Temperature District Heating (LTDH) System

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July 2021

"The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 767799-COOL DH- H2020-EE-2016-2017/H2020-EE-2017-RIA-IA"

COOL DH – Abbreviation

- **C**ool ways of using low grade heat sources from c**OO**ling and surplus heat for heating of energy efficient buildings with new **L**ow temperature **D**istrict **H**eating solutions.

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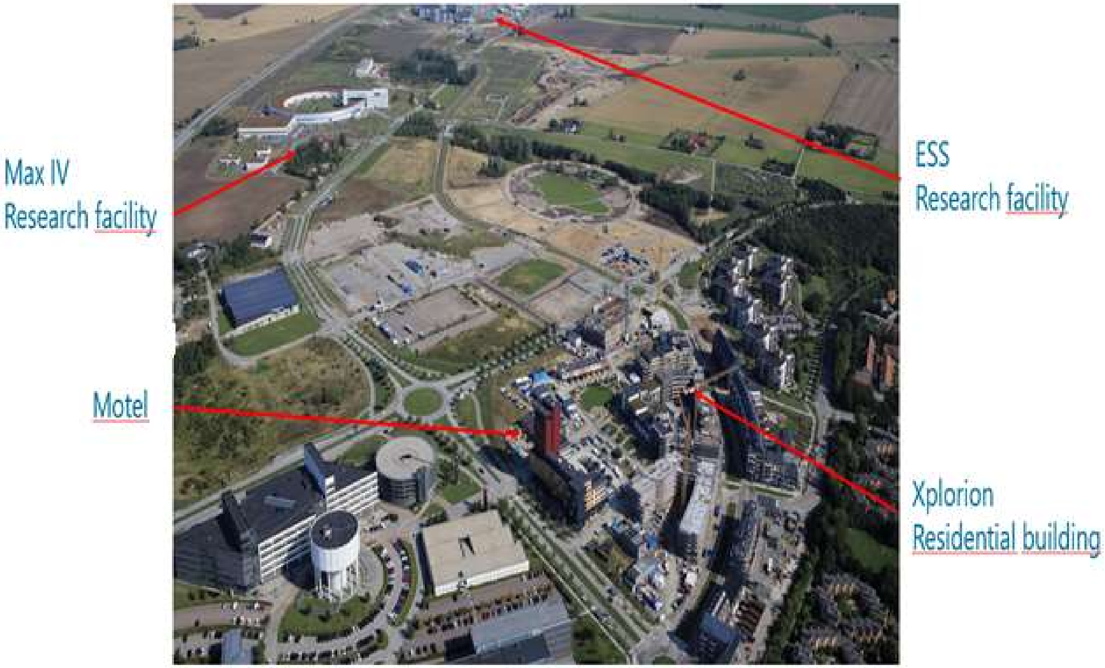
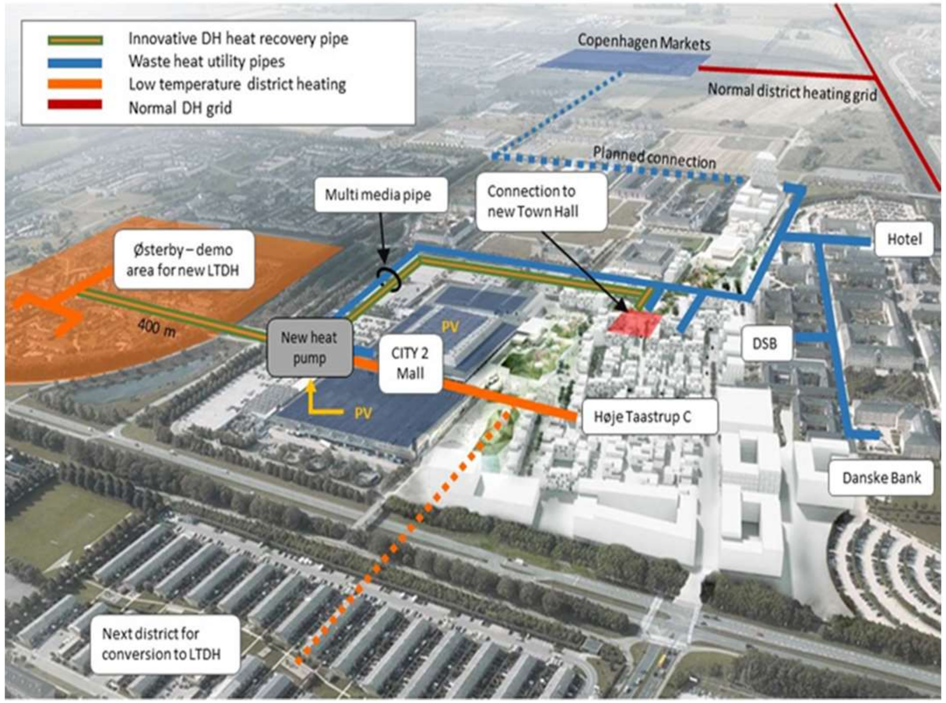
COOL DH – Demos (2017 – 2022)

