

District Heating and Cooling with Large Centrifugal Chiller - Heat Pumps

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- **Friotherm at a glance**
- **Friotherm history**
- **Compressor portfolio**
- **Capacity range single stage, 2-stage**
- **Principle P&I's**
- **Heat pump applications**





Friotherm AG - at a glance

* **Headquarter**

- * Design / Engineering
- * R & D
- * Compressor manufacturing

Winterthur, Switzerland

* **Friotherm companies**

- * Design / Engineering for Nuclear Power Plants
Unit packaging
- * Unit packaging

Weissensberg, Germany

São Bernardo, Brazil

* **Represented abroad by**

- * **Branch Offices**
- * Agents / Partner

France, Sweden

China, Finland, UAE,...

* **Export share**

>95%

* **Main export countries**

**Europe (Sweden, Norway, Finland,
France, Italy, Germany), Brazil and
Far East**





FRIOTHERM compressors development

- 1878** **Manufacturing of the first refrigeration compressor**
- 1920** **First Turbo refrigeration compressor for Ammonia**
- 1927** **Manufacturing of the worlds largest refrigeration compressor**
- 1958** **First Turbo refrigeration compressor for HCFC's**
- 1978** **Development of new generation of 1- and 2-stage Turbo compressors for heat pump applications**
- 2000 - 2009**
 - Design of a high efficiency impeller (2000)**
 - Extension of capacity range by Uniturbo 43BX (2005)**
 - Extension of capacity range by Uniturbo 22S (2009)**





