DISTRICT COOLING 2016 A CLIMATE SOLUTION
IDEA CONFERENCE NOV. 13 - 15

JØRGEN SMEDEGAARD, RAMBOLL ENERGY

KING ABDUL AZIZ ROAD PROJECT.

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AGENDA FOR MY PRESENTATION 20161115.

- **Welcome to this presentation –Jørgen Smedegaard.**
- **KAAR Project**
- **In Numbers**
- **Scope of deliveries.**
- **Status of KAAR project.**
- **Distribution Network Design**
- **Questions.**
- **Thank you.**

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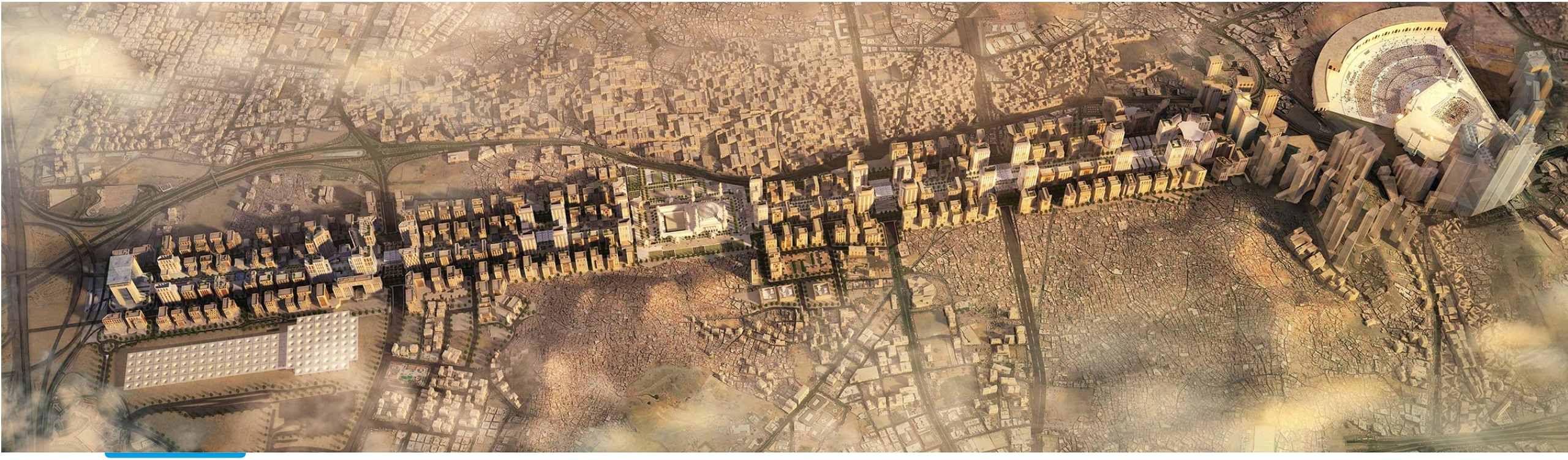
DISTRICT COOLING IN MAKKAH
KINGDOM OF SAUDI ARABIA
KAAR – PROJECT
KAAR - KING ABDUL AZIZ ROAD



Area covered:	1.35 million m^2
Gross floor area:	6.45 million m^2
Cooling capacity:	148,000 TR = 519 MW
	Revised values
Main DC network:	3,500 metres
Residents:	123,600
Transportation capacity	120,000 people/hour

Ramboll offices in Project:
Run by Ramboll Energy-District Energy division.
UK, Sweden, Middle East and DK.
Subcontractor: District Cooling project knowledge from Middle East
Head count: Approx. 20.

SCOPE OF SERVICES.

PHASE 1

- **Activity 1 Market demand estimations and load profiles**
- **Activity 2 Concept Design**
- **Activity 3 Financial analysis**
- **Activity 4 Baseline procurement and contracting strategy**
- **Activity 5 Employer's requirements**
  - **Activity 5.1 Design basis**
  - **Activity 5.2 Concept design drawing moved to Phase 2, partly done**
  - **Activity 5.3 Technical specifications**
  - **Activity 5.4 Bill of Quantities moved to Phase 2, partly done**
- **Activity 6 Review of network part of act. 2.**

PHASE 2

- **Finalization of Employer's Requirements.**
- **Appointment of the DC Operator.**
- **Appointment of Design and build Contractor.**
- **Appointment of DC provider.**
- **Design Review Services.**
- **Preparation/review of DC services Agreement.**
- **Preparation/review of DC concession Agreement.**
- **Preparation/review of Operation and Maintenance Agreement.**