The Brunnshög demo site 2020





Østerby

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COOL DH – Brunnshög

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COOL DH – Main Characteristics

- Integration of heat pumps for heat recovery and topping hot water
- 2 LTDH networks (4GDH)
- 1 ULTDH demo (5GDH)
- Prosumers role: Shopping, Bank data centers, Hotels
- New Plastic PE-RT pipes
- Flat stations
- Heat recovery pipes
- RES share

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COOL DH – Outcomes

- Energy: More efficiency & lower heat losses
- Economical impacts: Lower cost
- Emissions: Reduction in CO_2
- Social study: Increasing comfort, safety & customer satisfactions
- Replicability: More than 800 DH utilities in both countries

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- Heat source: The heat recovery system at MAX IV composed by a series of HPs

- Purpose: Supply cooling demand of the facility and at the same time recovering the surplus heat from low temperature heat source to supply local district heating network.

- Combining Cooling & Heating to Provide Heat for a LTDH System

- RES: The district heating is entirely supplied by renewable sources since the electricity for the heat pumps is produced by hydropower.

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HP installed at MAX IV

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DH distribution pipe, heat exchanger & circulation pump

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Vibration sensitive

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Properties of the system

- Capacity: 5.8 MW for the heating and 5.2 MW for the cooling circuit
- 2021 Consumption Estimation: 16.7 GWh of cooling and heat recovery of 23.3 GWh
- COP_h = 3.6 and COP_c = 2.5 in high-temperature mode
- Expected COP_h > 4 when in low-temperature mode.

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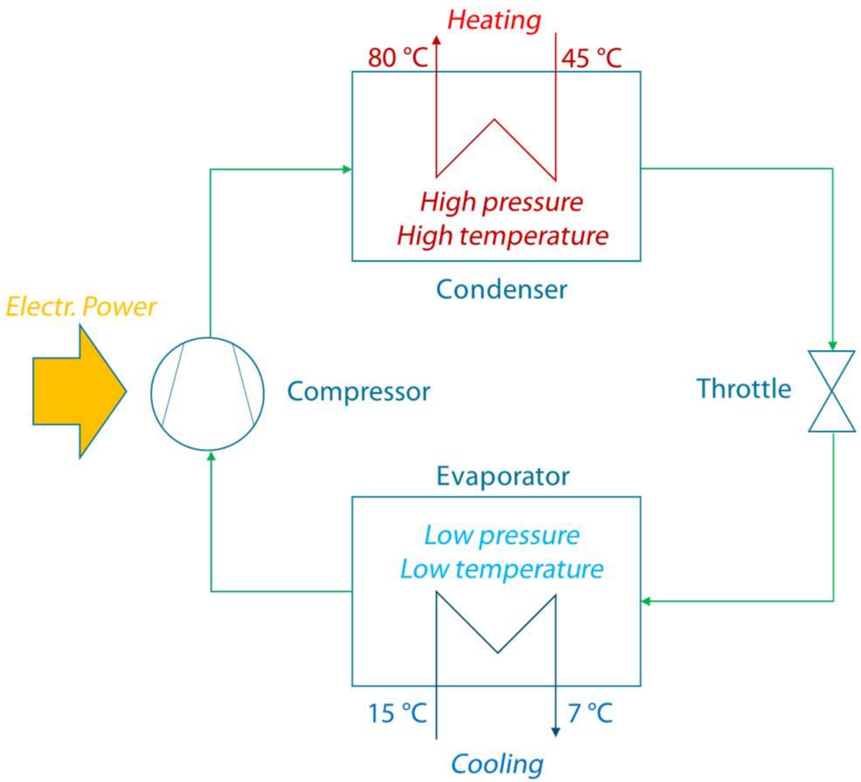
HP Basics



$$COP_{Carnot} = \frac{T_{Cond}}{T_{Cond} - T_{Evap}}$$ (Temperatures in Kelvin)