Compressors for chillers / heat pumps

UNITURBO 22S



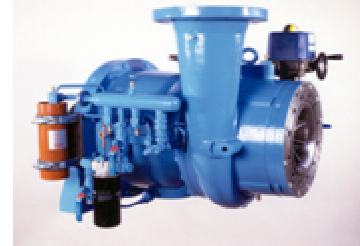
Q_0 up to 1.5MW

UNITURBO 22



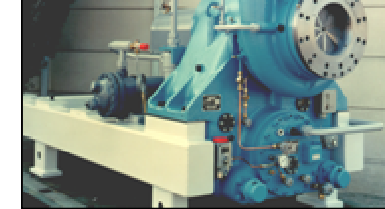
Q_0 up to 2.8MW

UNITURBO 23



Q_0 up to 3.8MW

UNITURBO 28
UNITURBO 33



Q_0 up to 5.0MW/6.8MW

Refrig. capacity range 0.5MW to 10.5 MW per unit

Temperature range -50°C to $+120^{\circ}\text{C}$

UNITURBO 43



Q_0 up to 10.5MW

UNITURBO 34



Q_H up to 9.5MW

UNITURBO 50



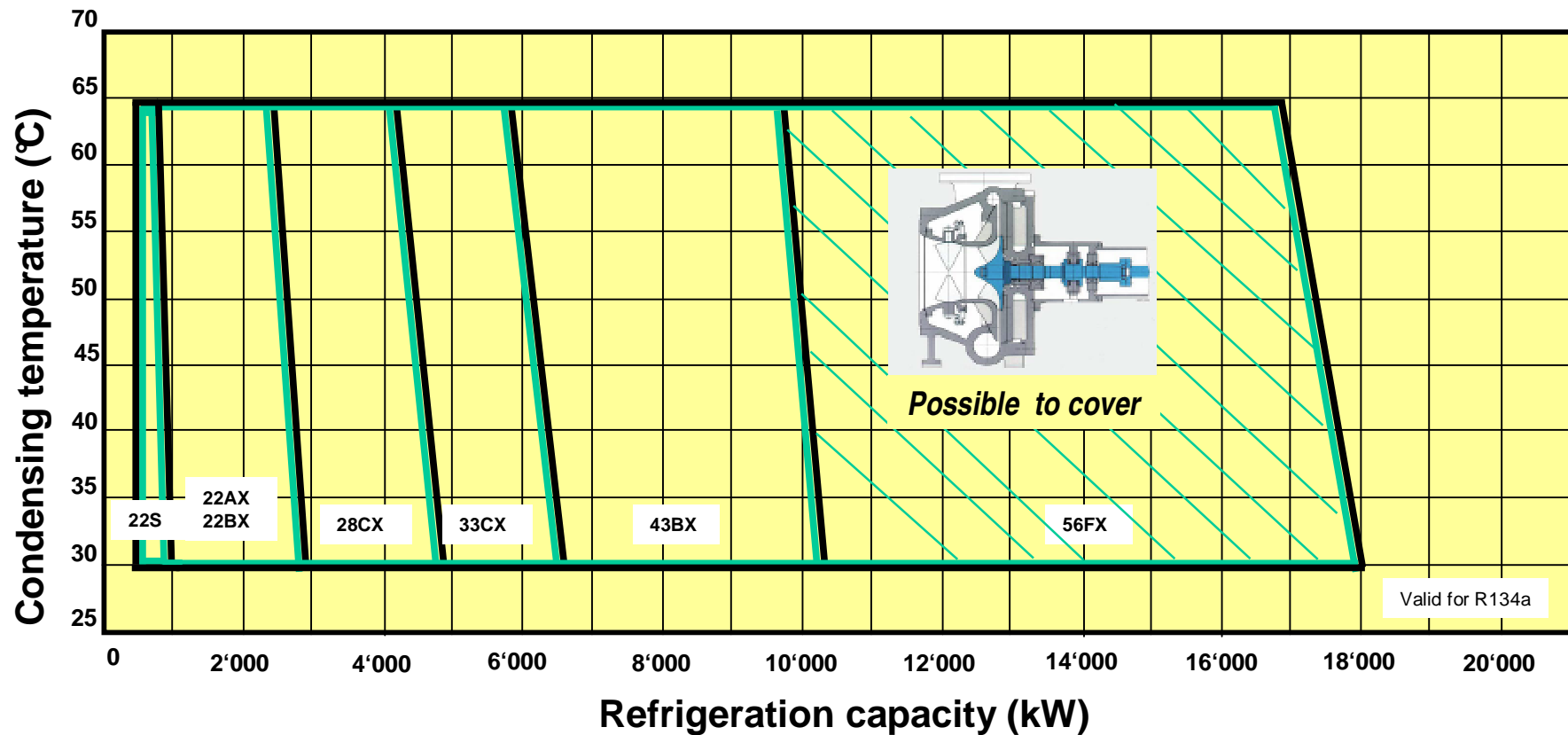
Q_H up to 20MW





Uniturbo® capacity range

Single stage compressors Uniturbo®





Single stage heat pumps



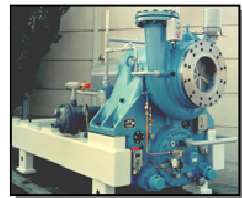
Uniturbo® 22S



Uniturbo® 22



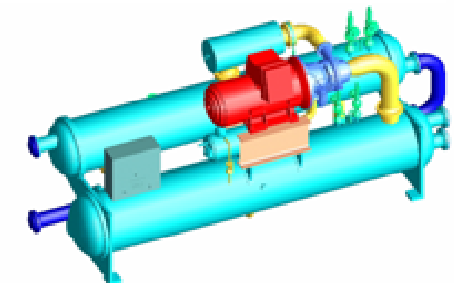
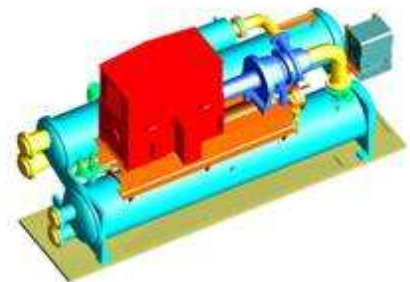
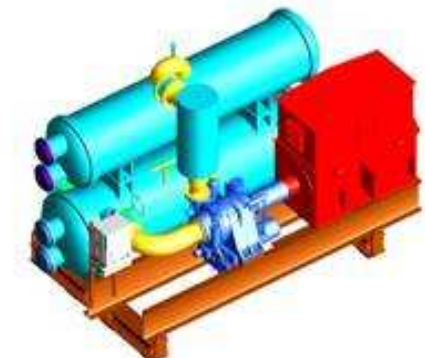
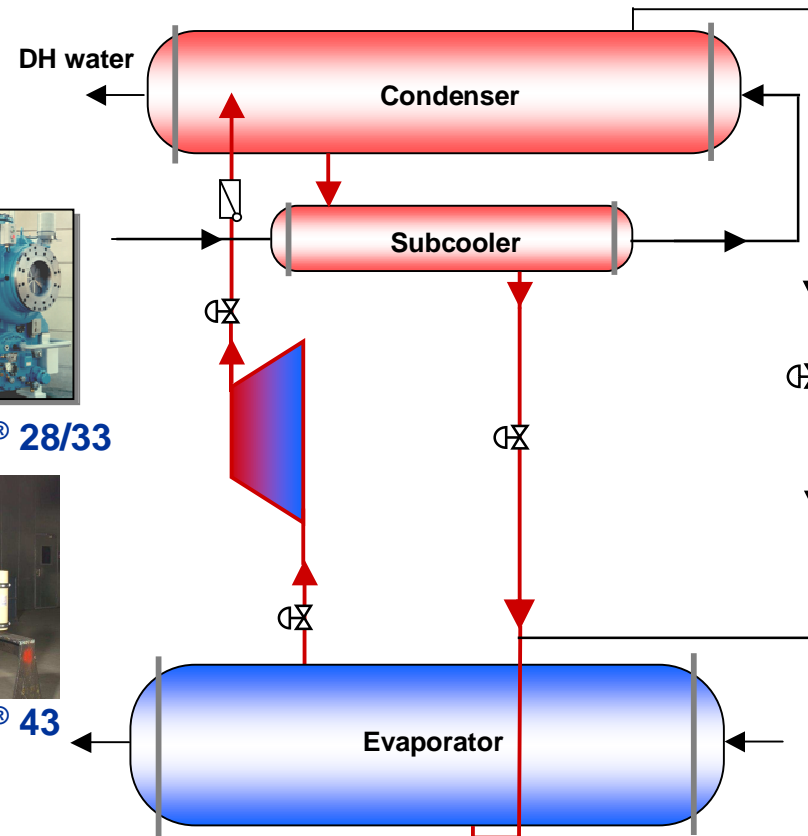
Uniturbo® 23