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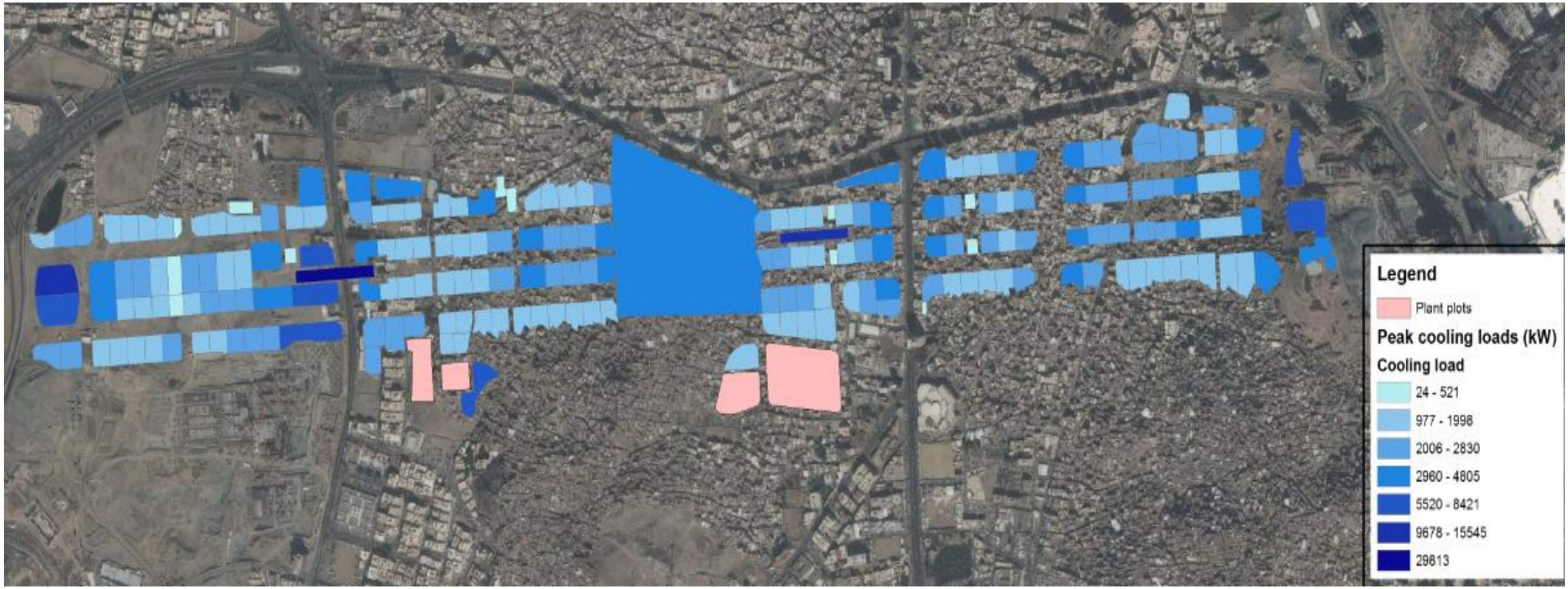
LOAD CALCULATIONS.



Load calculation:

- **Building categorization**
- **Peak loads for 22C**

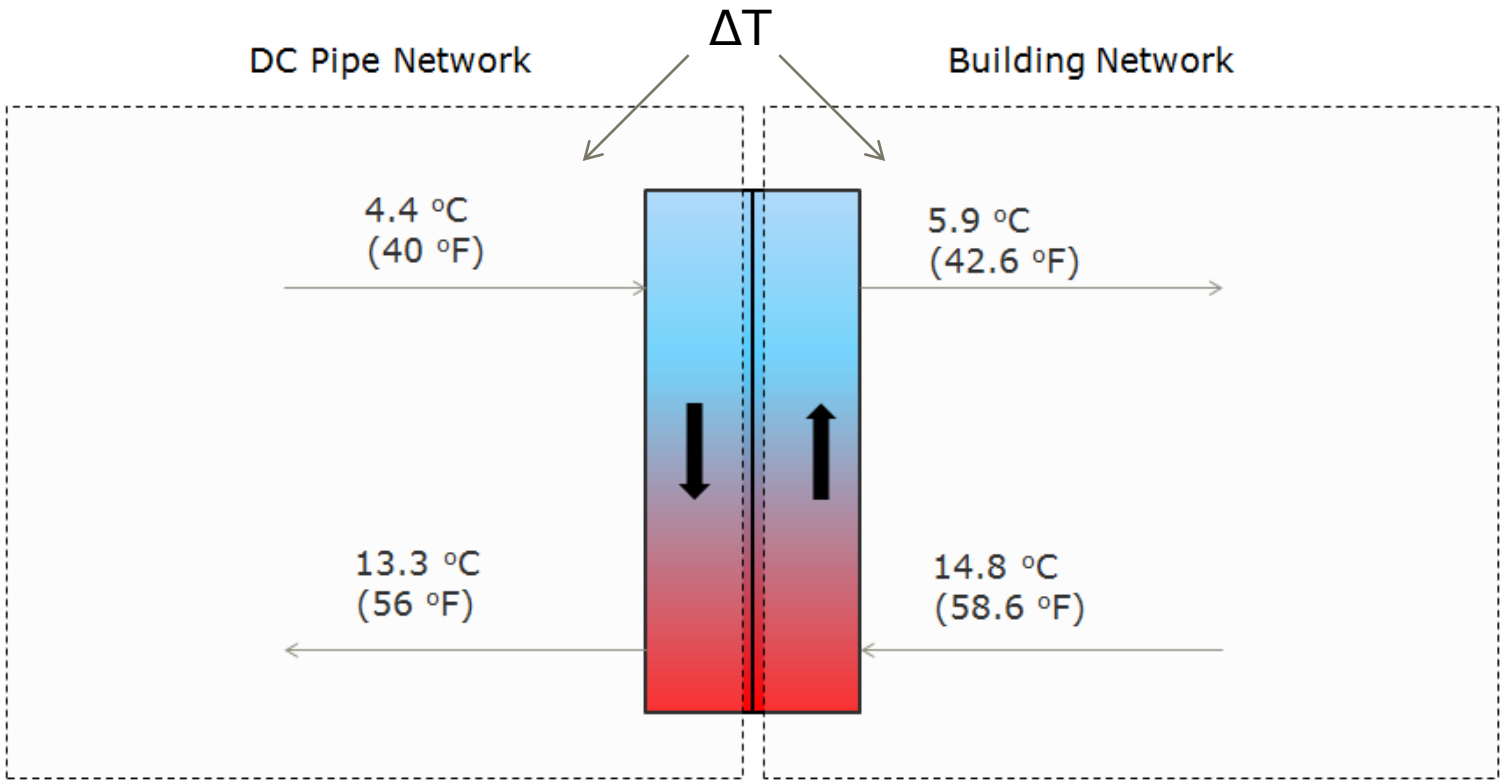
DESIGN PHILOSOPHY

Pressure rating: **16 bar**

(Highest building 120m)

Approach temperature: **1.5 °C**

(Inversely proportional to area)