COPc = (273+80)/(80-7) = 4,8

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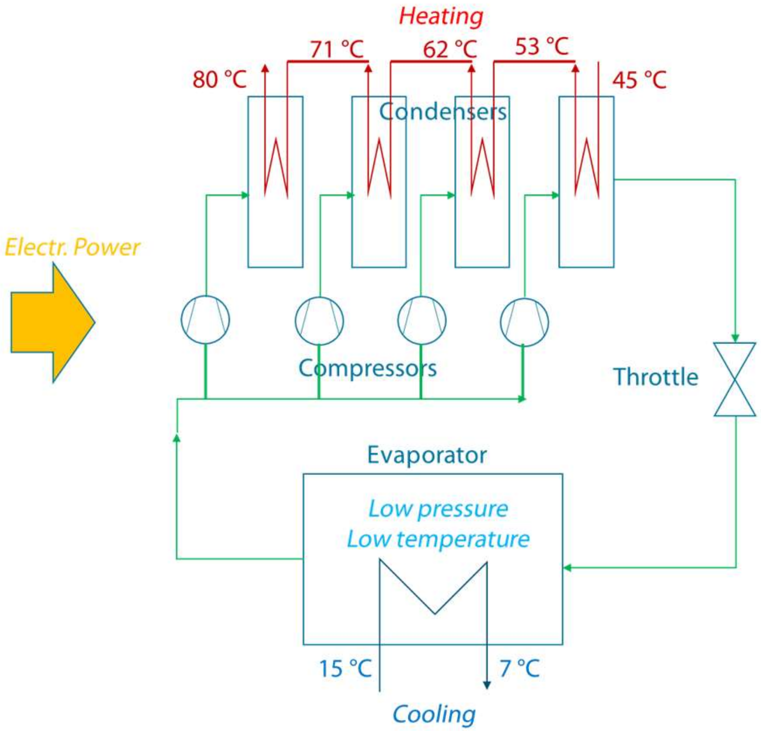
Cascade Coupling



$$COP_{Carnot} = \frac{T_{Cond}}{T_{Cond} - T_{Evap}}$$ (Temperatures in Kelvin)

COPc = 0,25* (273+80)/(80-7) +
0,25* (273+71)/(71-7) ..... = 5,8

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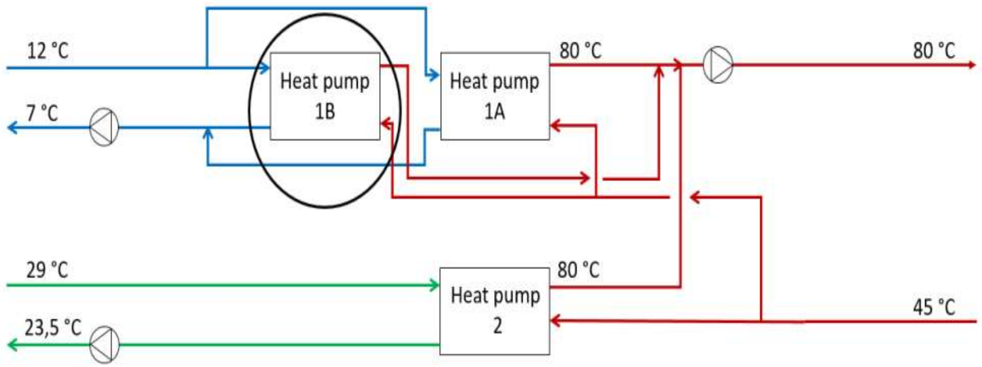
Heat Pump System

- Division into several temperature levels
- Three main HPs
- Optimization of the cooling temperatures
- Cascade coupling of the individual units
- Supply both the high and low-temperature district heating network



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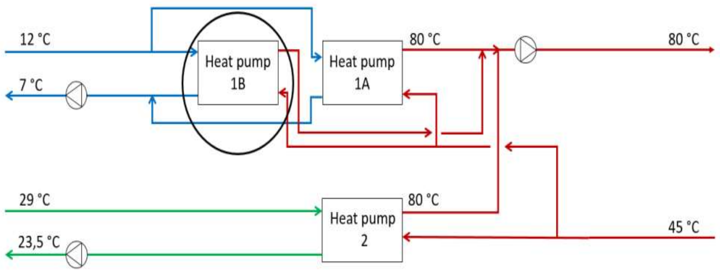
Results of HP1



Cold Side

Flow [m³/h]	Water temp in [°C]	Water temp out [°C]	Cooling power [kW]
101.1	16.9	7.3	1131
100.1	16.8	7.2	1116
102.2	16.9	7.2	1156
116.1	16.2	7.7	1140

Hot Side

Flow [m³/h]	DH water temp return [°C]	DH water temp supply [°C]	Heating power [kW]
45.8	40.6	78.1	2001
48.2	41.1	78.2	2081
46.6	40.7	78.1	2019
40.2	40.2	78.2	1780