Uniturbo® 28/33



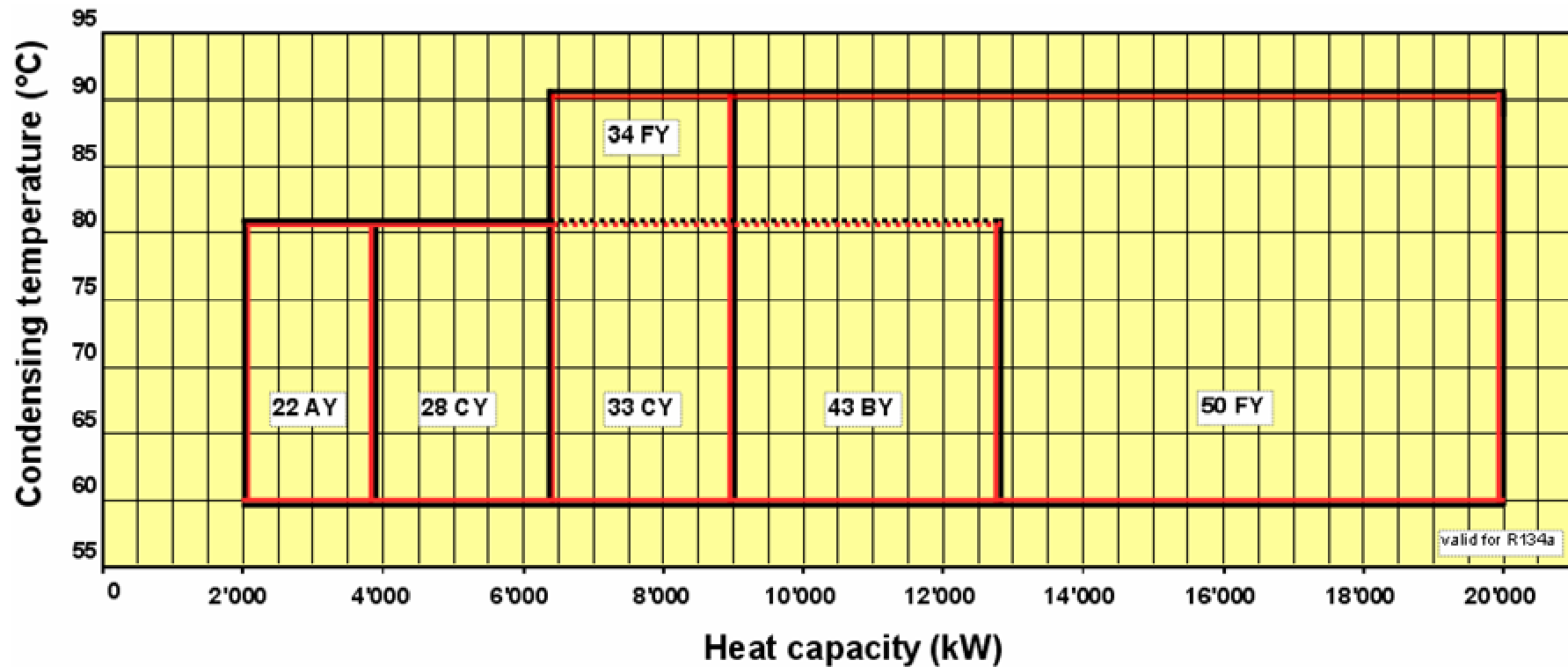
Uniturbo® 43





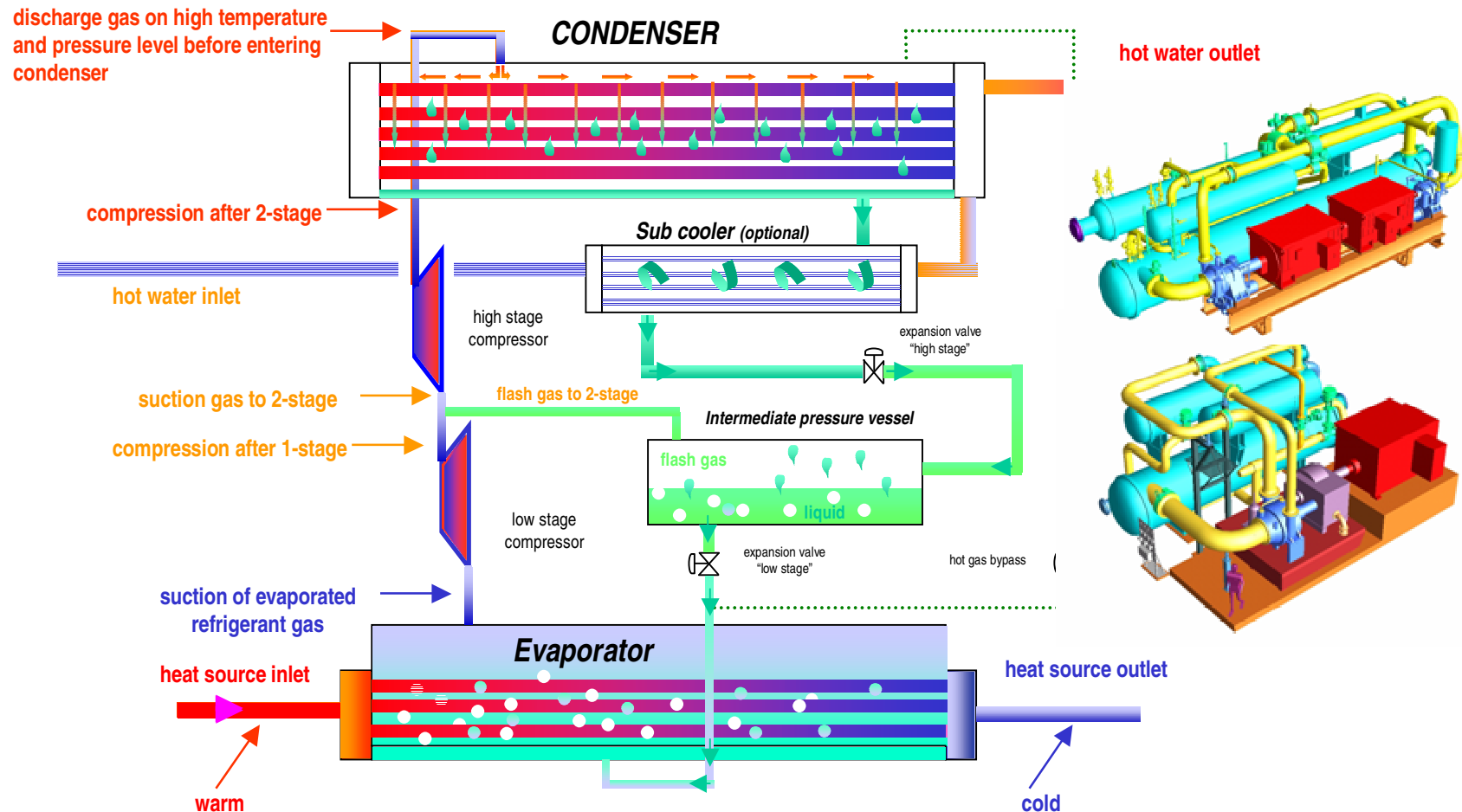
Uniturbo® capacity range

2 - stage compressors Uniturbo®





2-stage heat pump (with open flash economizer)





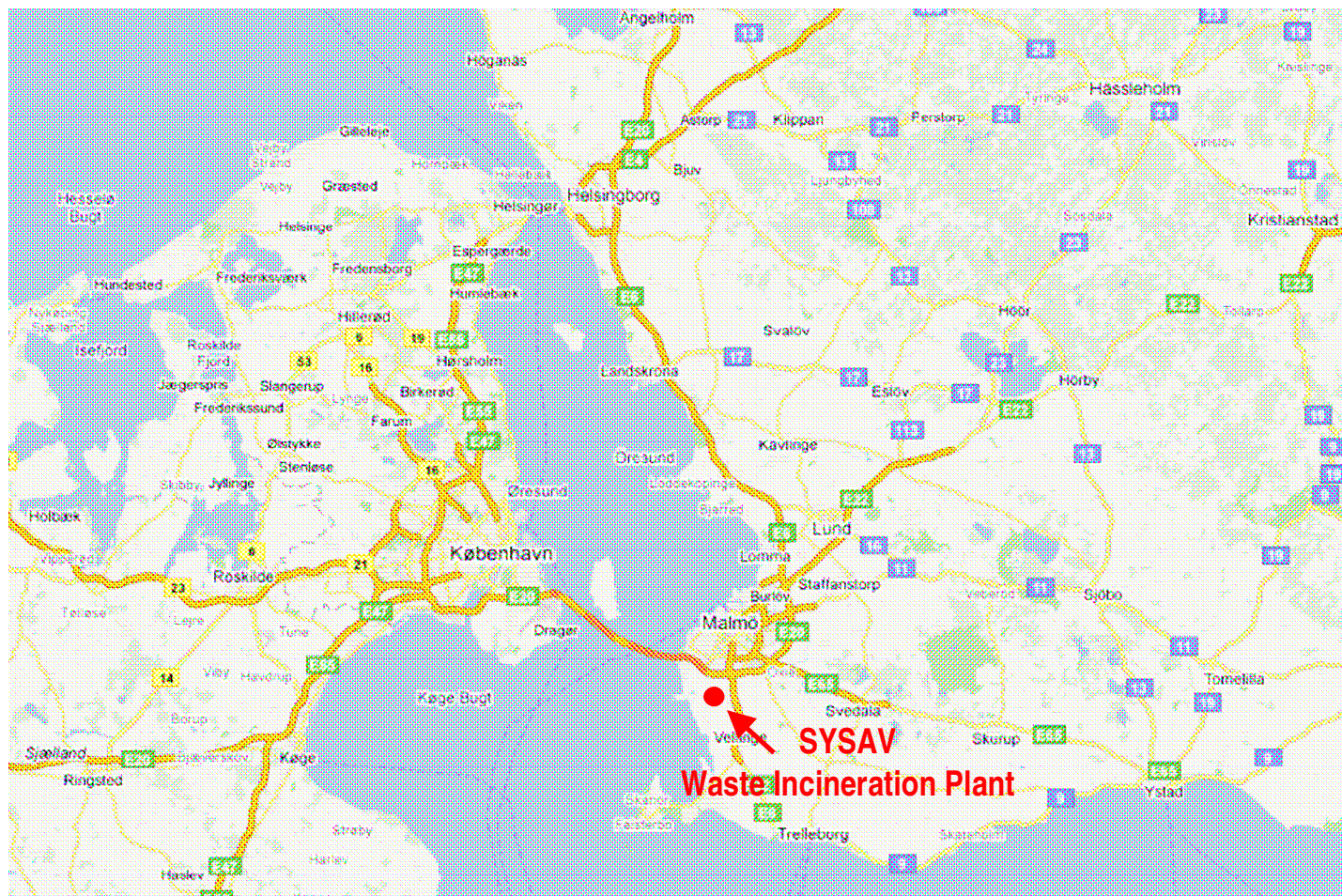
Heat Pump Plants



New Applications



Malmö Waste Incineration Plant- Heat recovery from flue gas cleaning process



Malmö Waste Incineration Plant- Heat recovery from flue gas cleaning process



Due to the fact that both heat pumps are switched counter flow wise in series temperature lift is equalized to only 30K for each heat pump

units in series

Number of units	2
Type	Heat Pump
Refrigerant	R134a
Cooling capacity	15'500 kW
Cold water temp. in/out	34.2 / 24.3 °C
Cold water flow	1'350 m ³ /h
Heating temp. in/out	50 / 59.2-70 °C
Heating water flow	1'800 m ³ /h
Power at terminal	3'500 kW
Heating capacity	19'000 kW