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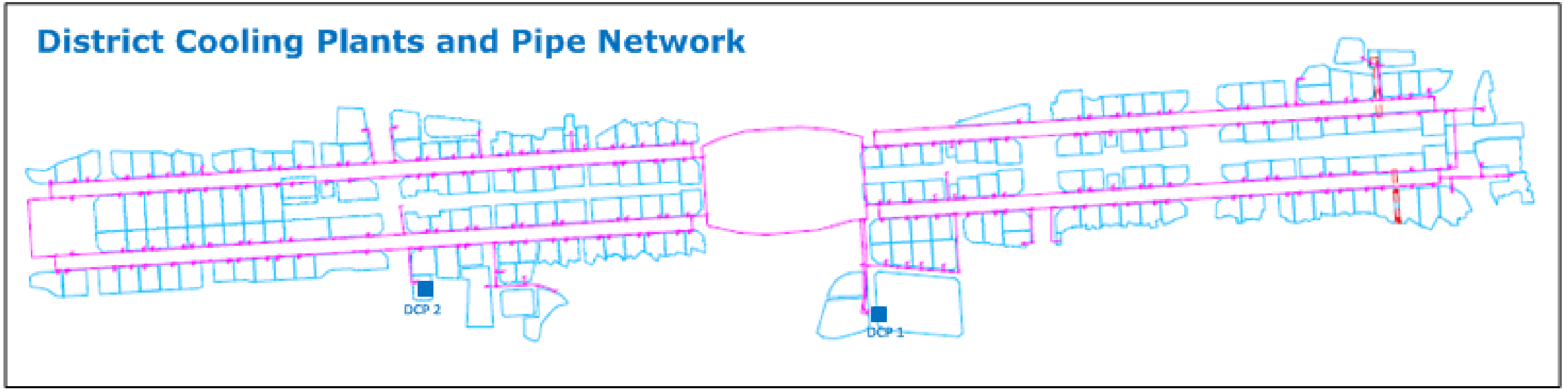
NET WORK AND DC PLANTS

2 SEPARATE COOLING PLANTS EACH EQUIPPED WITH

- 225,1 MW chiller capacity based on 16 chillers.
  4,16 kV supplied double compressor centrifugal chiller units in 8 production lines each with 2 x 28,1 MW cooling capacity with counter flow setup, refrigerant R1234zd.

- 272,6 MW cooling tower capacity, open circuit type, based on 6 cooling towers in parallel.
  690 V supplied.

- TSE water treatment facility and storage.



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COOLING SYSTEM DESIGN

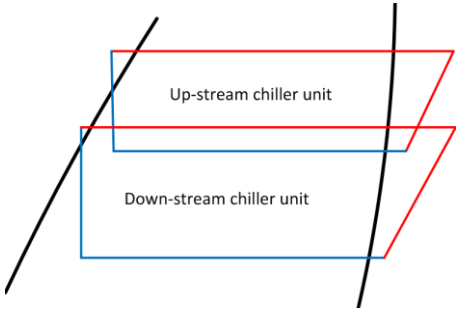
Chiller configuration

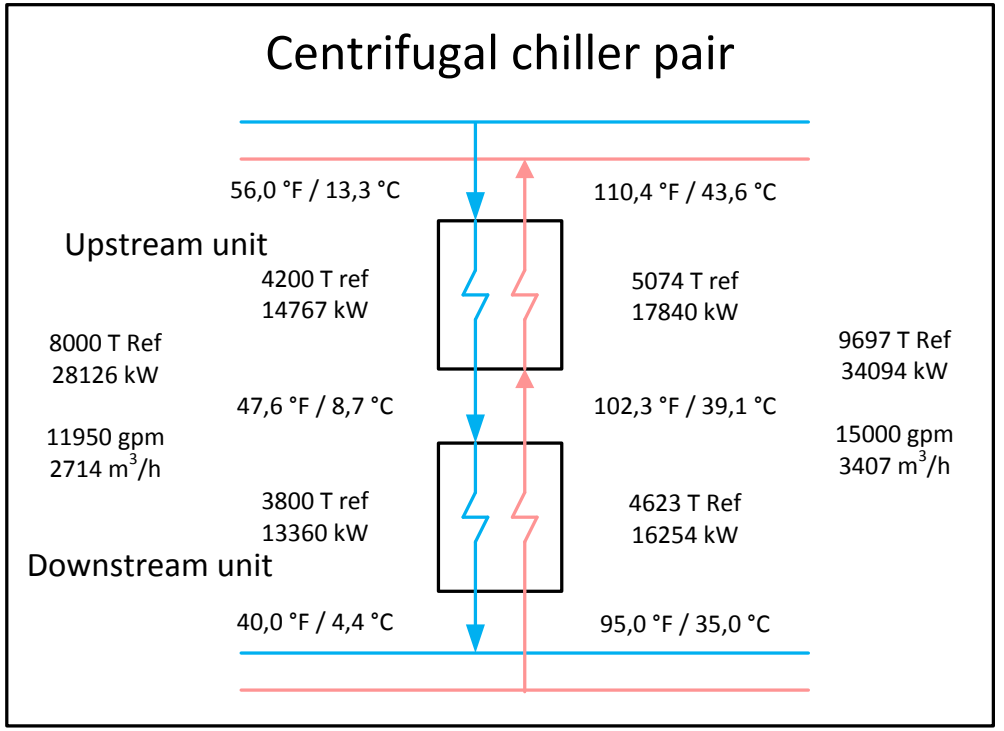
To obtain the demand of a high COP the chillers are organized two and two (A Pair) in counter stream.

This results in COP = 5,30 (At Peak capacity)