COPs

Power consumption [kW]	COP_C	COP_H
666	1.7	3.0
704	1.6	3.0
690	1.7	3.0
608	1.9	2.9

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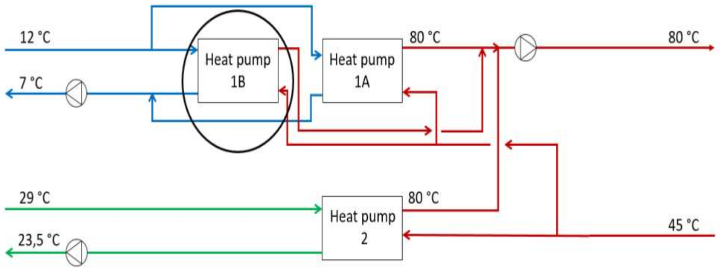
Results of HP2



Cold Side

Flow [m³/h]	Water temp in [°C]	Water temp out [°C]	Cooling power [kW]
167.8	27.1	22.8	854
166.3	27.2	23.1	778
160.2	27.1	22.8	796
162.7	27.1	22.0	971

Hot Side

Flow [m³/h]	DH water temp return [°C]	DH water temp supply [°C]	Heating power [kW]
32.3	40.6	73.2	1226
28.2	41.1	74.4	1086
26.7	40.7	76.8	1128
30.2	40.2	79.4	1381

COPs

Power consumption [kW]	COP_C	COP_H
342	2.5	3.6
302	2.6	3.6
320	2.5	3.5
403	2.4	3.4

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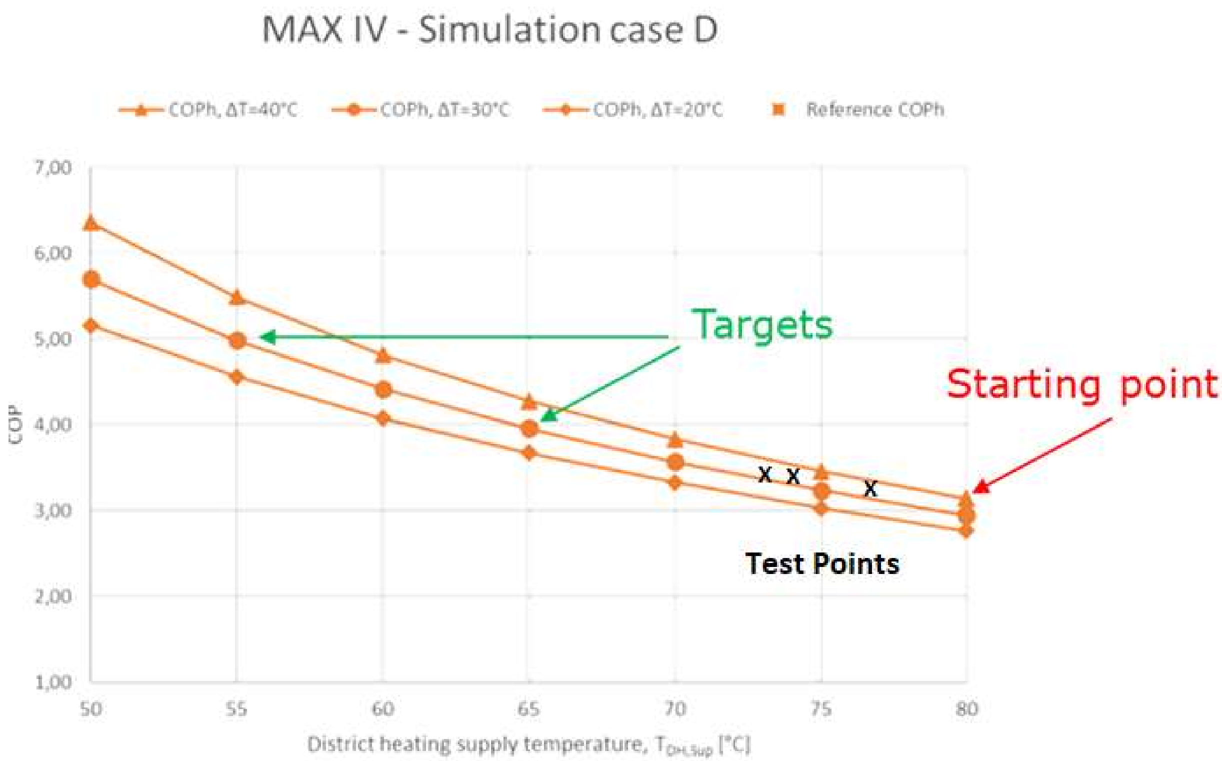
Results – COP of hot side