Coefficient of performance 5.43

Heat pump no.1 has to produce the cold water for the flue gas condenser, therefore it is getting the cold return from DH-System

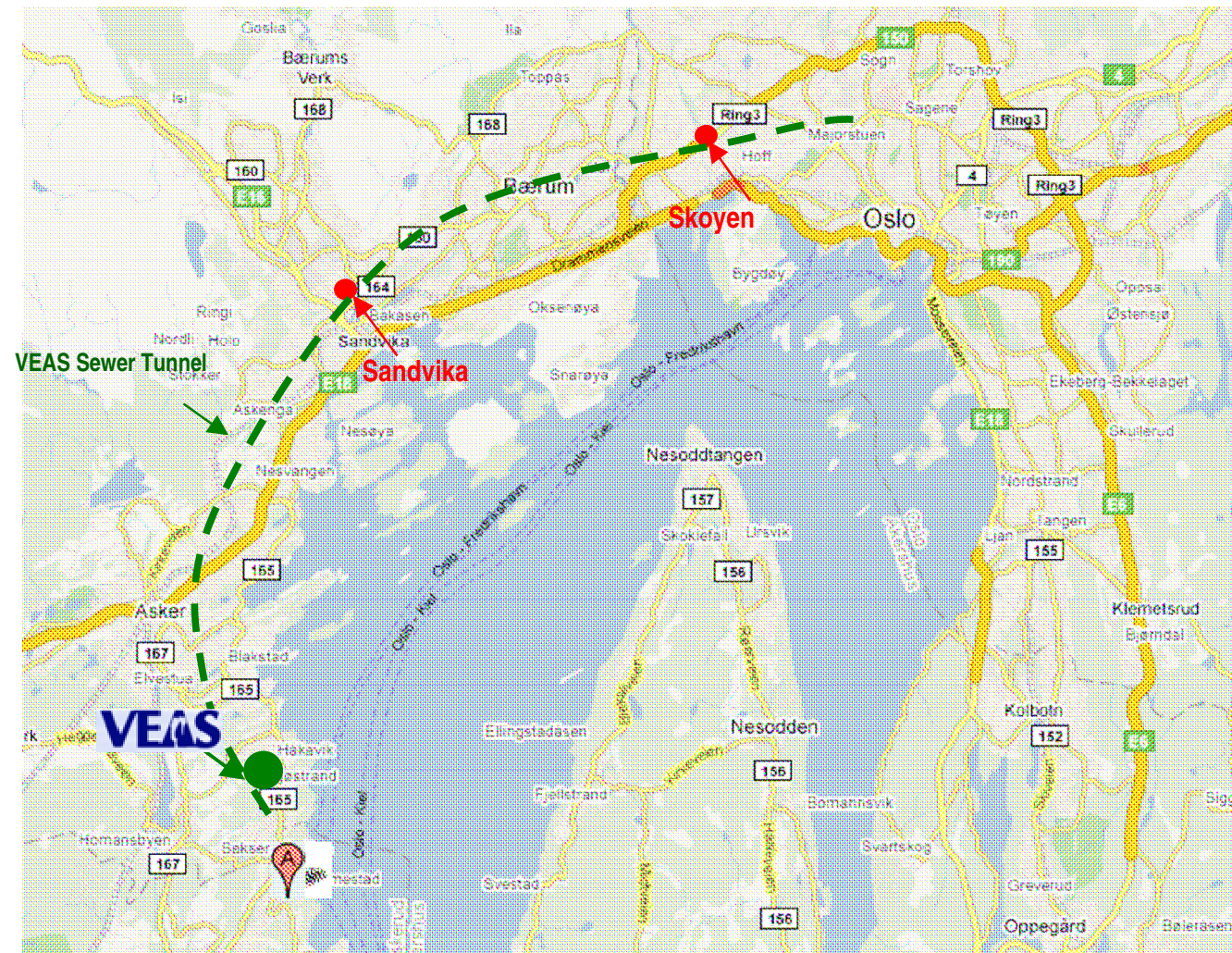


Heat pump no.2 is getting the warm water from flue gas condenser, therefore it has to produce the hot water outlet for DH-System





Sandvika Plant - Oslo / Norway

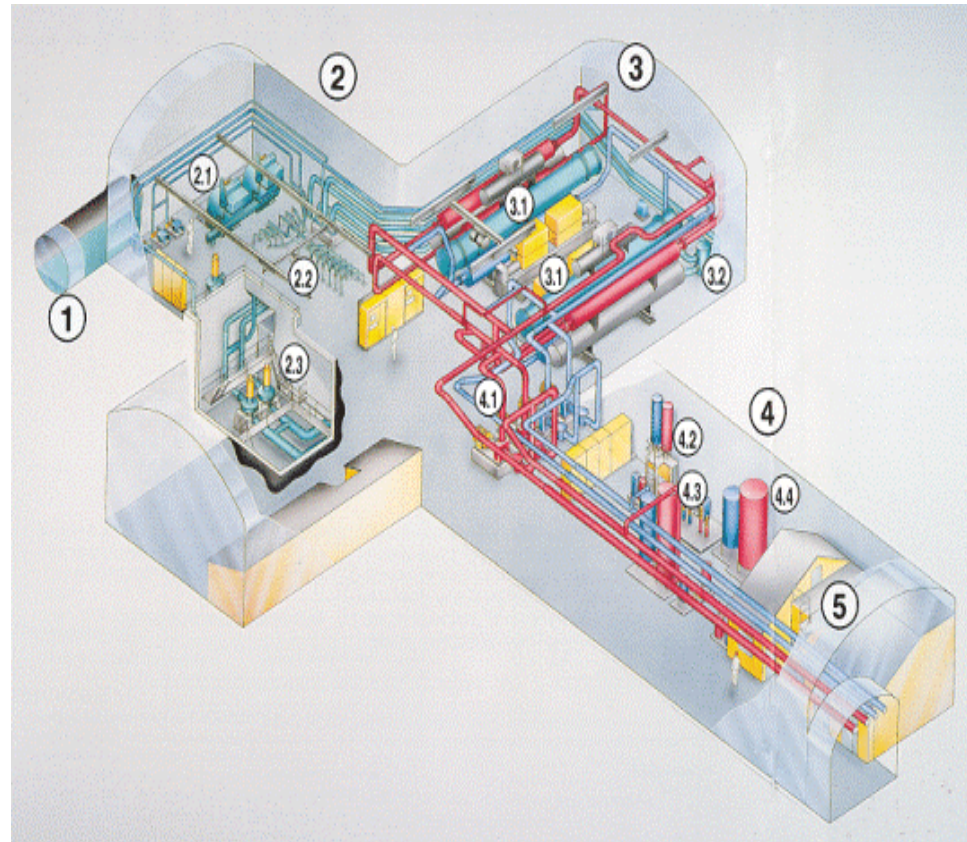




Sandvika Plant - heat source: raw waste water

District heating / cooling production plant “Sandvika”, Oslo, Norway

- 1 Waste water tunnel
- 2 Filter station
 - 2.1 Mechanical filtration
 - 2.2 Sedimentation
 - 2.3 Waste water pumps
- 3 Energy production hall
 - 3.1 Heat pumps / Chiller units
 - 3.2 Change over valves
- 4 Auxiliary machinery hall
 - 4.1 Pumps
 - 4.2 Vacuum vent
 - 4.3 Expansion tanks
 - 4.4 Feed water tanks
- 5 Local control room