The calculated Annual COP = 6,1

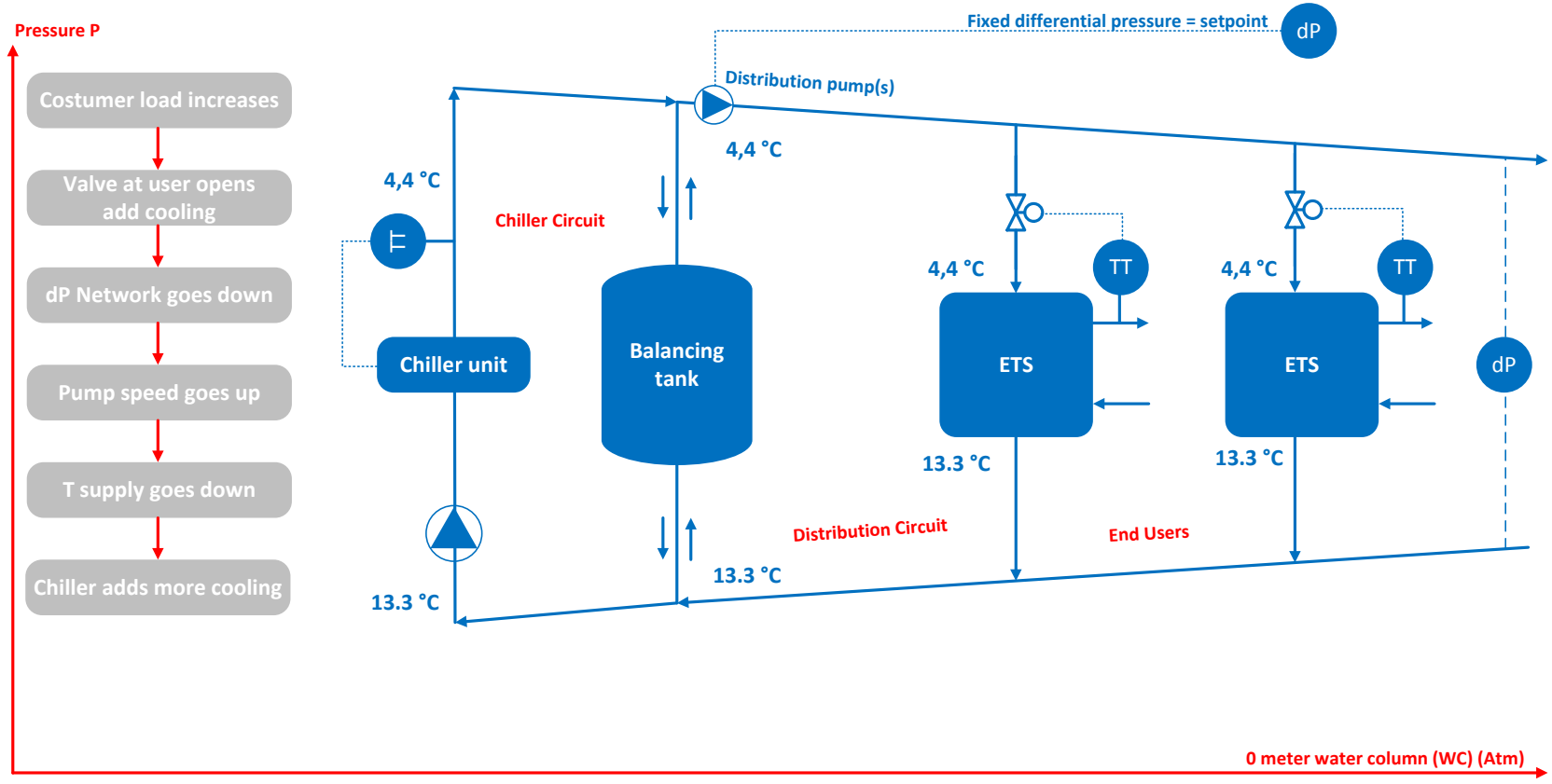
Further each chiller are equipped with two centrifugal compressors on common evaporator (chiller) and condenser



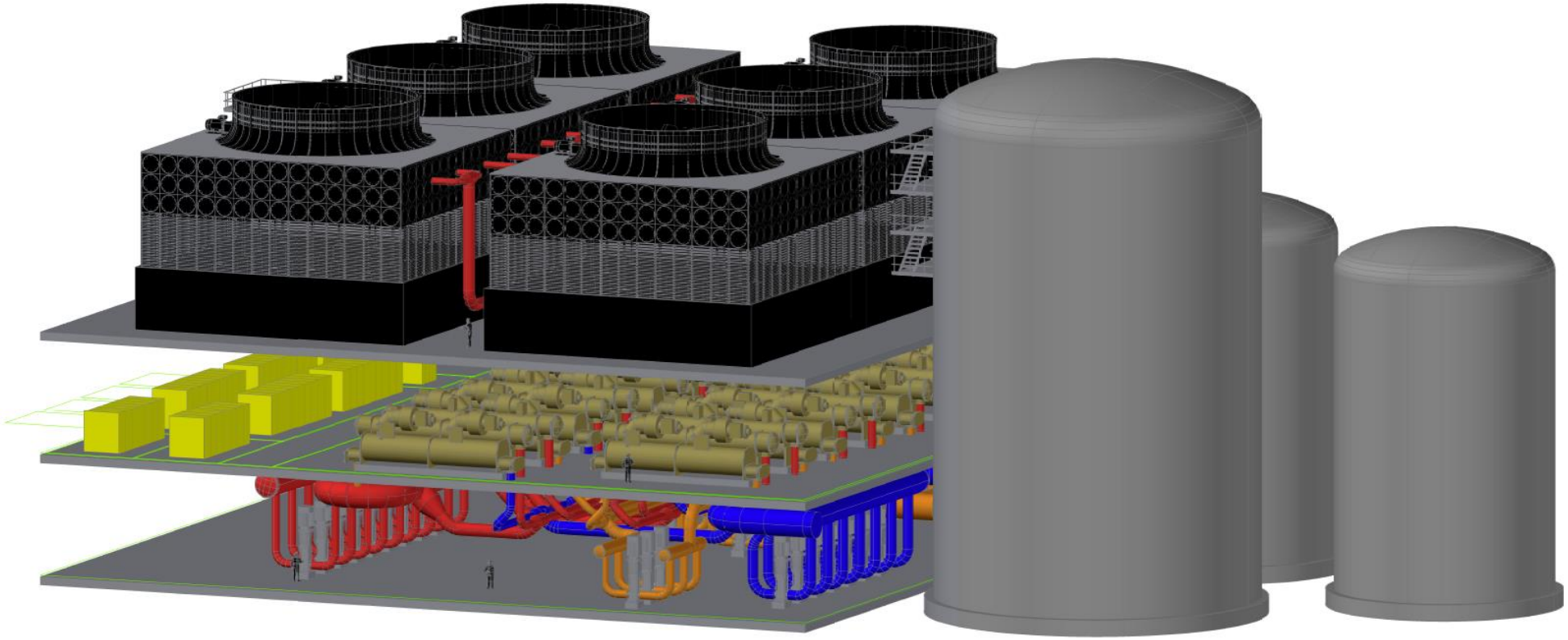


CONTROL STRATEGY

One Cooling Plant Operation



3D – MODEL DISTRICT COOLING PLANTS.