- Importance of LTDH system



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COOL DH - Challenges

- COVID-19 (Stop & delay)
- Coordination between companies & municipalities in two countries
- Progress is not the same as planned
- Low knowledge & experiences in innovations & new concepts
- Changes in project plans (Demos & fabrication)
- Communication with costumers and partners

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COOL DH – Lessons Learned

- Predict unexpected events
- Importance of planning
- Mutual understanding
- Considering practical delays
- Training
- Flexibility for changes
- Having plan B
- Social awareness

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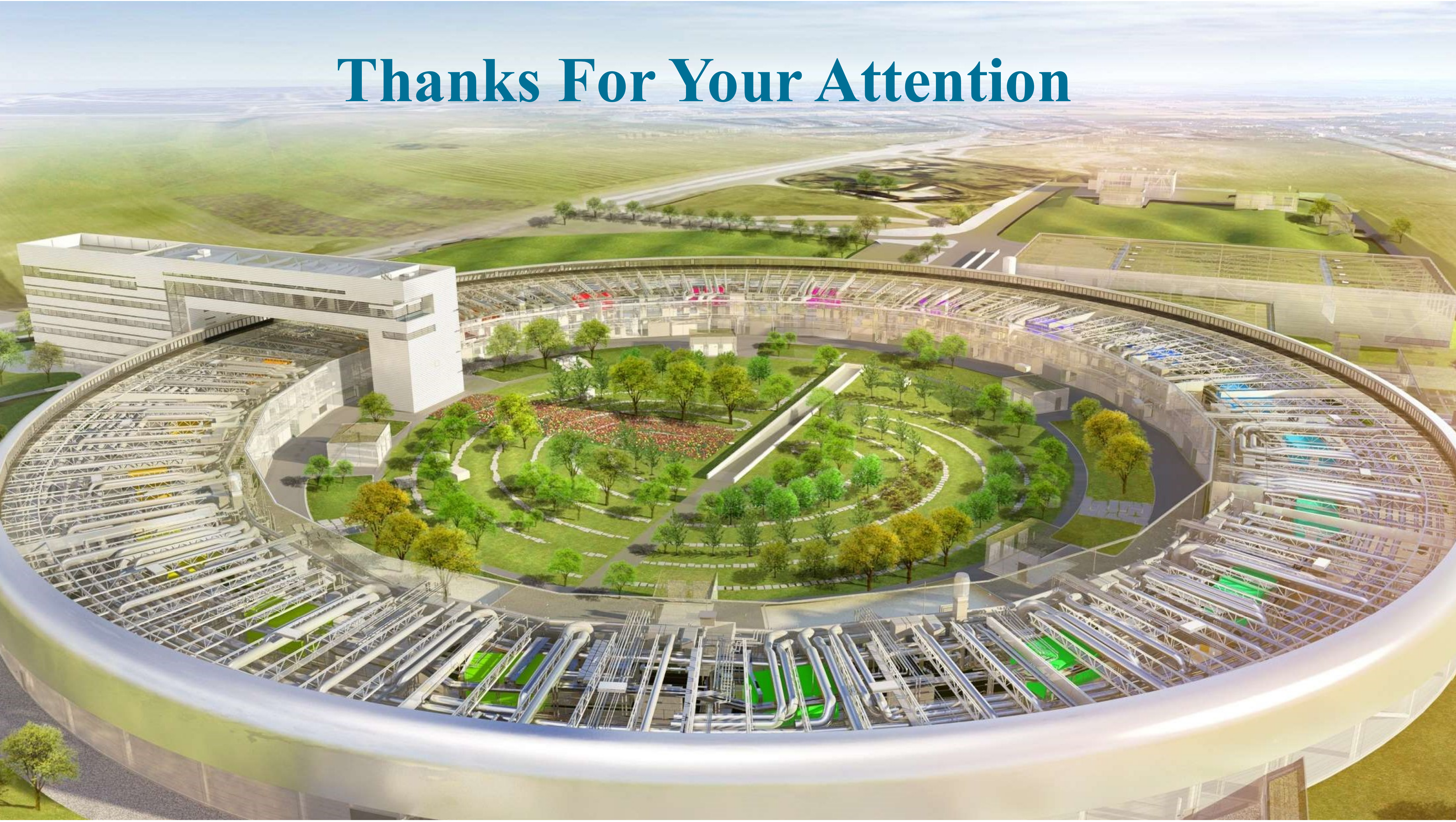
Thanks For Your Attention