Sandvika Plant - heat source: raw waste water

District heating / cooling production plant “Sandvika”, Oslo, Norway

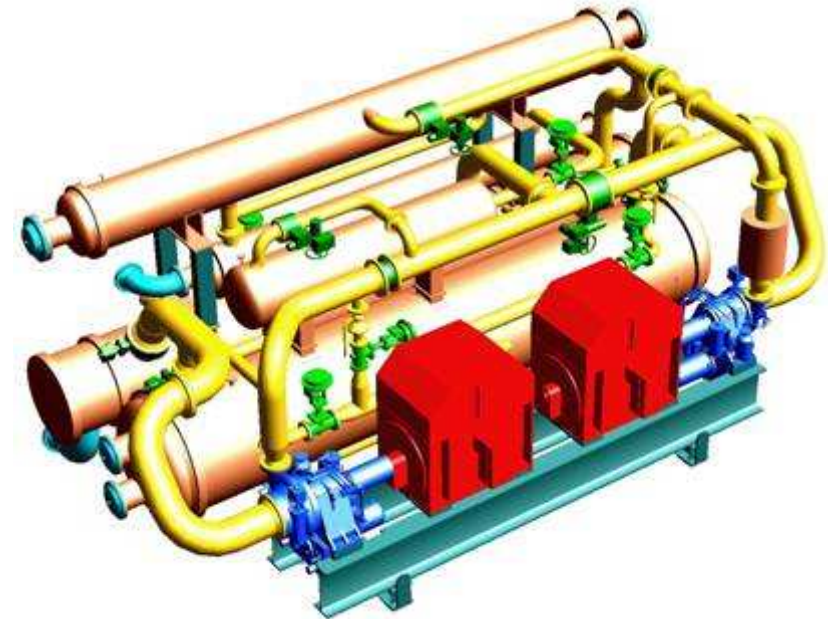




Sandvika Plant - heat source: raw waste water

District heating / cooling production plant “Sandvika”, Oslo, Norway

Number of units	2
Type	UNITOP® 28/28 CY Refrigerant R134a
Cooling medium	Raw sewage water or chilled water or both simultaneous
Cooling/heat source capacity	9'500 kW
Raw sewage water in/outlet	10.0 / 6 °C
Chilled water temp. in/out	8.0 / 4.0 °C
Heating capacity [always required]	14'000 kW
Heating water temp. in/out	57.0 / 78 °C
Heating water flow	573 m³/h
Power at terminal	4'500 kW
COP (heating)	3.1
overall COP (heating + cooling)	5.22



2 units into successful operation since 1989 (more than 160'000 operating hours)

1 additional unit into operation since June 2008

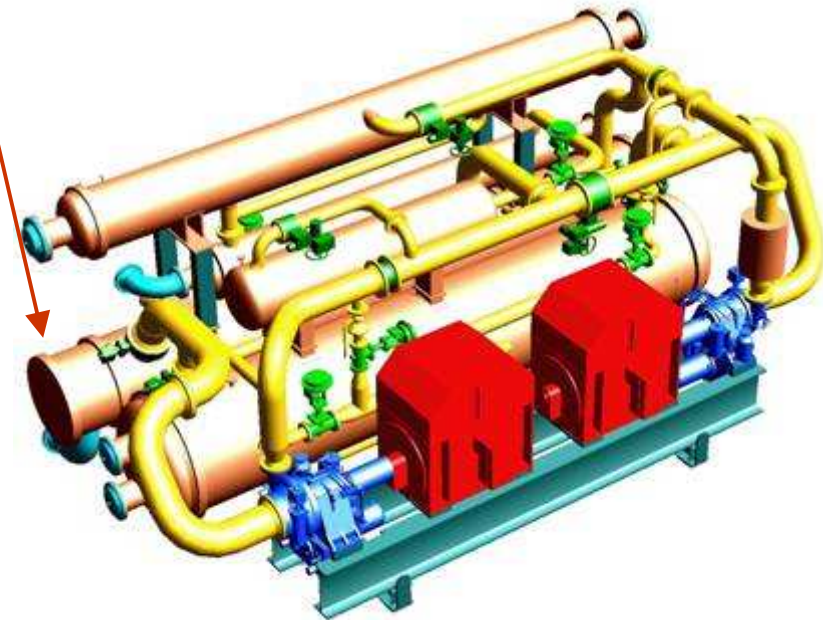




Sandvika Plant - WINTER OPERATION

District heating / cooling production plant “Sandvika”, Oslo, Norway

Number of units	2
Type	UNITOP® 28/28 CY Refrigerant R134a
Heat source medium	Raw sewage water
Heat source capacity	9'500 kW
Raw sewage water in/outlet	10.0 / 6 °C
Heating capacity [always required]	14'000 kW
Heating water temp. in/out	57.0 / 78 °C
Heating water flow	573 m³/h
Power at terminal	4'500 kW
COP (heating)	3.1





Sandvika Plant - SUMMER OPERATION

District heating / cooling production plant “Sandvika”, Oslo, Norway

Number of units

2

Type

UNITOP® 28/28 CY Refrigerant R134a

Cooling medium

chilled water

Cooling capacity

9'500 kW

Chilled water temp. in/out

8.0 / 4.0 °C

Heating capacity [always required]