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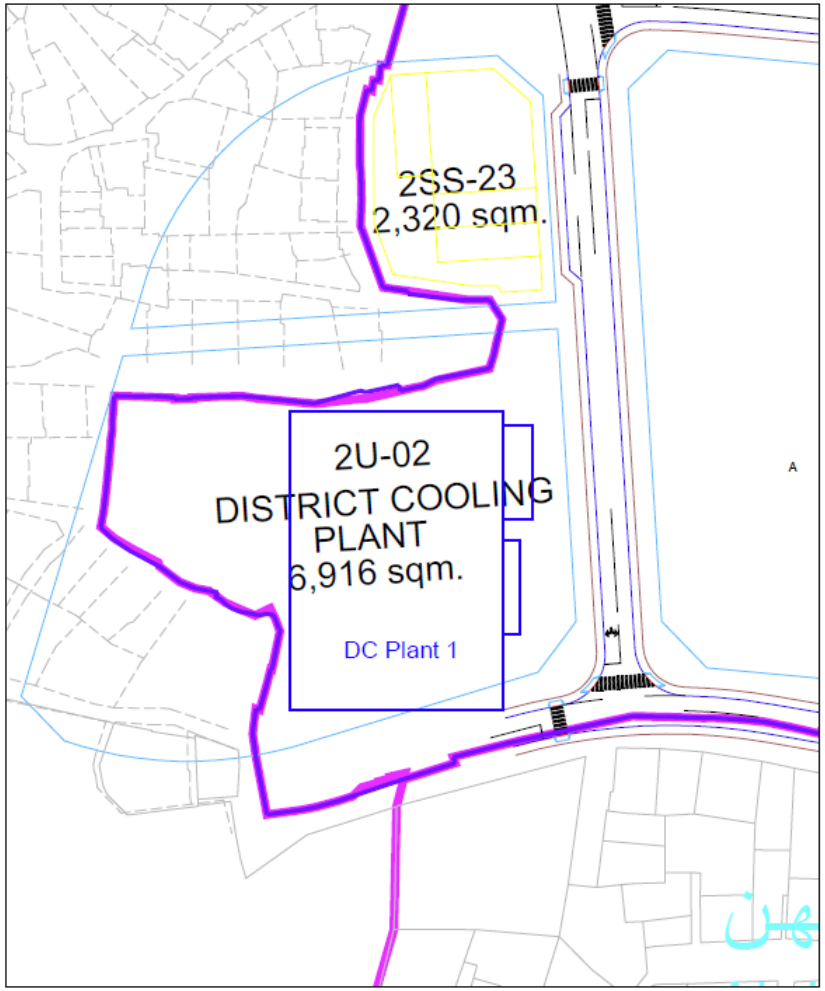
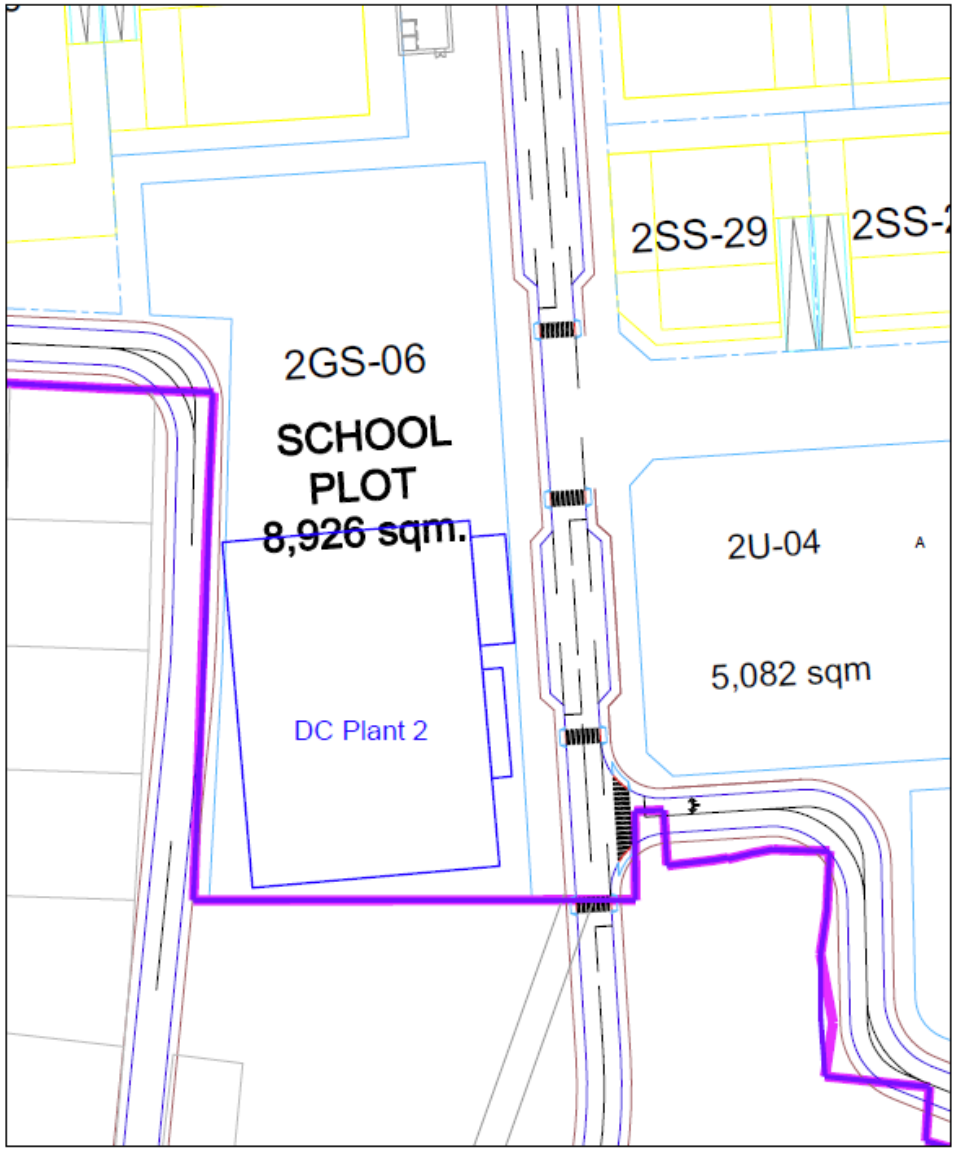
PLACEMENT AND SIZE OF DISTRICT COOLING PLANT IN KAAR MASTERPLAN.





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PIPE DESIGN AND SUPPLY SECURITY.

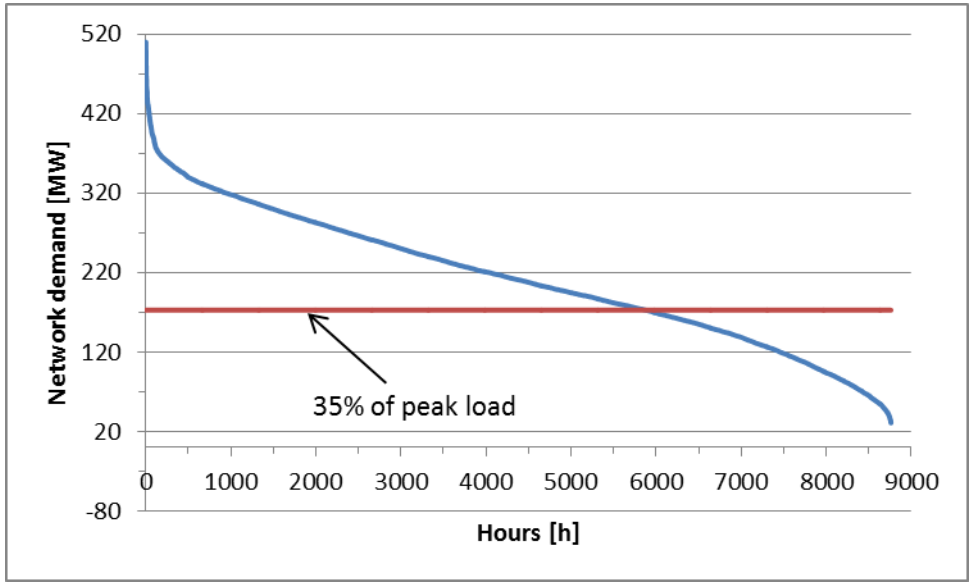
Hydraulic capacity of supply up to 57% of peak load in case of supply from only chiller plant 1

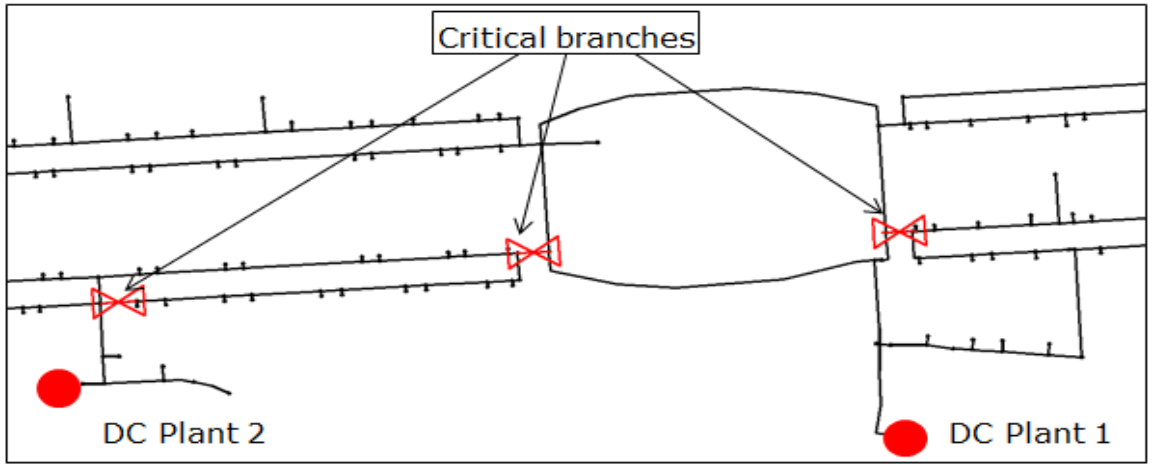
Hydraulic capacity of supply up to 40% of peak load in case of supply from only chiller plant 2

Duration curve and 35% of peak load = 181.6 MW Possible to supply 2800 h in case of maintenance.

Two critical branches that are closed one at the time in order to simulate maintenance in the network.

Security of supply simulations is carried out for other critical branches for instance the branches around the central Mosque.