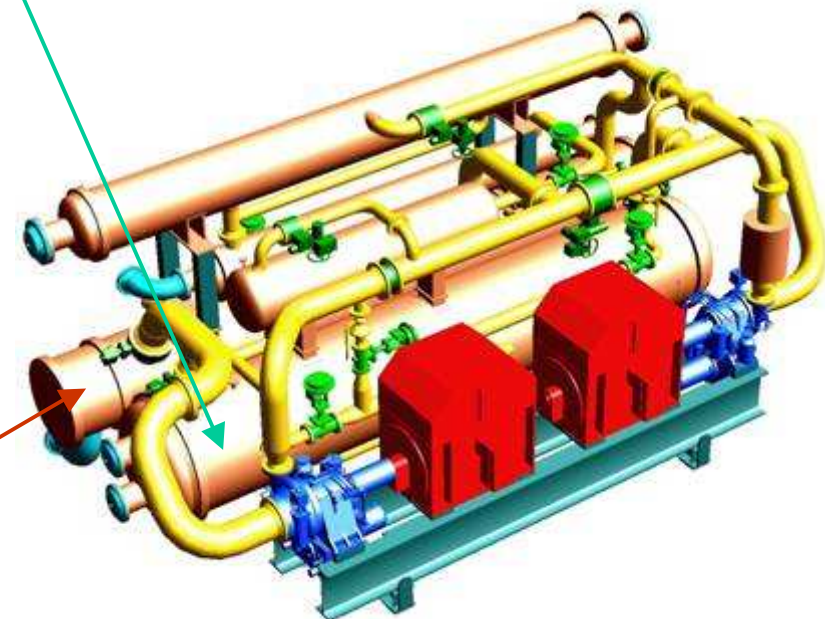
not required

cooling water temp. in

15 °C

cooling medium raw sewage water

sewage evaporator operates as condenser

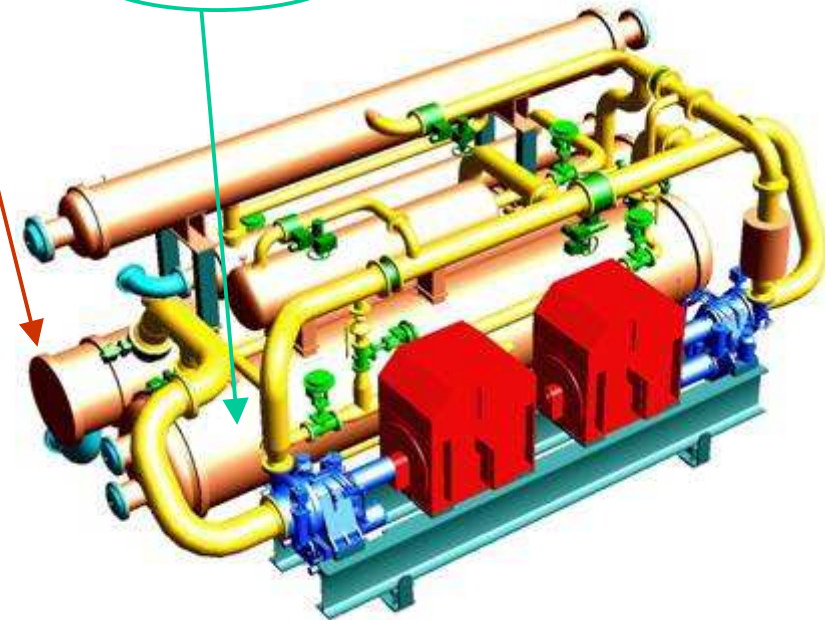




Sandvika Plant - SPRING/AUTUMN OPERATION

District heating / cooling production plant “Sandvika”, Oslo, Norway

Number of units	2
Type	UNITOP® 28/28 CY Refrigerant R134a
Cooling medium	Raw sewage water and chilled water simultaneous
Cooling&heat source capacity	9'500 kW
Raw sewage water in/outlet	10.0 / 6 °C
Chilled water temp. in/out	8.0 / 4.0 °C
Heating capacity [always required]	14'000 kW
Heating water temp. in/out	57.0 / 78 °C
Heating water flow	573 m³/h
Power at terminal	4'500 kW
COP (heating)	3.1
overall COP (heating + cooling)	5.22





Sandvika Plant - heat source: raw waste water

District heating / cooling production plant “Sandvika”, Oslo, Norway



**Machine room, 2 Unitop® 28/28
with heat distribution pipe work**



**Machine room, left Unitop® 28/28,
right: heat/cold distribution pumps**





Sandvika Plant - heat source: raw waste water

Sandvika extension of existing plant:
after 20 years of successful operation the customer ordered a 3rd heat pump for extension of DC & DH



Workshop pictures from 11th April 2008





Skoyen Vest +90°C - heat source: raw waste water

Heat Production with two large heat pumps type Unitop 50FY and 34FY





Skoyen Vest +90°C - heat source: raw waste water

Heat Production with two large heat pumps type Unitop 50FY and 34FY



**Entrance tunnel,
with heat distribution pipe work**



**Remote
Control room**





Skoyen Vest +90°C - heat source: raw waste water

The machinery rooms at “Skoyen Vest”, Oslo, Norway





Skoyen Vest +90°C - heat source: raw waste water

50FY-101711U and 34FY-81411U - series operation



Number of units	1 heat pump	1 heat pump		
Type	UNITOP® 50 FY	UNITOP® 34 FY		
Refrigerant	R134a	R134a		
Cooling medium	Raw waste water	Raw waste water		
Waste water temp. in/out	10.0 / 5.76 °C	10.0 / 6.3 °C		
Waste water flow	2'400 m3/h	1'400 m3/h		
Heating water temp. in/out	75.5/ 90 °C	60 / 75.5 °C (up to 90 °C)		
Heating water flow	824 m3/h			
Power at terminal	6'566 kW	3'184 kW	total	9'750kW
Heat capacity	18'400 kW	9'200 kW	total	27'600kW
Coeff. of performance	2.80	2.89	overall	2.83 up to 3.5

1st unit into successful operation since December 2005

2nd unit into successful operation since November 2007





Skoyen Vest - hot water production at +90°C

Viken Fjernvarme Oslo, for District heating “Skoyen Vest”, Oslo, Norway



**Sewage-
water-
pumps**





Skoyen Vest +90°C - heat source: raw waste water

Viken Fjernvarme Oslo, for District heating “Skoyen Vest”, Oslo, Norway



Waste water filter station
Mechanical filtration



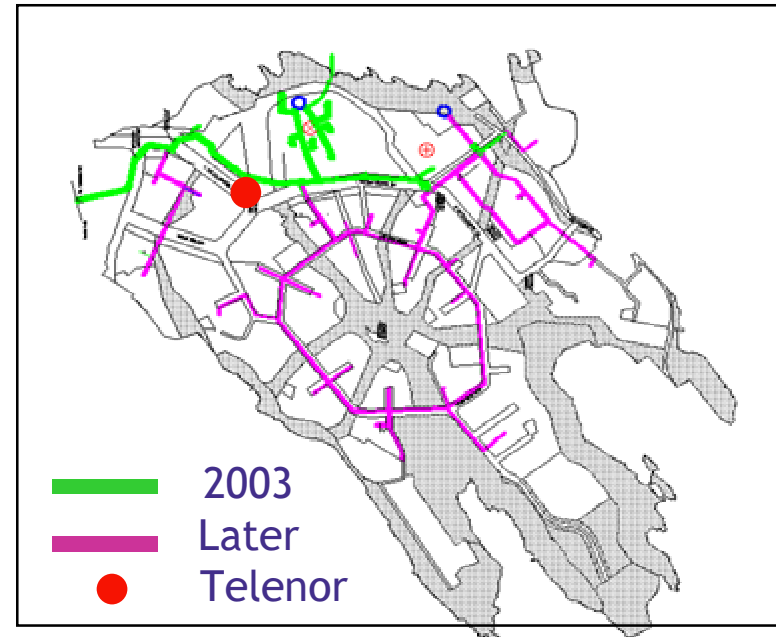


Fornebu Plant - heat source: sea water

District heating & cooling production plant “Fornebu”, Oslo, Norway
Unitop® 28 / 22 and Unitop® 33 / 28



Fornebu development site



Fornebu development site
Proposed distribution network



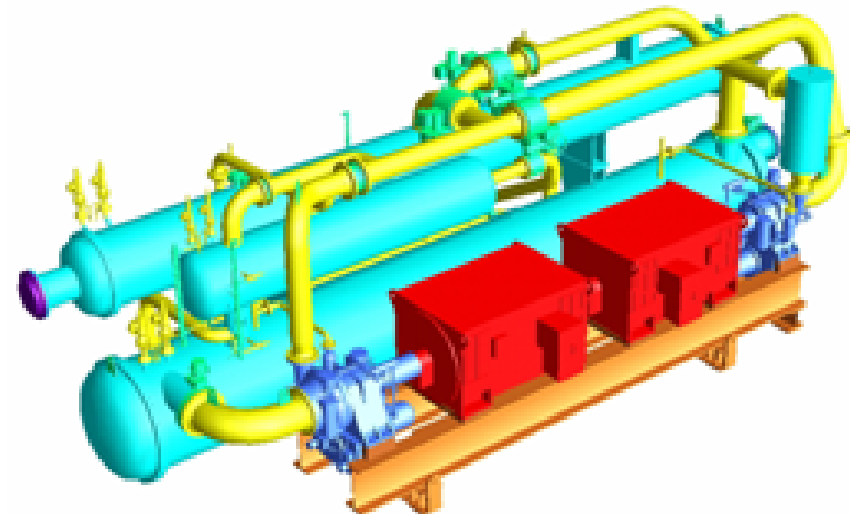


Fornebu Plant - heat source: sea water

Unitop® 28 / 22 in 2001



Unitop® 28 / 22 for Fornebu
in the workshop before
loading for transport



Unitop® 28 / 22 for Fornebu
Front left: compressor type 28CX
Front right: compressor type 22BX