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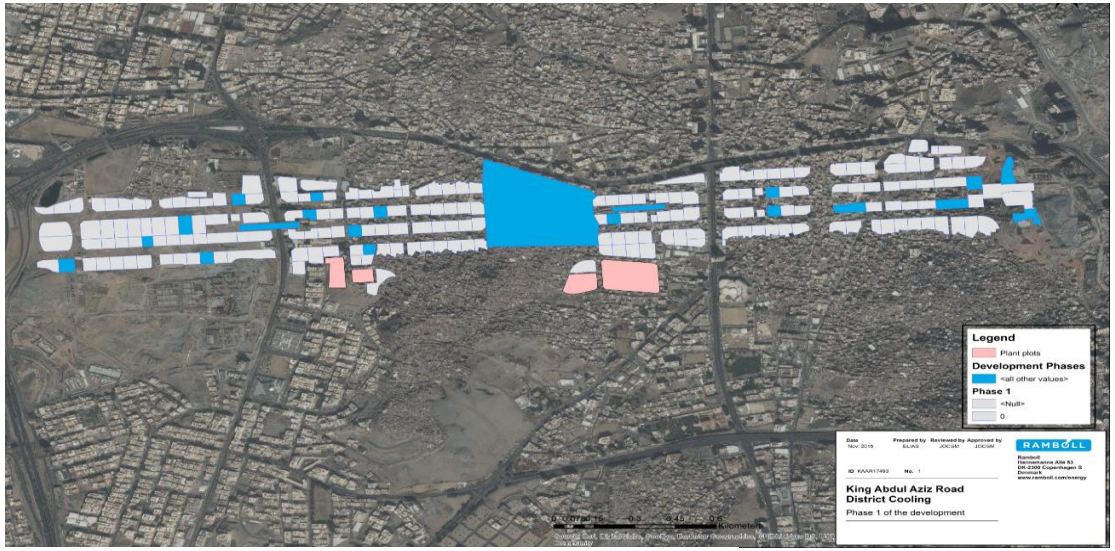
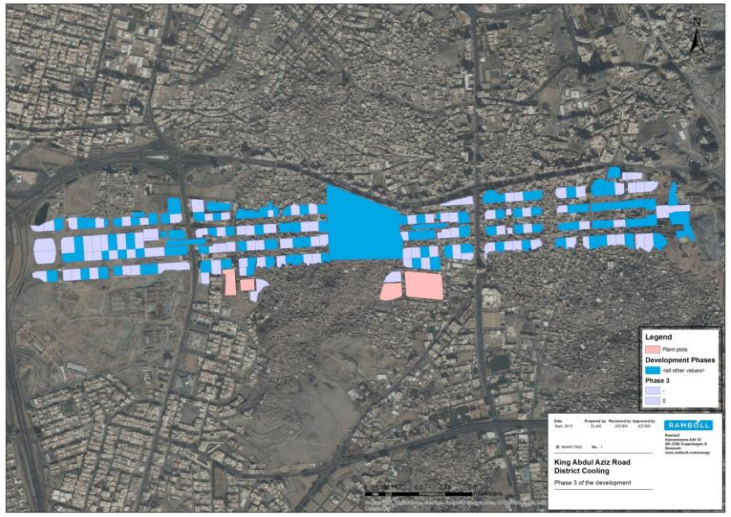
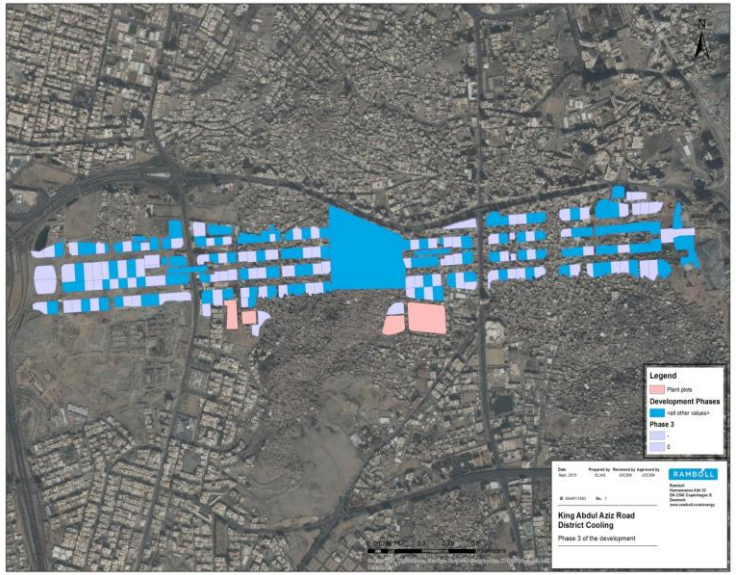
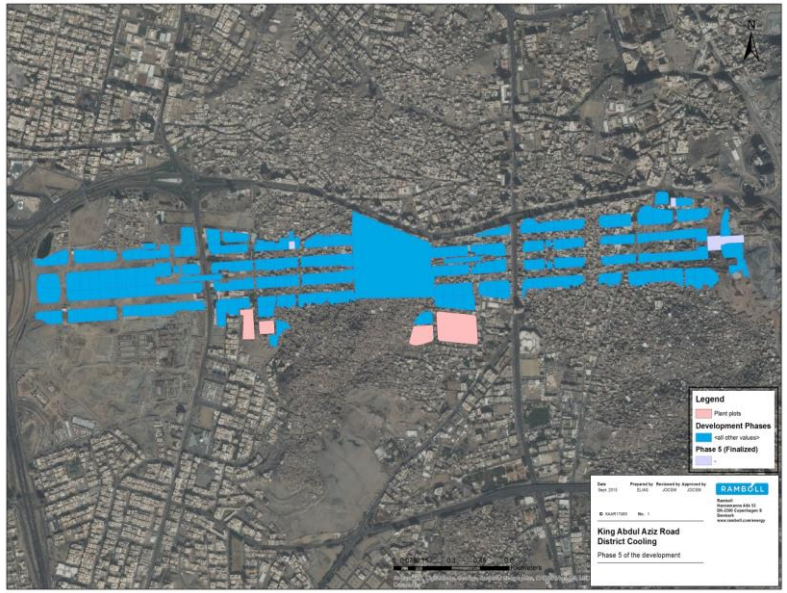
PHASING 1 - 5

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Cooling Load (MW)	90.6	250.8	295.3	434.0	519.0