Fornebu Plant - heat source: sea water

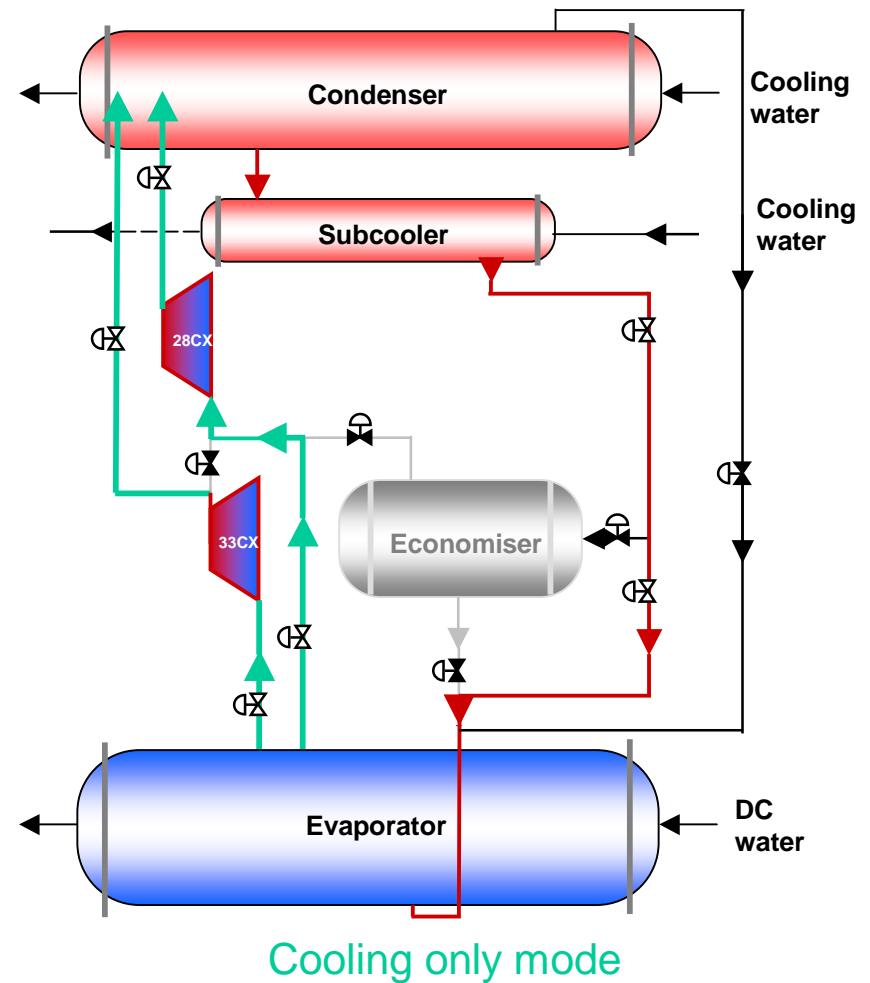
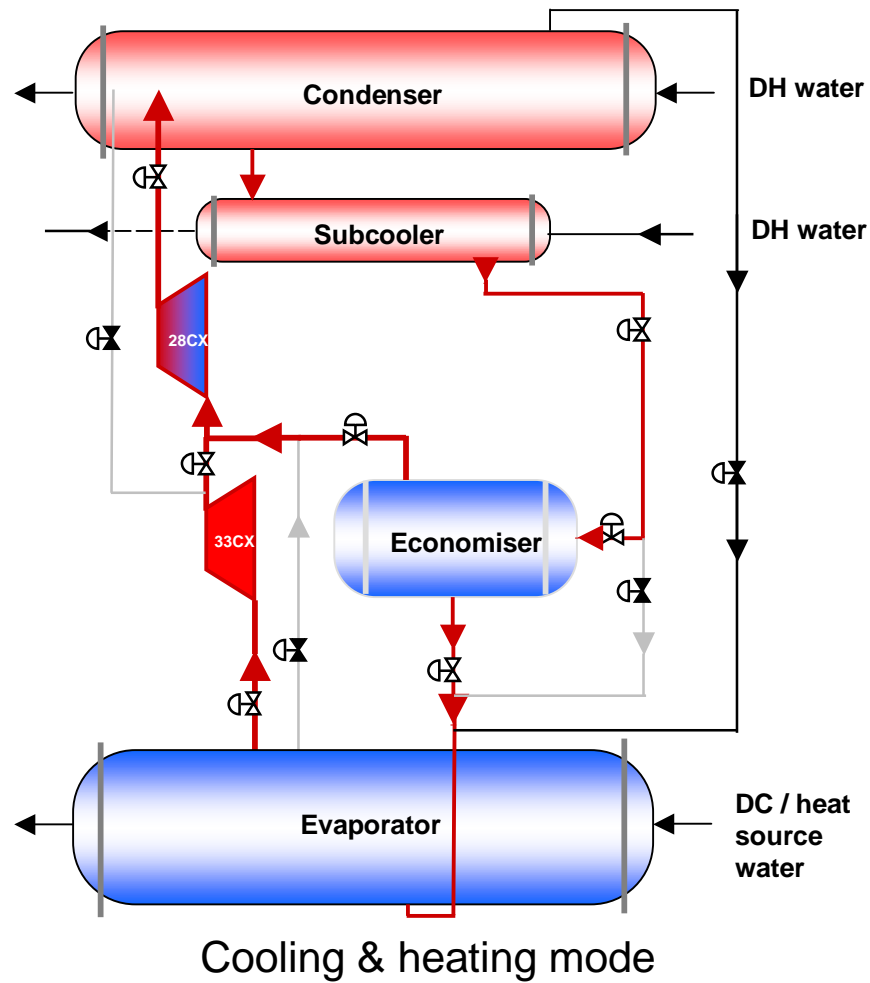
Unitop® 33 / 28 in 2006



Transport of Unitop® 33 / 28 for Fornebu



Combined heating & cooling





Fornebu Plant - heat source: sea water

total cooling & heating production with heat pumps / chillers

	Summer	Winter	Spring / Autumn
Number of units	1	2	
Type	UNITOP®28/22 & 33/28	UNITOP®28/22 & 33/28	
Refrigerant	R134a	R134a	
Cooling medium	District cooling water	Sea water, indirect	
Cooling capacity	17'600 kW	9'205 kW	
Cold water temp. outlet	5.0 °C (2.5 °C)	2.5 °C	
Cooling water temp. inlet	25.0 °C		
Heating water temp. in/out	--	50.0 / 75 °C	
Power at terminal	3'389 kW	4'475 kW	
Heating capacity	--	13'700 kW	
COP	5.193	3.061	5.118 [22'905 / 4'475]