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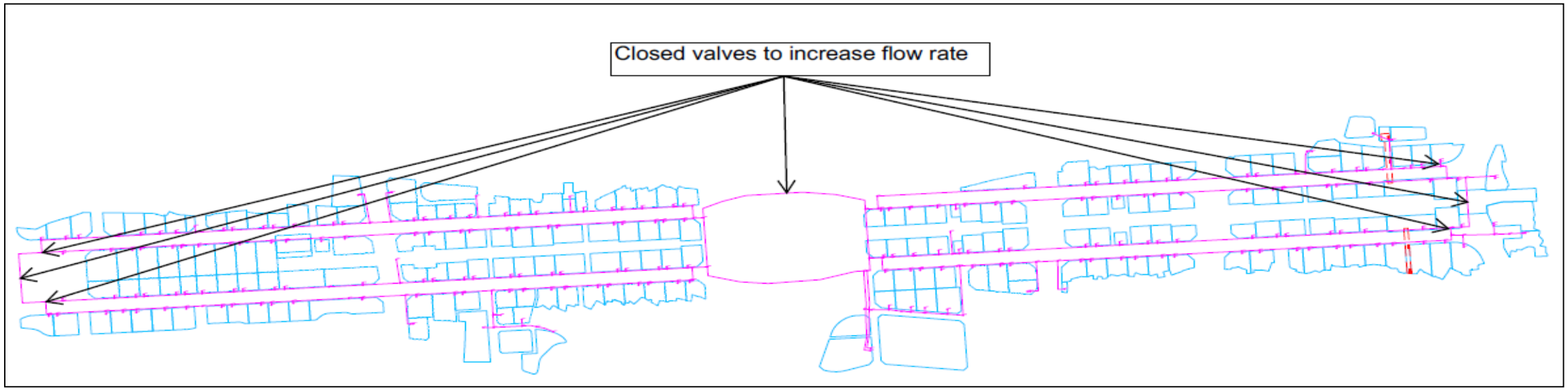
PHASE 1 – CHILLER PLANT 1



- The network demand in the low load situation of phase 1 is 6.3 MW (7% of 90.6 MW). Supply temperature > 5.4 ºC.

- Plot 1: 5.6 ºC
- Plot 2: 5.8 ºC
- Plot 3: 5.8 ºC
- Plot 4: 12.1 ºC
- Plot 5: 6.0 ºC

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PHASE 2

The network demand in the low load situation of phase 2 is 17.6 MW (7% of 250.8 MW).

The demand is higher than in phase 1. In phase 2 it is only necessary with a bypass at plot 6 with a bypass flow of 3 m^3/h.

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PHASE 3

- **Open the valve in the loop around the central Mosque otherwise there is not enough capacity.**
- **The other valves should still be closed. The network demand in the low load situation of phase 3 is 20.7 MW (7% of 295.3 MW).**
- **As in phase 2 it is necessary with a bypass at plot 6. The bypass should have a flow of 2 m^3/h in phase 3.**

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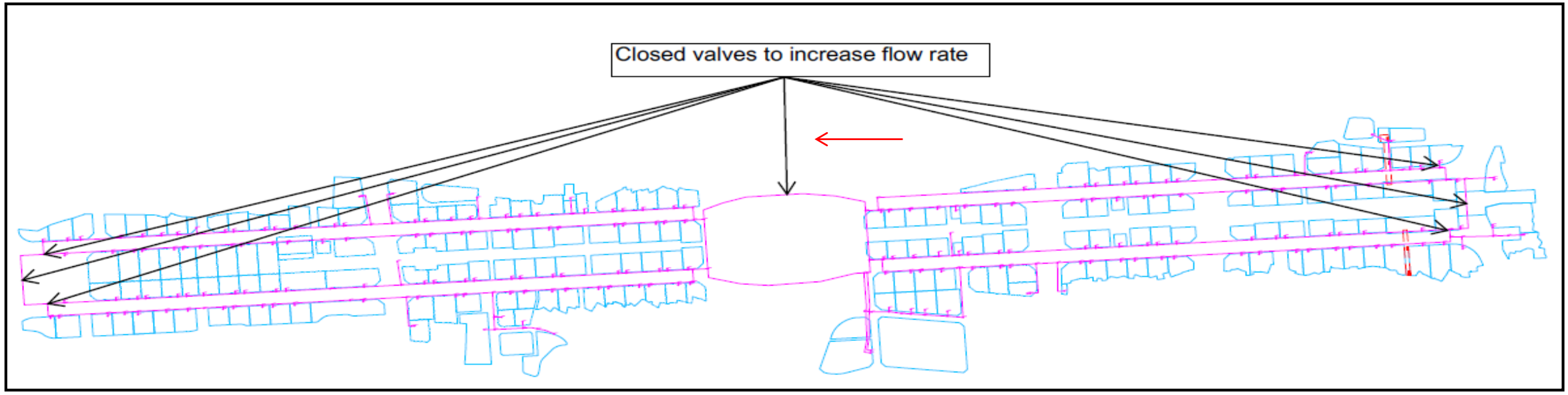
BYPASS IN NETWORK



PHASE 4

- **In phase 4 all the valves should be opened.**
- **In phase 4 it is necessary due to the hydraulic capacity of the network also to have Chiller Plant 2 in operation. The network demand in the low load situation of phase 4 is 30.4 MW (7% of 434 MW).**
- **In phase 4 it is necessary with a bypass at plot 6 like when all buildings are connected in phase 5. The bypass should have a flow of 0.7 m^3/h.**

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DISTRIBUTION PUMPS

- **Distribution pumps controlled to maintain a differential pressure 1 bar across all consumer installations.**
- **The distribution pumps are located at both Chiller Plants.**

Plant	Flow m^3/h	Pump head mWC
Chiller plant 1	21700	60
Chiller plant 2	27900	70

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ENERGY LOSS AND TEMPERATURE INCREASE

- **In the peak situation there is a temperature increase of 0.4 ºC in the supply from Chiller Plant to the most critical consumer with highest supply temperature.**
- **It means the supply temperature is 4.8 ºC at most critical plot. The Plot has an estimated peak load demand of 26 kW and is located at the end of a 100 m service pipe. The temperature increase to 4.8 ºC is not critical.**
- **In a low load situation (7% of peak load) the supply temperature at the plot is 8.8 ºC which is too high. If a bypass is established on the primary side just before the ETS. The supply temperature can be reduced to 5.4 ºC if the flow rate in the bypass is 0.7 m^3/h.**
- **The highest supply temperature in the rest of the network in the low load situation is 5.1 ºC if only Chiller Plant 1 is in operation in this low load situation. If only Chiller Plant 2 is in operation in the low load situation highest supply temperature in the network (besides the 5.4 ºC) is 4.9 ºC.**

Energy loss (gain), kW	**931**
Friction, kW	**3614**

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