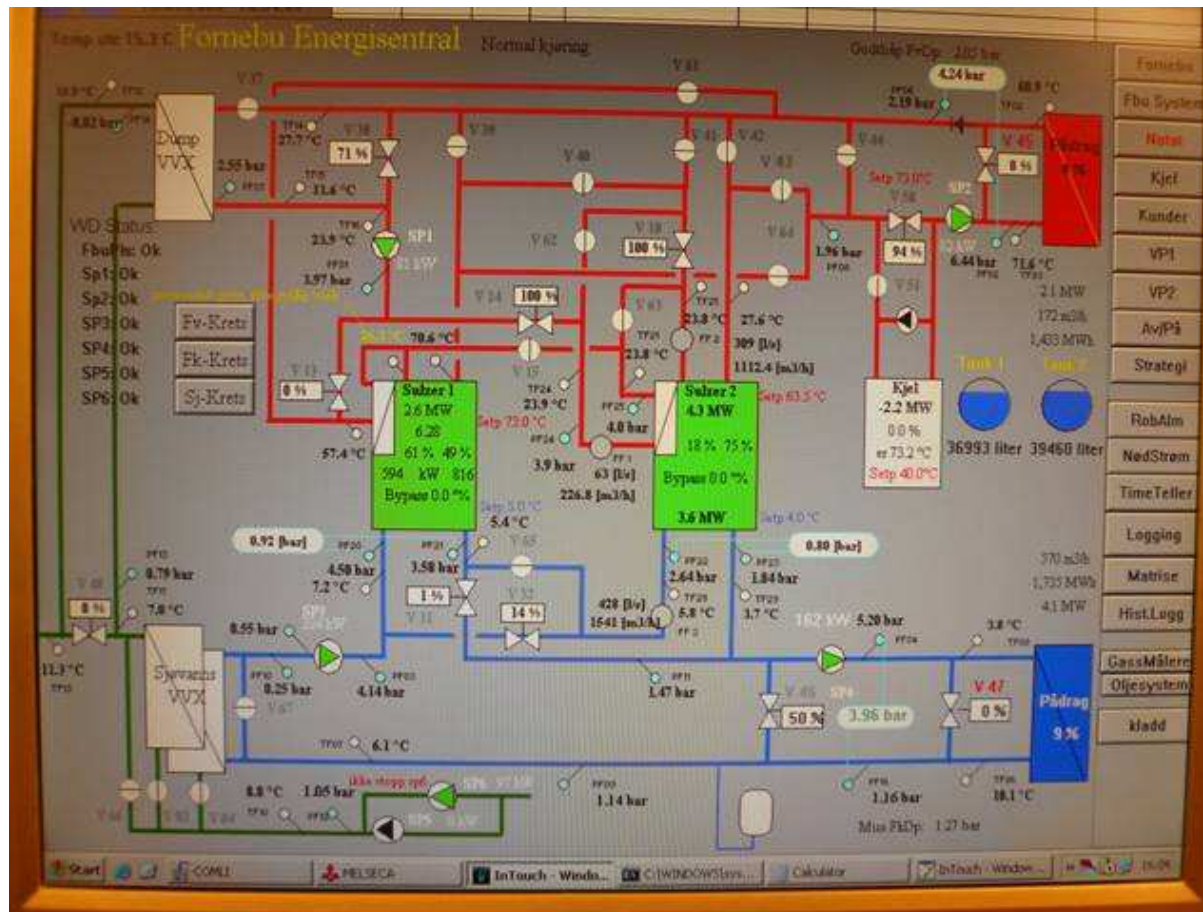
1 Unitop 28 / 22 into successful operation since 2001

1 Unitop 33 / 28 into successful operation since 2006





Fornebu Plant - heat source: sea water



Possible operating modes:

single operation in:

- heat pump mode
- chiller mode

parallel operation in:

- heat pump mode
- chiller mode

series operation in:

- heat pump mode
- chiller mode

operation of:

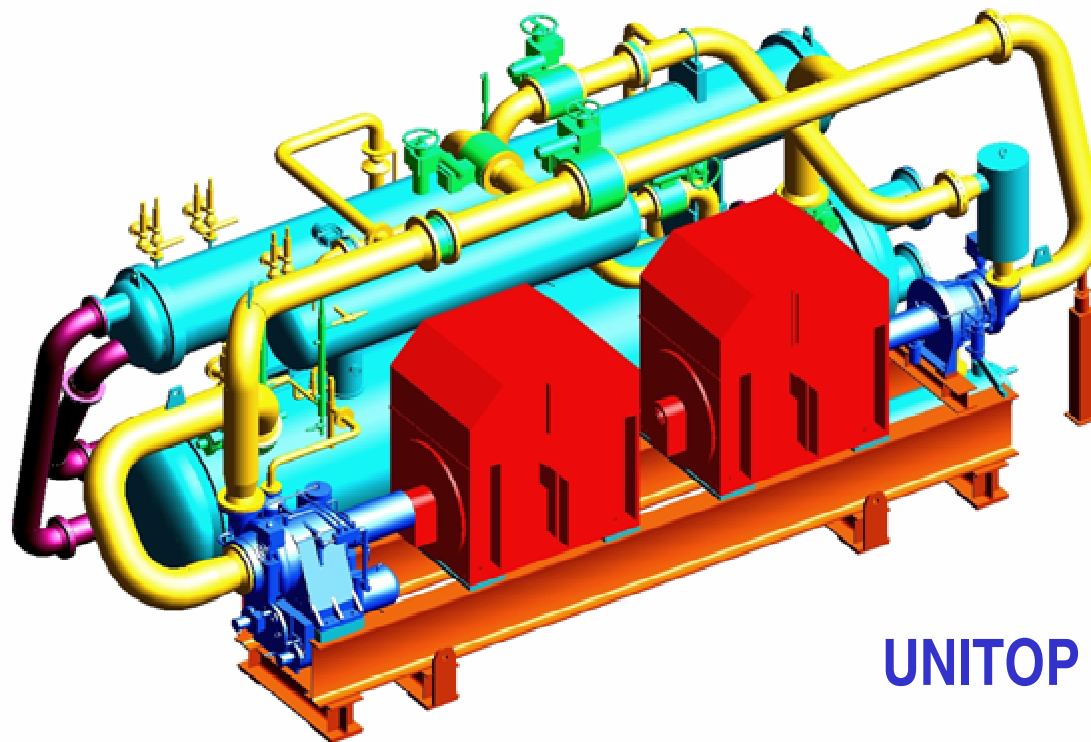
- one unit in heat pump mode and
- one unit in chiller mode and
- simultaneous cooling and heat production





Lysaker Plant - heat source: sea water

District heating & cooling production plant “Lysaker”, Oslo, Norway
One Unitop® 28 / 22 in operation since 1999 and capacity increase
by a new Unitop® 28 / 22 in June 2012



UNITOP 28/22CPY-61307U





Lysaker Plant - heat source: sea water

cooling & heating production with heat pumps / chillers from June 2012

	Summer	Winter
Number of units	1	2
Type	UNITOP®28/22 & 28/22	UNITOP®28/22 & 28/22
Refrigerant	R134a	R134a
Cooling medium	District cooling water	Sea water, indirect
Cooling capacity	10'500 kW	6'056 kW
Cold water temp. outlet	2.0 °C	2.0 °C
Cooling water temp. inlet	20.0 °C	
Heating water temp. in/out	--	50/75 °C (80°)
Power at terminal	2'415 kW	3'263 kW
Heating capacity	--	9'137 kW
COP	4.35	2.80

1 Unitop 28 / 22 into successful operation since 1996

1 Unitop 28 / 22 will go in operation about June 2012

